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The research reported in this issue of the journal was commissioned by the HTA Programme as project number 06/46/01. The contractual start date was in November 2006. The draft report began editorial review in May 2007 and was accepted for publication in February 2008. As the funder, by devising a commissioning brief, the HTA Programme specified the research question and study design. The authors have been wholly responsible for all data collection, analysis and interpretation, and for writing up their work. The HTA editors and publisher have tried to ensure the accuracy of the authors' report and would like to thank the referees for their constructive comments on the draft document. However, they do not accept liability for damages or losses arising from material published in this report.

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Abstract

A systematic review of the clinical effectiveness and cost-effectiveness and economic modelling of minimal incision total hip replacement approaches in the management of arthritic disease of the hip

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Objectives: To assess the clinical effectiveness and cost-effectiveness of minimal incision approaches to total hip replacement (THR) for arthritis of the hip.
Data sources: Major electronic databases were searched from 1966 to 2007. Relevant websites were also examined and experts in the field were consulted.
Review methods: Studies of minimal (one or two) incision THR compared with standard THR were assessed for inclusion in the review of clinical effectiveness. A systematic review of economic evaluations comparing a minimal incision approach to standard THR was also performed and the estimates from the systematic review of clinical effectiveness were incorporated into an economic model. Utilities data were sourced to estimate quality-adjusted life-years (QALYs). Due to lack of data, no economic analysis was conducted for the two mini-incision surgical method.
Results: Nine randomised controlled trials (RCTs), 17 non-randomised comparative studies, six case series and one registry were found to be useful for the comparison of single mini-incision THR with standard THR. One RCT compared two mini-incision THR with standard THR, and two RCTs, five non-randomised comparative studies and two case series compared two mini-incision with single mini-incision THR. The RCTs were of moderate quality. Most had fewer than 200 patients and had a follow-up period of less than 1 year. The single mini-incision THR may have some perioperative advantages, e.g. blood loss [weighted mean difference (WMD) –57.71 ml, $p < 0.01$] and shorter operative time, of uncertain practical significance. It may also offer a shorter recovery period and greater patient satisfaction. Evidence on long-term outcomes (especially revision) is too limited to be useful. Lack of data prevented subgroup analysis. With respect to the two-incision approach, data were suggestive of shorter recovery compared with single-incision THR, but conclusions must be treated with caution. The costs to the health service, per patient, of single mini-incision THR depend upon assumptions made, but are similar at one year (£7060 vs £7350 for standard THR). For a 40-year time horizon the costs were £11,618 for mini-incision and £11,899 for standard THR. Two existing economic evaluations were identified, but they added little, if any, value to the current evidence base owing to their limited quality. In the economic model, mini-incision THR was less costly and provided slightly more QALYs in both the 1- and 40-year analyses. The mean QALYs at 1 year were 0.677 for standard THR and 0.695 for mini-incision THR. At 40 years, the mean QALYs were 8.463 for standard THR and 8.480 for mini-incision. At 1 year the probabilistic sensitivity analyses indicate that mini-incision THR has a 95% probability of being cost-effective if society's willingness to pay for a QALY were up to £50,000. This is reduced to approximately 55% for the 40-year analysis. The results were driven by the

assumption of a 1-month earlier return to usual activities and a decreased hospital length of stay and operation duration following mini-incision THR. If mini-incision THR actually required more intensive use of resources it would become approximately £200 more expensive and would only be cost-effective (cost per QALY > £30,000) if recovery was 1.5 weeks faster. A threshold analysis around risk of revision showed, using the same cost per QALY threshold, mini-incision THR would have to have no more than a 7.5% increase in revisions compared with standard THR for it to be no longer considered cost effective (one more revision for every 200 procedures performed). Further sensitivity analysis involved relaxing assumptions of equal long-term outcomes where possible. and broadly similar results to the base-case analysis were found in this and further sensitivity analyses.

Conclusions: Compared with standard THR, minimal incision THR has small perioperative advantages in terms of blood loss and operation time. It may offer a shorter hospital stay and quicker recovery. It appears to have a similar procedure cost to standard THR, but evidence on its longer term performance is very limited. Further long-term follow-up data on costs and outcomes including analysis of subgroups of interest to the NHS would strengthen the current economic evaluation.

Contents

List of abbreviations

BMI	body mass index
BNF	British National Formulary
CEAC	cost-effectiveness acceptability curve
CI	confidence interval
DVT	deep vein thrombosis
HES	Hospital Episode Statistics
HRG	healthcare resource group
ICER	incremental cost-effectiveness ratio
MI	mini-incision
2MI	two mini-incision
MIS	minimally invasive surgery, mini-incision surgery
NHS EED	National Health Service Economic Evaluation Database
NICE	National Institute for Health and Clinical Excellence
NJR	National Joint Registry
ODEP	Orthopaedic Device Evaluation Panel
OR	odds ratio
QALY	quality-adjusted life-year
PE	pulmonary embolism
RCT	randomised controlled trial
SD	standard deviation
SF-6D	Short Form with 6 Dimensions
SF-12	Short Form with 12 Items
SF-36	Short Form with 36 Items
SI	standard incision
SIGN	Scottish Intercollegiate Guidelines Network
THR	total hip replacement
WMD	weighted mean difference
WOMAC	Western Ontario and MacMaster Universities

All abbreviations that have been used in this report are listed here unless the abbreviation is well known (e.g. NHS), or it has been used only once, or it is a non-standard abbreviation used only in figures/tables/appendices in which case the abbreviation is defined in the figure legend or at the end of the table.

Executive summary

Description of proposed service

Minimal incision total hip replacement (THR) is performed with significant variations between surgeons but approaches fall into two main groups. Of these, the 'double-incision' or 'two-incision' approach is novel and specific to minimally invasive hip surgery, whereas the single mini-incision approach is a development of traditional anterolateral and posterior approaches. Minimal incision techniques can be used for all the main categories of hip prostheses. Although shorter incisions may result in less muscle dissection, they may also reduce visualisation at operation, leading to potential risks that the placement of the prosthesis will be sub-optimal and may, therefore, lead to a higher rate of revisions than might be expected with standard THR.

Epidemiology and background

Osteoarthritis was the primary diagnosis in 94% of THR operations in England and Wales in 2005. Its incidence increases with age, and consequently THR is most common in older people (the average age of patients is 68 years). With improvements in implant design and longevity, younger patients are also now considered for THR. Over 55,000 primary THRs are recorded annually in the National Joint Registry, of which 6–14% are reported to be mini-incision THR. Minimally invasive surgery (MIS) is thought to be less suitable for patients who are obese, very muscular or with severe osteoporosis.

Objective

This review aimed to assess the clinical effectiveness and cost-effectiveness of minimal incision approaches to THR for arthritis of the hip.

Methods

The search strategy included electronic databases (covering 1966–2007) and relevant websites, contact with experts in the field and scrutiny of retrieved papers to identify reports of published and ongoing studies. Systematic reviews and selected conference proceedings were also searched.

Studies of minimal (one or two) incision THR compared with standard THR were assessed for inclusion for the review of clinical effectiveness. Studies of two-incision THR compared with one mini-incision THR were also eligible. Randomised controlled trials (RCTs), quasi-RCTs, prospective non-randomised studies with concurrent comparisons and matched-pair studies, and retrospective comparative studies with prospective design or total population recruitment were included. Additional long-term data were sought from national registries, and also single-surgeon case series with a minimum follow-up of 3 years and multiple-surgeon case series with a minimum follow-up of 1 year. Pre-specified subgroups were based on age, gender, deformity, muscularity and body mass index (BMI), and also operative approach (i.e. posterior, anterior).

Two reviewers independently extracted data and assessed methodological quality. Meta-analyses were performed with the RCT data; dichotomous data were combined using the Peto odds ratios and continuous data were combined using the inverse variance weighted mean differences.

A systematic review of economic evaluations comparing a minimal incision approach to standard THR was performed and the estimates from the systematic review of clinical effectiveness were incorporated into an economic model. This model estimated the cost–utility of single mini-incision THR for time horizons of 1 and 40 years (although few long-term data relevant to the 40-year time horizon were available). Many of the outcomes produced by the meta-analysis were implausible and it was not possible to incorporate them into the model. Data were suggestive of equal outcomes following standard and mini-incision THR, hence the risks of revision, postoperative dislocation and infection, deep vein thrombosis (DVT) and pulmonary embolism (PE) were assumed to be equal but with wide confidence intervals (CIs) [relative risk (RR) 1, 95% CI 0.1 to 1.89]. The key costs included in the model were operative costs in terms of hospital costs, equipment and staffing for the two procedures and hospital stay. Differences in hospital stay [weighted mean difference (WMD) –0.5 days, $p \leq 0.01$] and operation duration (WMD –3.70 minutes, $p \leq 0.01$)

both favoured single mini-incision THR and were taken directly from the meta-analysis conducted as part of the review of effectiveness. The management costs of postoperative complications were also included, such as the cost of a revision surgery (£7858) after a subsequent failure, the cost of reoperations, due to both dislocations (£1925) and infections (£3365) and the cost associated with managing DVT (which varied depending on severity) and non-fatal pulmonary embolisms (£1326). Long-term costs of care included the follow-up of patients in consultant-led outpatient visits (£103 per visit) and the management costs of those patients whose surgeries have failed and who, therefore, are treated non-operatively for the remainder of their lives (annual cost £743). Utilities data were sourced to estimate quality-adjusted life-years (QALYs) and therefore utilities were also assigned to the main quality of life outcomes included in the model, such as success (0.75), failure (0.33) and the utility associated with various complications. Due to lack of data, no economic analysis was conducted for the two mini-incision surgical method.

Results

Number and quality of studies, and direction of evidence

Fifty-five reports describing 42 studies were identified. Of these, 32 studies (nine RCTs, 17 non-randomised comparative studies and six case series and one registry) were useful for the comparison of single mini-incision THR with standard THR. One RCT compared two mini-incision THR with standard THR and nine studies (two RCTs, five non-randomised comparative studies and two case series) compared two mini-incision with single mini-incision THR. The RCTs were of moderate quality. The majority had fewer than 200 patients (range 20–219). The majority of comparative studies comparing single mini-incision with standard THR (four RCTs, 12 non-randomised) and those comparing the two mini-incision THR with single mini- or standard THR (one RCT, three non-randomised) had a follow-up period of less than 1 year.

Summary of benefits

The single mini-incision THR may have some perioperative advantages, namely less blood loss (WMD –57.71 ml, $p \leq 0.01$) and shorter operative time, of uncertain practical significance. The mini-incision approach may also offer a shorter recovery period and greater patient satisfaction with the operation and scar appearance. Evidence on long-term outcomes (especially revision) is too limited to be useful. Subgroup analysis was not possible due to lack of suitable data.

With respect to the two-incision approach, data were suggestive of shorter recovery compared with single-incision THR, although the data were not in a form amenable to meta-analysis. As data were sparse, conclusions must be treated with caution.

Costs

The costs to the health service, per patient, of single mini-incision THR depends on the assumptions made, but are similar (£7060) to standard THR, which costs the NHS, on average, £7350 per patient. In the base-case analysis, the cost difference between standard and single mini-incision THR for a 1-year time horizon was approximately £300 less per patient than standard THR (for the 40-year time horizon the costs were £11,618 for mini-incision and £11,899 for standard THR).

Cost-effectiveness

Two existing economic evaluations were identified, but they added little, if any, value to the current evidence base owing to their limited quality. In the economic model, mini-incision THR was less costly and provided slightly more QALYs and therefore dominated standard THR, in both the 1- and 40-year analyses. The mean QALYs at 1 year were 0.677 for standard THR and 0.695 for mini-incision THR. At 40 years, the mean QALYs were 8.463 for standard THR and 8.480 for mini-incision. The probabilistic sensitivity analyses conducted indicate that mini-incision THR has a 95% probability of being cost-effective at threshold values of up to £50,000 for society's willingness to pay for a QALY. This probability is reduced to approximately 55% for the 40-year analyses. The cost-effectiveness results were driven by the assumption of a 1-month earlier return to usual activities and a decreased hospital length of stay and operation duration following mini-incision THR.

Sensitivity analyses

Although it appeared that mini-incision THR was associated with a shorter recovery, the precise reduction could not be estimated, so a threshold analysis was performed around time to return to usual activities following mini-incision THR. This analysis was conducted for the base-case model and a model assuming more intensive use of resources for mini-incision patients. In terms of the base-case model, as mini-incision THR is less

costly than standard THR, mini-incision continued to dominate standard THR. When increased resource use was assumed for mini-incision compared with standard THR (mini-incision THR is approximately £200 more expensive than standard THR in this analysis), then provided that recovery was 1.5 weeks faster, the incremental cost-effectiveness per QALY would be £30,000 or less.

One major area of uncertainty is in risk of revision. Initially it was assumed that revision rates in the long-term would be equal (with wide CIs). A threshold analysis around risk of revision showed that if society would be willing to pay £30,000 for a QALY, mini-incision THR would have to be associated with a 7.5% increase in revisions compared with standard THR for it to be no longer considered cost-effective (one more revision for every 200 procedures performed).

Further sensitivity analysis involved relaxing assumptions of equal long-term outcomes where possible. Data produced by the meta-analysis in relation to postoperative dislocation [odds ratio (OR) 1.72, 95% CI 0.43 to 6.92] favouring standard THR, and DVT (OR 0.39, 95% CI 0.12 to 1.30), favouring mini-incision THR, were utilised in this sensitivity analysis. Broadly similar results to the base-case analysis were found in this and further sensitivity analyses.

Limitations of the calculations (assumptions made)

Much of the information available was reported in a form unsuitable for meta-analysis. Few data were available for many outcomes, including revision rates. Lack of standardisation in outcome measures was also evident and some outcomes were assessed in only one or two reports. The extent of the imprecision surrounding estimates was such that many of the meta-analysis results were not included in the base-case model (risk of revision, postoperative dislocation, DVT and PE). Consequently, these outcomes in relation to mini-incision are assumed to have, on average, equal relative effect sizes compared with standard THR (but with wide CIs). This represents an analyst assumption and is a limitation of the data inputs used by the model. Further limitations related to the estimates of costs and the impact that minimal incision THR had on QALYs in both the short and long term. In terms of utility, very few comparative and short-term data were available. Cost data would be greatly enhanced if they were collected within a full economic evaluation, alongside a clinical trial, for example.

Other important issues regarding implications

If the use of MIS were increased from its current level of 6% of all THRs to 25% of all THRs, then NHS costs may reduce by £4.1 million per year. These savings depend on judgements made about the relevance in reality of reductions in operation time, length of stay, the need for little extra specialised equipment and whether differences exist in longer term outcomes.

The increased adoption of mini-incision techniques may allow an earlier return to usual activities, which, in turn, reduces loss of income or need for informal care by family and friends. However, few patients currently have access to minimal incision THR and more surgeons would need training in this approach, which would be costly and take time to achieve. Furthermore, not all patients are clinically suitable.

Notes on the generalisability of the findings

Only two of the nine trials were conducted in the UK. No data were available to conduct any worthwhile subgroup analysis. No UK economic studies were identified.

Conclusions

Compared with standard THR, minimal incision THR has small perioperative advantages in terms of blood loss and operation time. It may offer a shorter hospital stay and quicker recovery. It appears to have a similar procedure cost to standard THR, but evidence on its longer term performance is very limited.

Further data are needed to assess long-term outcomes of single mini-incision or two mini-incision THR before robust decisions can be made. Further long-term follow-up data are also required on costs and outcomes.

Recommendations for further research

No useful data on long-term outcomes of single mini-incision or two mini-incision THR were available. Such data are required before robust decisions can be made. The sparse effectiveness data limit subsequent economic analysis. Further long-term follow-up data on costs and outcomes including analysis of subgroups of interest to the NHS (e.g. obese or muscular patients, patients with significant bone deformity or severe osteoporosis and patients who present as emergency cases) would strengthen the current

economic evaluation. The economic evaluation would also be strengthened by the collection of costs on long-term events and management, such as failure. In relation to utilities, short-term differences in recovery are required, in addition to long-term differences in outcomes which depend on both subsequent failures and differences in quality of life, caused by long-term implications of different degrees of dissection. If a large RCT addressing long-term effectiveness is conducted in the future, it is strongly recommended that a full economic evaluation be incorporated as an integral part of the study from design to dissemination. Further careful work would be required to explore the value of such a large RCT more formally.

Chapter 1
Background

Description of underlying health problem

Introduction

Hip replacement has been described as "the operation of the (20th) century"[1] and it has become outstandingly successful in relieving pain and disability. It is estimated that over 80,000 primary hip replacements are now performed annually in the UK.[2,3]

The usual indication for the procedure is arthritis of the hip, most commonly osteoarthritis, but inflammatory arthropathies such as rheumatoid arthritis may provide indications. Occasionally it may also be undertaken for other pathologies such as fracture or tumour, or deformity secondary to childhood hip disease. Osteoarthritis affects all the tissues in a joint, with the most marked effects on the articular cartilage (which may be damaged and destroyed) and the underlying bone (which may become thickened and sclerotic). The joint surface becomes irregular and the joint space is reduced. Osteophytes (spurs of bone) form around the joint in an attempt at repair. The result is pain, stiffness, deformity and loss of function, such as a reduced walking distance and a limp. Total hip replacement (THR) involves exposing and dislocating the hip joint, preparing the cup-shaped acetabulum in the pelvis by excising any osteophytes, reaming the surface to remove remaining articular cartilage down to subchondral bone and inserting an artificial cup with or without cement. The proximal femur is usually prepared by excising and discarding the head of the femur and inserting a metal stem with a ball top into the medullary canal of the proximal femur, again with or without cement.

Many variations of the operation exist, with differences in the design of the implants and their composition (metal, plastic, ceramic), and whether they are inserted with bone cement or not (cementless THR). There are also different combinations of the implants, producing different bearing surfaces (metal or ceramic-on-plastic; metal-on-metal; ceramic-on-ceramic). Whatever implant is chosen, the surgeon should follow the guidance from the National Institute for Health and Clinical Excellence (NICE)[4,5] and the Orthopaedic Device Evaluation Panel (ODEP).[6]

Resurfacing arthroplasty has returned as a possible option. The head of the femur is prepared and a large-diameter metal cap is fitted, which articulates with a thin-walled metal cup implanted in the acetabulum. These methods were considered by NICE in 2001, but few data were available.[7] More recently, it has been reported that with improved metallurgy and implant finishing, these prostheses seem to be functioning well.[8] However, long-term results are awaited. It is reserved for more active younger patients with good bone stock and has the attraction that subsequent revision, if required, may be simpler.

Epidemiology

Osteoarthritis is the single biggest cause of locomotor problems, and the commonest joint disease, in the UK and was the diagnosis in 94% of THR operations in England and Wales in 2005.[3] Its incidence increases with age, and THR is more commonly performed on this older population (average age 68 years), approximately 60% of whom are women.[3] However, with improvements in anaesthesia, older patients with medical co-morbidities may have surgery. With improvements in implant design and longevity, increasing numbers of younger patients are also now considered for hip replacement (in 2005 12% were aged less than 55 years).[3] The principal indication for surgery remains pain.

Current service provision

The National Joint Registry (NJR) for England and Wales holds information on hip and knee replacement procedures performed in the NHS and the independent sector in England and Wales since 2003.[3,9,10] In 2005, the NJR recorded an estimated 77% (124,036) of all hip and knee joint replacement procedures carried out in England and Wales, compared with 60% (93,885) in 2004 and 51% (46,798) in 2003.

A total of 61,881 hip replacement procedures were recorded on NJR in 2005. This represents a 1-year increase of 26% from 48,987 in 2004 and a 2-year

increase of 148% from 24,997 in 2003, which is likely to reflect improved reporting to the registry rather than a true increase in the number of surgical procedures.

About 90% (55,812) of hip replacement procedures recorded in 2005 were performed as primary procedures and the majority of these procedures used cement (*Table 1*). The other 10% were revisions (5769) and re-operations (300). Currently, only a very small subset of revisions and re-operations can be linked to the primary operation data captured by NJR. Since at least 90% of hip implants are expected to last 10 years or more, fewer revision procedures are likely to occur before that time.

Use of minimally invasive surgery (MIS) was reported in 6% of primary THRs in 2005, an increase of 2% over 2003 (*Table 2*). It is worth noting, however, that 14% of the procedures were also recorded as having a short incision length of 10 cm or less in the same year. Although not shown in the table, in 2005, 9% of those not classified as minimally invasive had a short incision length (⩽10 cm), and 24% of those classified as minimally invasive had a long incision length (>10 cm). This reflects inconsistency in the definition of MIS.

In Scotland, the number of THRs recorded in the Scottish Arthroplasty Project[2] has been increasing steadily over the last decade and especially since 2002. In 2004–5, around 86% (4823) of Scottish THRs were primary procedures, whereas 14% (753) were revision procedures. No data are available on the number of MIS for THRs performed in Scotland.

Outside the UK, the Norwegian Arthroplasty Register[11] reported a lower rate of MIS (2% of 6566 primary hip replacements) performed in 2005, compared with that recorded in England and Wales. On the other hand, the Canadian Joint Replacement Registry[12,13] recorded a higher rate of MIS for hip replacements: 9% of 12,474 hip replacements (including revisions) in 2003–4 and 12% of 14,307 hip replacements (including revisions) in 2004–5. Almost all minimally invasive procedures (99%) were primary procedures, rather than revisions. The proportions of MIS were significantly higher among males than females [odds ratio (OR) 1.12, 95% confidence interval (CI) 1.02 to 1.24], but significantly lower among patients who were overweight and obese than those who were underweight or normal weight (22% versus 34%). The use of a minimally invasive procedure was not associated with patients' age. After adjusting for other factors, females and overweight or obese patients were still significantly less likely to receive MIS.

TABLE 1 *Primary hip procedures in England and Wales, 2005*[3]

Procedure type	*N*	%
Cemented THR	28,602	51
Cementless THR	13,955	25
Hybrid or reverse hybrid THR	8232	15
Primary resurfacing	2746	5
Other	2277	4
Total	55,812	100

Description of new intervention

Outline of the procedure

Minimal incision hip arthroplasty continues a general trend towards less invasive approaches, both in orthopaedics[14] and other surgical specialties.[15] Historically, the concept arose in North America, where the typical incision length had perhaps been rather longer than in Europe.[16]

Minimal incision THR is not a uniform procedure, but is performed with significant variations

TABLE 2 *MIS in primary hip replacement procedures in England and Wales, 2003–2005*[3,9,10]

	2003	2004	2005
Primary hip replacement	22,672	44,262	55,812
Minimally invasive			
Yes	883 (4%)	2733 (6%)	3124 (6%)
No	21,779 (96%)	39,528 (94%)	47,437 (94%)
Incision length			
⩽10 cm	NR	4390 (17%)	6448 (14%)
>10 cm	NR	21,678 (83%)	40,605 (86%)

NR, not reported.

between surgeons. Approaches, however, fall into three main groups. Of these, the so-called 'double incision' or two-incision approach can be regarded as novel and specific to MIS, whereas the anterolateral and posterior approaches are essentially developments of traditional approaches performed through smaller incisions. Further variation within these groups will depend on the precise surgical interval used, the extent of the deep dissection (which may or may not be less than with conventional surgery) and the use or otherwise of instruments specially designed for minimally invasive procedures. Minimal incision techniques can be used for the implantation of cemented, cementless or hybrid (cemented stem and cementless cup) prostheses.

The two-incision technique[17] is performed with the patient supine and, unlike other minimal incision approaches, X-ray fluoroscopy is required throughout the procedure. A short incision is made anterior to the femoral neck and the hip approached by means of medial retraction of the sartorius and rectus femoris muscles and lateral retraction of tensor fascia lata. The lateral circumflex vessels are coagulated and the femoral head and neck resected after a capsulotomy. Lighted angled retractors are used to obtain acetabular exposure, allowing for preparation and cup implantation. A second incision is then made laterally above the greater trochanter and deepened to form a track through which the femoral instrumentation can be inserted. After femoral preparation and trial reduction, the definitive femoral component is implanted.

The posterior (or posterolateral) approach is a minimal incision adaptation of the approach originally described by Moore.[18] The patient is positioned laterally and an incision made along the posterior edge of the greater trochanter and deepened through the gluteal fascia. Obturator internus and the gemelli muscles are divided close to their insertions, with or without piriformis superiorly and part of quadratus femoris inferiorly. Care is taken to avoid injury to the nearby sciatic nerve and a capsulotomy is performed, allowing dislocation and resection of the femoral head. With appropriate retraction and positioning of the leg, acetabular and subsequently femoral preparation and implantation can be performed.

Minimal incision anterolateral (or anterior) approaches are usually derivates of the Hardinge approach,[19] or sometimes the Watson-Jones approach.[20] The patient may be positioned supine or more commonly laterally. A skin incision is made over the anterior part of the greater trochanter and again deepened through fascia lata. With the Hardinge-type approach the anterior parts of gluteus medius/minimus and vastus lateralis are reflected subperiosteally. The Watson-Jones variation is performed more anteriorly between tensor fascia lata and gluteus medius. Capsulotomy and dislocation/resection of the femoral head allow acetabular and femoral exposure for the procedure to be performed. The anterior Smith Peterson approach has also been used in hip surgery, although perhaps it is relatively rarely used in hip replacement.

Criteria for treatment

The indications for minimal incision THR are the same as that for standard THR, namely severe pain due to primary or secondary degenerative conditions of the hip joint which does not respond to conservative treatment.[21] Degenerative conditions necessitating hip replacement may include primary and secondary osteoarthritis, inflammatory arthritis and the consequences of osteonecrosis and metabolic bone conditions. Hip fracture and tumour are additional indications for THR, but these conditions fall outside the scope of this review.

It has been claimed that the majority of patients suitable for THR are theoretically suitable for minimal incision procedures,[17] depending on the particular expertise of the operating surgeon and the facilities available. Contraindications suggested for the use of minimal incision techniques,[22] however, include:

- obese or excessively muscular patients
- patients with abnormal anatomy requiring complex reconstruction (due, for example, to severe developmental hip dysplasia, acetabular erosion or previous fracture)
- previous hip surgery
- bone weakness, such as osteoporosis.

Personnel involved

For a single minimal incision THR, substantially the same staff are required for the operation. The precise configuration of staff is described in more detail in Chapter 5. However, it has been suggested that an additional nurse may be required during the procedure. Additionally, a further outpatient appointment may be required during patient follow-up, although the need for this may decline, as experience and confidence with the technique improve. Again, the impact of the addition of an extra outpatient visit is discussed further in Chapter 5.

For the two-incision approach, few data are available to determine the staff required. Nevertheless, it is likely that for the operation the surgical team will be similar to that for standard THR. However, additional personnel will be required to provide the additional imaging needed for the two-incision approach.

Setting and equipment required

Both the minimal incision and the standard techniques can be performed in the same setting using the same prostheses. The single minimal incision THR can be performed with the same equipment as a standard THR, although specialised equipment such as angled retractors with a light source and other customised instruments are available to expose the hip, to prepare the socket and to insert prostheses. The likely purchase cost for such equipment is approximately £3000 but, as the equipment is reusable, this equates to an additional cost of approximately £13 per patient (note: many manufacturers will supply the instrumentation free of charge if their implant is being used).

The two-incision approach typically requires specialised equipment and prostheses which are marketed by specific manufacturers as a package. As noted above, additional X-ray fluoroscopy guidance is recommended to aid positioning of instruments and prostheses during the procedure. Further, computer-assisted navigation tools may also be used for both minimal incision (single or double) and standard THR.

Degree of diffusion

Concern has been raised that commercial pressures and direct to consumer marketing rather than clinical evidence were largely responsible for its initial spread in popularity.[23,24] The current guidance by NICE on the safety and efficacy of single mini-incision surgery for THR states that it "should only be used in appropriately selected patients by clinicians with adequate training in this technique".[5] The NICE guidance on the safety and efficacy of two-incision surgery for THR states that, owing to lack of evidence of this procedure, it should not be used "without special arrangements for consent and for audit or research".[4] In this regard, the NICE guidance recommends clinicians undertaking two-incision surgery to "inform the clinical governance leads in their Trusts" and to "ensure that patients understand the uncertainty about the procedure's safety and efficacy and provide them with clear written information" and also to "have adequate training before performing this procedure".

Anticipated costs

The current use of mini-incision THR is low but there is the potential for its use to increase dramatically. The anticipated costs of mini-incision THR surgery based on different degrees of diffusion are illustrated in *Table 3*. The total direct costs to the NHS for a follow-up period of 3 months after surgery are based on mean costs of £7345 and £7064 for standard and single mini-incision THR, respectively (the methods used to estimate these costs are described in Chapter 5). The number of hip replacements per year is based on the data for 2005 reported in *Table 2*.

These projections suggest that if the use of minimally invasive THR increased to a relatively modest 10% from the 6% figure quoted in *Table 2*, then the total cost to the NHS in England and Wales would decrease by approximately £826,300 per year. However, these estimates are subject to considerable uncertainty. First, the costs of both standard and mini-incision THR are not known precisely. Second, the calculations have assumed a fixed operation cost and therefore have not considered whether the unit cost of aspects such as specialist instrumentation used for mini-incision THR would change as diffusion increases. Finally, these figures do not reflect the cost of training the increased numbers of surgeons required to perform the additional operations.

TABLE 3 *Cost of surgery for primary THR*

Proportion of total THRs performed minimally invasively (%)	NHS cost (£ million)	Reduction in cost below the cost of current provision (£000)
5.0	431.1	826.3
10.0	430.3	1,652.6
15.0	429.5	2,478.9
20.0	428.7	3,305.2
25.0	427.8	4,131.5

Chapter 2

The decision problem

The aim of this study was to assess the relative effectiveness and cost-effectiveness of (1) single mini-incision THR compared with standard THR and (2) two mini-incision THR compared with standard THR or single mini-incision THR (as the quantity of data available was expected to be limited). It was hypothesised that the mini-incision approaches may involve less soft tissue dissection that would facilitate shorter recovery. The smaller incision may lead to poorer visualisation of the hip, however, and this may lead to higher revision rates.

As described in Chapter 1, patients receiving either minimal incision or standard THR follow a similar pathway of care. However, there is uncertainty surrounding minimal incision compared with standard incision performance in terms of:

- short- and long-term clinical performance
- short- and long-term safety
- resource use and costs
- patient-centred measures such as quality of life
- cost-effectiveness.

For single mini-incision THR, this study sought to address the following questions:

1. Short- and long-term clinical performance:
   (a) Does single minimal incision THR compared with standard THR provide better outcomes
      (i) in terms of clinical effectiveness measures of surrogates for long-term outcomes (implant position, implant migration, heterotopic ossification and cement quality)?
      (ii) in terms of long-term measures of treatment success (revision rates, time to revision, dislocation rates and limb length inequalities)?
2. Short- and long-term safety
   (b) How does single minimal incision THR compare with standard THR with respect to blood loss, intraoperative fractures, periprosthetic fractures and various complications, such as wound infections, nerve injuries, vascular injuries and the risk of thrombosis [deep vein thrombosis (DVT) and pulmonary embolism (PE)]?
3. Resource use and costs
   (c) Is single minimal incision THR compared with standard THR:
      (i) associated with a shorter operation time and length of stay?
      (ii) less costly when differences in operation time, length of stay, staffing and equipment are taken into account?
      (iii) less costly when differences in the costs of treating revisions and other long-term events are taken into account?
4. Patient-centred measures such as quality of life
   (d) Does single minimal incision THR compared with standard THR improve:
      (i) the short-term quality of life (measured in terms of postoperative pain, use of pain relief, return to usual activities and formal measures of quality of life)?
      (ii) long-term quality of life (measured in terms of long-term pain, functional results, mortality and formal measures of quality of life)?
      (iii) patient satisfaction?
      (iv) quality of life as measured by QALYs when differences in speed of recovery and longer term outcomes including complications are accounted for?
5. Cost-effectiveness
   (e) Is single minimal incision THR compared with standard THR cost-effective as judged against standard decision rules on how much an extra unit of outcome (i.e. a QALY) is worth to society?[25]

In addition to these questions, the performance of single minimal incision THR may vary according to the experience of the surgeon and by the characteristics of the patients selected for surgery. Therefore, if possible, the differences in the outcomes were reconsidered in the light of evidence on:

- experience of the surgeon
- characteristics of the patient (obese; muscular; have significant bone deformity or severe osteoporosis; and who present as emergency cases).

These subgroups were chosen because, as described in the section 'Criteria for treatment' (p. 3), it has been argued that surgeon expertise might influence outcomes and it has been suggested that minimally invasive THR may be contraindicated in these patients.

For the comparison of two mini-incisions THR with standard or single mini-incision THR, an attempt was made to address the same questions as set out above.

Chapter 3 reports the methods used and results obtained for the questions on short- and long-term clinical performance, short and long-term safety, and question (c)(i) for 'resource use and costs' and questions (d)(i) and (d)(ii) for 'patient-centred measures'. Chapters 4 and 5 address the remaining questions under 'resource use and costs' and 'patient-centred measures' and address the cost-effectiveness question. The questions relating to the subgroups and the two incision approach will be addressed where data will be available in the relevant subsections of Chapters 3, 4 and 5.

Chapter 3
Effectiveness

Methods for reviewing effectiveness

Search strategy

The search strategy involved searching electronic databases and relevant websites, contact with experts in the field and scrutiny of bibliographies of retrieved papers. Extensive electronic searches were conducted to identify reports of published and ongoing studies on the effectiveness of minimal incision THR. Searches were carried out for both full papers and conference abstracts and there were no language restrictions in this search of titles and abstracts. The databases searched were MEDLINE (1966–February Week 3 2007), MEDLINE In-Process (1 March 2007), EMBASE (1980–2007 Week 8), BIOSIS (1985–1 March 2007), Science Citation Index (1985–2 March 2007), Cochrane Controlled Trials Register (The Cochrane Library, Issue 1, 2007) and current research registers (National Research Register, Issue 4, 2006), Current Controlled Trials (December 2006) and Clinical Trials (December 2006)). Additional databases searched for systematic reviews and other background information included the Cochrane Database of Systematic Reviews (The Cochrane Library, Issue 1, 2007), Database of Abstracts of Reviews of Effectiveness (December 2006), HTA Database (December 2006) and Health Management Information Consortium (1979–January 2007). Full-text searching of key surgical journals (American and British editions of the *Journal of Bone and Joint Surgery*, *Journal of Arthroplasty* and *Clinical Orthopaedics and Related Research*, all from 2000 to February 2007) was also undertaken. Recent relevant conference proceedings and reference lists of all included studies were scanned to identify additional potentially relevant studies. Websites of national orthopaedic registries were searched, and also both key professional organisations (including the American Association of Orthopaedic Surgeons, British Orthopaedic Association and British Hip Society) and manufacturers (DePuy International, Smith and Nephew, Stryker Howmedica and Zimmer). Full details of the search strategies used and websites consulted are documented in Appendix 1.

All titles and abstracts identified in these ways were assessed to identify potentially eligible studies. Two reviewers independently assessed them for inclusion, using a study eligibility form developed for this purpose (Appendix 2). Any disagreements were resolved by discussion.

Inclusion and exclusion criteria

Types of studies

All randomised controlled trials (RCTs) and quasi-RCTs were included. Prospective non-randomised studies with concurrent comparisons and matched-pair studies, irrespective of duration of follow-up, were also included. Retrospective comparative studies were eligible only if there was clear evidence of prospective design, consecutive series or total population recruitment. Additionally, case series or single cohort studies with two or more surgeons with a minimum follow-up of 1 year, and single-surgeon case series with a minimum follow-up of 3 years, and where a report was available in full text were included. We also included data from national registries where these registries provided long-term outcomes such as revision rates. Studies or reports reported in a language other than English, Chinese or Japanese were excluded after full-text copies of all potentially relevant reports were obtained.

Types of participants

All adults eligible for standard THR for arthritis were included. Studies that focused solely or primarily on patients undergoing total hip arthroplasty for other reasons, such as osteoporosis, fracture or tumour, were excluded.

Types of interventions

We included studies of single mini-incision primary THR compared with standard primary THR. Additionally, we also considered two-incision primary THR compared with either standard primary THR or single mini-incision primary THR. Revision surgery, hip resurfacing or computer modelling surgery were excluded.

Types of outcomes

The following measures of outcomes were sought.

Clinical performance:

1. revision rates

2. time to revision
3. dislocation
4. surrogates for long-term outcomes
   (a) implant position (radiographic analysis)
   (b) implant migration (radiostereometric analysis)
   (c) heterotopic ossification
   (d) cement quality
5. limb length inequality.

Safety:
1. blood loss
2. intraoperative fracture
3. periprosthetic fracture
4. wound infection
5. nerve injury
6. vascular injury
7. DVT and PE.

Resource utilisation:
1. duration of surgery
2. length of hospital stay.

Patient-centred measures:
1. 30-day mortality
2. long-term mortality
3. pain relief
4. postoperative pain
5. long-term pain
6. time to return to usual activities
7. functional result, e.g. Harris Hip, Mayo, Oxford Hip and Charnley Scores
8. health-related quality of life
9. patient satisfaction.

Other:
1. operating theatre throughput
2. opposite method initiated (preoperatively)
3. conversions to alternative procedure (intraoperatively) and reasons for conversion.

Opposite method initiated was defined as a minimal incision THR initiated when a standard THR was randomly allocated, or vice versa. Duration of operation was defined as time from first incision to last suture or, where this was not available, time in theatre or duration of anaesthesia. Length of hospital stay was defined as time from admission to discharge. Conversion was defined as a procedure initiated as minimal incision but converted to a standard THR intraoperatively.

Data extraction strategy

Full-text copies of all potentially relevant reports were obtained. Two reviewers independently selected studies for inclusion and extracted data using a standard data extraction form (Appendix 3). Discrepancies were solved by discussion, with involvement of a third reviewer when necessary. The reviewers were not blinded to authors, institutions or publication details. Where there was insufficient information in the published report, attempt was made to contact the authors for clarification (one case).

Quality assessment strategy

Methodological quality of RCTs, quasi-RCTs and comparative studies of other designs was assessed using the Delphi criteria list (Appendix 4).[26] Each study was assessed independently by two reviewers. Any disagreements were resolved through discussion.

Data synthesis

Quantitative data syntheses were performed with the trial data only. For trials with multiple publications, only the most up-to-date or complete data for each outcome were included. The data from the comparative studies were not formally combined in data synthesis to avoid the risk of accentuating possible systematic bias inherent in any non-randomised studies. To estimate a summary measure of effect on relevant outcomes in the trial data, dichotomous outcome data were combined using the Peto OR method, since there were relatively few events reported for many of the dichotomous outcomes. Continuous outcomes were combined using the inverse variance weighted mean difference (WMD) method; 95% CIs and p-values were calculated for the estimates of OR and WMD. The results were reported using a fixed-effects model. To explore statistical heterogeneity across studies χ^2 tests and I^2 statistics were used. Where there was evidence of heterogeneity, a random effects model was applied for continuous outcomes and also possible reasons for heterogeneity were explored. Quantitative syntheses were performed using the standard Cochrane software RevMan 4.2.

Owing to a lack of uniformity of the data present in many studies, a qualitative review looking for consistency between studies was performed. For continuous variables, this was supplemented by two additional analyses. First, where standard deviations (SDs) were not reported by the authors, they were estimated on the basis of available information on p-values (calculated SDs). This approach made the assumption that SDs are the same in both arms of the trial. Where studies only reported p-values less than a certain value (e.g. $p < 0.05$), we calculated SDs on the basis of a

p-value equal to that value (i.e. $p = 0.05$). Second, where information on *p*-values was also unavailable, SDs were estimated as the weighted means of SDs reported in the other studies which did report data on the same outcome (dummy SDs) or where they could be inputed from *p*-values. A judgement was made for each outcome as to which of the three analyses, namely (1) reported means and SDs, (2) reported means and SDs with calculated SDs, (3) reported means and SDs with calculated and dummy SDs, should be used as the base case. This judgement was based on consideration of the nature and pattern of missing data. The other analyses are reported in appendices. Where a quantitative synthesis was considered to be inappropriate or not feasible, a narrative synthesis of results was provided.

Results

Quantity and quality of research available

Number of studies identified

The results of the searches are summarised in *Tables 4* and *5*. The numbers retrieved from the searches in Science Citation Index, BIOSIS, CENTRAL and full-text journal searches include only the additional reports found after excluding those identified from the MEDLINE/EMBASE multi-file search. A total of 887 reports were identified, of which 186 were selected for full assessment.

TABLE 5 *Paper selected for full assessment*

Assessment	No. of papers
Included in review	55
Retained for background information	42
Excluded	81
Unobtainable	8
Total	**186**

Number and type of studies included

Fifty-four papers (43 full text papers[17,27–68] and 11 abstracts[69–79]) met the inclusion criteria for the review. In addition, relevant data were supplemented by a published registry report (Norwegian Arthroplasty Register)[11] and extra information from the registry holders (Espehaug B, Norwegian Arthroplasty Register: personal communication; 5 January 2007). In total, 55 reports describing 42 studies [12 trials, 22 non-randomised comparative studies and eight case series (including registry data)] were identified as relevant to the review. Of these, 32 studies were useful for the comparison of single mini-incision with standard incision, including nine trials,[31,32,40,43,46,58,69,75,77] 17 comparative studies,[28–30,33–36,42,44,45,48,52,54–56,74,78] and six case series or registry;[11,39,41,49–51] one was used for the comparison of two mini-incision THR with standard THR (one trial)[57] and nine were relevant to the comparison of two mini-incision with single mini-incision THR, including two trials,[72,73] five comparative studies[38,47,53,71,79] and two case

TABLE 4 *Search results*

Database	No. retrieved	No. selected for assessment
MEDLINE/EMBASE/MEDLINE In-Process multi-file search (after de-duplication in Ovid)	552	104
SCI	61	11
BIOSIS	28	3
CENTRAL	4	0
Full-text journals	19	4
NRR	22	8
CCT	24	3
Clinical Trials	4	4
DARE	35	7
HTA database	35	11
HMIC	0	0
Conference abstracts	96	24
Registry Reports	7	7
Total retrieved	**887**	**186**

CCT, Current Controlled Trials; DARE, Database of Abstracts of Reviews of Effects; HMIC, Health Management Information Consortium; NRR, National Research Register; SCI, Science Citation Index.

series.[27,37] The list of included studies and associated references is given in Appendix 5. In addition, 14 ongoing trialists were identified and contacted for information. The list of ongoing trials identified is given in Appendix 6.

Number and type of studies excluded, with reasons for specific exclusions

A total of 81 reports were also obtained but did not meet the inclusion criteria and were subsequently excluded. Of these, four studies did not use concurrent comparisons (i.e. had historical controls), 10 were retrospective studies and 18 were descriptive studies. Five studies only included participants who received THR for reasons other than arthritis (e.g. fracture) and five studies primarily focused on revision surgery. Seventeen did not report relevant outcomes or did not have a sufficient length of follow-up (1 year for multiple-surgeon case series and 3 years for single-surgeon case series were required). The remaining 22 studies were excluded because they were reported in languages other than English, Japanese or Chinese.

Study quality, characteristics and evidence rating for RCTs and comparative studies

Table 6 provides a summary of the methodological quality of the 12 trials and 22 comparative studies by type of intervention and study design. Details of the quality assessment are given in Appendix 7.

Single mini-incision procedure

With respect to the studies examining the single mini-incision procedure, randomisation was performed in nine studies. In only three of these

TABLE 6 *Summary of the methodological quality of the included trials and comparative studies*

Criteria		One incision		Two incisions	
		Trials	Comparative	Trials	Comparative
1a. Was a method of randomisation performed?	Y	9	0	3	0
	N	0	17	0	5
	U	0	0	0	0
1b. Was a method of sequence generation adequate?	Y	3	0	2	0
	N	3	17	0	5
	U	3	0	1	0
2. Was the treatment allocation concealed?	Y	1	0	0	0
	N	5	17	0	5
	U	3	0	3	0
3. Were the groups similar at baseline regarding the most important prognostic indicators?	Y	6	6	3	3
	N	1	7	0	1
	U	2	4	0	1
4. Were the eligibility criteria specified?	Y	6	12	1	3
	N	3	5	2	2
	U	0	0	0	0
5. Was the outcome assessor blinded?	Y	8	6	0	1
	N	0	5	0	1
	U	1	6	3	3
6. Was the care provider blinded?	Y	5	1	0	0
	N	2	7	0	2
	U	2	9	3	3
7. Was the patient blinded?	Y	4	2	0	0
	N	1	10	0	3
	U	4	5	3	2
8. Were point estimates and measures of variability presented for the primary outcome measures?	Y	4	10	1	1
	N	4	7	2	4
	U	1	0	0	0
9. Did the analysis include an intention-to-treat analysis?	Y	4	9	0	1
	N	1	0	0	0
	U	4	8	3	4

N, no; U, unclear; Y, yes.

studies was this considered to be adequate (e.g. a computer-generated sequence, random number tables or a card drawn by the anaesthetist at the time of surgery).[31,46,58] Methods used for allocation concealment were considered inadequate (e.g. alternation, sealed envelopes) in five studies[31,32,40,43,46] and unclear in a further three (which were abstracts or poster).[69,75,77]

Six of the nine randomised trials reported that the intervention and comparison groups were similar at baseline,[31,43,46,58,69,75] although the two groups were not balanced in one,[77] and it was unclear for the other two.[32,40] The criteria by which patients were assessed as eligible for inclusion was not described in three trials.[43,69,77] All but one trial[75] reported that the outcome assessors were blinded. It is questionable whether blinding of care providers and patients is possible, given the nature of the intervention. Nevertheless, four trials[43,46,69,77] reported that both care providers and patients were blinded, and one further trial also suggested that care providers were unaware of the incision length.[58] One of these studies reported that blinding was achieved by means of a standard-length wound dressing.[46] Point estimates and measures of variability were presented for the primary outcome measures in just under half of the studies.[31,32,46,58] Four trials included an intention-to-treat analysis[31,32,46,58] but it was unclear if this was the case in four.[43,46,75,77]

Of the 17 (non-randomised) comparative studies examining the single mini-incision procedure, only six reported that the intervention and comparison groups were similar at baseline.[33–36,44,74] The groups were dissimilar in seven studies,[28,42,45,48,52,55,56] and it was unclear in a further four.[29,30,54,78] The eligibility criteria were not described in five studies.[29,36,48,74,78] In two-thirds of the studies, either the outcome assessors were not blinded[30,33,34,42,48] or it was unclear if they were blinded.[29,36,45,56,74,78] Only one study reported that both care providers and patients were blinded: this was done by means of a standard-length wound dressing.[28] One further study also suggested that patients were unaware of the incision length.[52] Point estimates and measures of variability were presented for the primary outcome measures in 10 studies.[30,34,36,42,44,45,52,54–56] An intention-to-treat analysis was included in nine.[28,34–36,44,45,48,52,55]

Two-incision procedure

In respect of the eight studies examining the two-incision procedure, an adequate method of random sequence generation (computerised randomisation) was performed in only two studies.[72,73] One further study reported that patients were randomised but did not provide information on the method of randomisation used.[57] No information was available as to whether treatment allocation was concealed in these studies. In all three randomised studies[57,72,73] and the majority of non-randomised studies,[38,47,71] the intervention and comparison groups were similar at baseline, although this was not the case for one[53] and unclear in another.[79] Only half of the studies described the patient eligibility criteria.[38,47,53,57] One study reported that the outcome assessor was blinded[53] but none of the studies reported blinding of the care provider or patient. Point estimates and measures of variability for the primary outcome measures were presented in two,[53,57] and only one study included an intention-to-treat analysis.[47]

Characteristics of included studies

Table 7 provides a summary of the baseline characteristics of the participants in the included trials, comparative studies and case series and registry. This is described in more detail in Appendix 8.

Within the nine trials and 17 comparative studies comparing single mini-incision and standard incision, there were 27 comparisons, as one non-randomised comparative study divided the participants into three groups postoperatively according to the incision length, namely mini-incision (<10 cm), midi-incision (10–14 cm) and standard incision (>14 cm).[52] The results of this study are presented as two comparisons, mini-incision versus midi-incision and mini-incision versus standard incision. Hip replacements were performed through several approaches, including anterolateral, lateral, posterolateral, anterior and posterior. It is worth noting that in three trials[58,75,77] and one comparative study,[48] the mini-incision procedure and the standard incision procedure were performed through different approaches (e.g. mini-incision anterior approach versus standard incision lateral approach). A further three comparative studies did not provide information on the operative approaches used.[54,74,78] This is a possible confounder, comparing the potential effects of different surgical approaches and also length of incision.

The sample sizes ranged from 20[48,78] to 219,[46] with only one trial[46] and one comparative study[29] having 200 or more participants. The total number of participants was 979 in the trials (recruited between November 1999 and June

TABLE 7 *Summary of the baseline characteristics*

Study	Comparator (operative approach, average incision length)	No. of participants	Age (years)[a]	Sex (M/F)	BMI	Comments
One incision						
RCT and quasi-RCT						
Charles, 2006[69b]	MI lateral	20	66.6	NR	25.8	
	SI lateral	20	70.8	NR	25.2	
Chimento, 2005[31]	MI posterolateral, 8 cm	28	67.2	16/12	25.2	
	SI posterolateral, 15 cm	32	65.6	13/19	24.8	
Chung, 2004[32]	MI posterolateral, 9.2 cm	60	61.0	24/36	NR	
	SI posterior, 20.0 cm	60	64.0	28/32	NR	
Hart, 2005[40]	MI posterolateral, 9–10 cm	60	72.4	40/80	27.6	
	SI posterolateral, 20 cm	60				
Kim, 2006[43]	MI posterolateral, 8 cm	70	55.6	53/17	25.6	Bilateral THRs (MI on one hip, SI on the other)
	SI posterolateral, 15–20 cm	70				
Ogonda, 2005[46]	MI posterior, 9.5 cm	109	67.4	49/60	28.2	
	SI posterior, 15.8 cm	110	65.9	58/52	28.9	
Rachbauer, 2006[75b]	MI anterior	60	NR	NR	NR	
	SI lateral	60	NR	NR	NR	
Sharma, 2006[77b]	MI posterior	20	67.0	NR	26.5	
	SI posterolateral, 12 cm	20	68.6	NR	24.4	
Zhang, 2006[58]	MI anterior, 7.9 cm	60	61.0	25/35	NR	
	SI posterolateral, 16.3 cm	60	62.5	28/32	NR	
Comparative studies						
Asayama, 2006[28]	MI lateral, 8–10 cm	52	64.3	24/28	26.1	
	SI lateral, 15–20 cm	50	65.1	25/25	28.7	
Berger, 2004[29]	MI anterolateral, 8.3 cm	100	57.0	NR	NR	
	SI anterolateral, 15–20 cm	100	59.0	NR	NR	
Chen, 2006[30]	MI posterior, ⩾10 cm[c]	51	68.1	28/23	NR	
	SI posterior, 15–20 cm	95	69.8	54/41	NR	
Ciminiello, 2006[33]	MI anterolateral, <12.7 cm	60	69.8	15/45	23.8	Matched-pair study
	SI anterolateral, ⩾12.7 cm	60	70.2	15/45	24.1	
de Beer, 2004[34]	MI lateral, 7.7 cm	30	71.0	10/20	32.4	Matched-pair study
	SI lateral, 13.9 cm	30	69.0	10/20	31.7	
DiGioia, 2003[35]	MI posterior, 11.7 cm	33	65.0	19/14	27.0	With image navigation; matched pairs
	SI posterior, 20.2 cm	33	65.0	19/14	28.0	
Dorr, 2007[36]	MI posterior, 9.6 cm	109	63.5	52/57	26.7	
	SI posterior, 17.9 cm	56	65.6	26/30	26.4	
Howell, 2004[42]	MI anterolateral	46	59.8	34/16	26.2	
	SI anterolateral	56	62.3	27/30	28.8	
Li, 2005[44]	MI posterolateral, 9.3 cm	18	NR	13/5	24.6	
	SI posterolateral, 16.8 cm	18	NR	14/4	26.1	
O'Brien, 2005[45]	MI lateral, 10cm	32	67.0	19/13	27.0	
	SI lateral, >10 cm	51	67.0	25/26	30.0	
Panisello, 2006[74b]	Mini-incision	40	NR	NR	NR	
	Classic approach	40	NR	NR	NR	
Pilot, 2006[48]	MI anterior, 8.6 cm	10	67.9	4/6	29.1	
	SI posterolateral, 17.4 cm	10	67.5	2/8	26.4	
Szendrói, 2006[52] (MI/MD)	MI lateral, 8.8 cm	38	64.0	NR	26.0	
	MD lateral, 12.6 cm	43	62.0	NR	28.0	
Szendrói 2006[52] (MI/SI)	MI lateral, 8.8 cm	38	64.0	NR	26.0	
	SI lateral, 16.1 cm	21	57.0	NR	29.5	

continued

TABLE 7 *Summary of the baseline characteristics (cont'd)*

Study	Comparator (operative approach, average incision length)	No. of partici-pants	Age (years)[a]	Sex (M/F)	BMI	Comments
Takahira, 2006[78b]	MI 7.5 cm	10	NR	3/7	NR	
	SI 13.8 cm	10	NR	1/9	NR	
Teet, 2006[54]	MI 10 cm	73	NR	NR	NR	
	SI 17–22 cm	54	NR	NR	NR	
Woolson, 2004[55]	MI posterior, ⩽10 cm[d]	50	60.0	29/21	25.1	
	SI posterior, 15–25 cm[d]	85	63.0	31/54	28.2	
Wright, 2004[56]	MI posterolateral, 8.8 cm	42	64.2	NR	24.4	
	SI posterolateral, 23 cm	42	65.0	NR	28.3	
Case series and registries						
Flören, 2006[39]	MI posterior	79	73.0	31/48	NR	Participants with min. 10-year FU only
Hartzband, 2006[41]	MI posterolateral	100	M61, F65	41/57	NR	
Pipino, 2004[49]	MI lateral, 8–10 or 12–15 cm	368	60.0	220/148	NR	Single surgeon in two locations
Siguier, 2004[50]	MI anterior, <10 cm	926	67.8	336/590	NR	
Swanson, 2005[51]	MI posterior, 8.8 cm	759	62.3	415/585	26.5	
Norwegian Arthroplasty Register 2006[11]	Mini-incision	200	NR	NR	NR	
Two-incision						
RCT and quasi-RCT						
Pagnano 2007a[72b]	Two-incision	10	NR	NR	NR	
	MI posterior	10	NR	NR	NR	
Pagnano 2007b[73b]	Two-incision	36	66	20/16	NR	
	MI posterior	36		20/16	NR	
Yan, 2005[57]	Two-incision	15	63.0	6/9	NR	
	SI posterolateral, 12 cm	15	61.0	7/8	NR	
Comparative studies						
Duwelius, 2007[38]	Two-incision	43	57.4	24/19	NR	Matched-pair study
	MI posterior	43	59.1	24/19	NR	
Greidanus, 2006[71b]	Two-incision	66	NR	NR	NR	
	Mini-incision	99	NR	NR	NR	
Pagnano, 2006[47]	Two-incision	26	69.0	10/16	NR	Staged bilateral THRs (2MI on one hip, MI on the other)
	MI posterior, 6–9 cm	26				
Tanavalee, 2006[53]	Two-incision	35	53.0	8/27	25.0	
	Mini-posterior, 9 cm	35	54.9	20/15	24.2	
Yoon, 2005[79b]	Two-incision	100	NR	NR	NR	
	Mini-incision, 7.5 cm	118	NR	NR	NR	
Case series						
Archibeck, 2004[27]	Two-incision	831	61	435/396	26	159 trainee surgeons
Duwelius, 2003[37]	Two-incision	375	30-76	188/112	NR	4 centres (4 surgeons)

FU, Follow-up; MD, midi-incision; MI, mini-incision; NR, not reported; SI, standard incision.
[a] Age is mean or as reported by individual studies.
[b] Abstract only.
[c] Includes two-incision surgeries in 29% of the mini-incision group.
[d] Incision length measured before the operation began.

2004) and 1686 in the comparative studies (recruited between October 1998 and January 2005). The range of average age of participants was comparable between the trials and comparative studies, between 55.6[43] and 72.4 years[40] in the trials, and between 57.0[52] and 71.0 years[34] in the comparative studies. There were more female than male participants across both trials (334 males versus 375 females) and comparative studies (510 males versus 567 females), excluding those studies which did not provide information about gender distributions.[29,30,52,54,69,74,75,77] Within the trials, participants' body mass index (BMI) was similar between the mini-incision group and the standard incision group, except in one trial where it was higher for the mini-incision group.[77] However, in nine comparative studies, the BMI in the mini-incision group was lower[28,33,35,42,45,52,55,56] and all but two reported this to be statistically significant.[33,35]

The nine trials were conducted in eight countries: two in the UK[46,77] and one each in Canada,[69] the USA,[31] Australia,[32] Czech Republic,[40] Korea,[43] Austria[75] and China.[58] Eight comparative studies took place in the USA,[28,29,33,35,36,54–56] three in Canada[34,42,45] two in China[30,44] and one each in Hungary,[52] Japan,[78] The Netherlands[48] and Spain.[74] Five trials[31,32,40,43,58] and five comparative studies[28,35,44,54,56] had a follow-up period of ⩾1 year. In four trials[31,32,43,46] and eight comparative studies[28,33,35,42,45,52,54,56] it was reported that all operations had been performed by or directly supervised by a single surgeon, and in two trials[69,75] and four comparative studies[34,36,48,55] it was reported that two or more surgeons performed operations in a single institution, and a further trial involved two surgeons from two institutions.[40]

For case series and registries regarding the single mini-incision procedure, a total of 1175 participants (551 males and 624 females) were identified between 1988 and July 2004 with the sample size in each study ranging from under 100[39] to over 1000.[50,51] Participants' average age was between 60[49] and 73 years.[39] Information on participants' BMI was available from only one study,[51] which gave a mean BMI of 26.5, comparable to the value reported in the trials and comparative studies examining the same mini-incision procedure. The case series and registry data came from five countries: Germany,[39] Italy,[49] France,[50] the USA[41,51] and Norway.[11] All case series were based on single surgeon experience, except for the French study, which involved two surgeons,[50] and the registry data.[11] Duration of follow-up ranged from 1 year,[11] through 3 years,[50,51] 6 years[41] and 7 years[49] to 10 years.[39]

With respect to eight studies comparing the two-incision procedure with either the single mini-incision[38,47,53,71–73,79] or standard incision[57] procedure, there were a total of 713 participants (122 in the trials and 591 in the comparative studies) recruited between 2002 and 2004. The sample sizes ranged from 20[72] to 218.[79] Where reported, there were more females than males (139 versus 204 females) with the average age between 53 and 66 years. Information on participants' BMI was largely unavailable. Four studies took place in the USA[38,47,72,73] and one each in China,[57] Canada,[71] Thailand[53] and Korea.[79] Four studies had an average follow-up of ⩾1 year.[38,53,72,73] Three studies[38,47,53] reported that a single surgeon performed all operations.

Two case series also examined the two-incision procedure.[27,37] Both studies were multi-centred and conducted in the USA. The first study involved 159 surgeons who attended corporate-sponsored training on the two-incision THR and who were asked to report to the company on their first 10 cases.[27] A total of 851 cases from 831 patients were reported between October 2002 and April 2004. The second study involved four surgeons in four different institutions performing a total of 375 procedures followed for a period of 1 year.[37] In both studies, the number of male participants was higher than that of female participants (435 versus 396 and 188 versus 112, respectively).

Description of surgery received

In one comparative study,[29] one patient assigned to the mini-incision group received a standard incision THR due to retained hardware (dynamic hip screw). In no other included trials and comparative studies was the opposite method initiated to the one to which the patient was assigned or randomised. No information was available on operating theatre throughput.

Two comparative studies reported conversions from single mini-incision surgery to single standard incision surgery.[52,56] The first of these studies reported that two of the 42 participants were converted to longer incisions in order to relieve skin tension and increase acetabular exposure.[56] In the second study, all participants were started with a short incision (<10 cm) and incisions were extended as necessary during surgery.[52] Participants were then divided into three

groups according to incision length, namely, mini-incision (<10 cm, $N = 38$), midi-incision (10–14 cm, $N = 43$) and standard incision (>14 cm, $N = 21$).

In terms of surgeon experience in the single mini-incision procedure, four studies (three trials and one comparative study) indicated that the surgeons involved were experienced in this procedure.[31,40,46,56] Two further non-randomised comparative studies did not report specifically on the level of experience of the surgeon performing the mini-incision procedure but reported that all procedures took place in a high-volume arthroplasty centre. In contrast, five studies (one trial and four comparative studies) suggested that the mini-incision procedure represented surgeons' early experience in this technique.[32,42,48,52,55]

In terms of surgeon experience in the two-incision procedure, one study reported that the study did not represent the surgeon's "initial learning curve",[38] whereas another study reported that the surgeon performing all operations was experienced in the standard single incision procedure but the two-incision procedure represented the surgeon's learning curve.[53]

THRs may be combined with the accelerated rehabilitation programme and the refined analgesic package. Although these may vary across studies, none of the included studies indicated that the programmes differed significantly between the groups.

Assessment of effectiveness

A full description of the selected outcomes reported in the included studies is given in Appendix 9. Detailed results of meta-analyses performed are given in Appendix 10.

One mini-incision versus one standard incision

Clinical performance

Revision rate

Table 8 and *Figure 1* show the number of patients requiring revision operations in the single mini-

TABLE 8 *Revision rate (number having revision surgery)*[a]

Study	Mini-incision		Standard incision		Reported *p*-values
	n/*N*	%	*n*/*N*	%	
RCT and quasi-RCT					
Chimento, 2005[31]	1/27		0/29		
Hart, 2005[40]	0/60		0/60		
Ogonda, 2005[46]	0/110		0/109		
Subtotal	1/197	0.5	0/198	0	
Peto OR (95% CI)					7.96 (0.16 to 402.02), $p = 0.30$
Comparative studies					
Asayama, 2006[28]	2/50		0/52		
Ciminiello, 2006[33]	1/60		0/60		
Li, 2005[44]	0/18		1/18		
Szendrói 2006,[52] MI/MD	0/38		0/43		
Szendrói 2006,[52] MI/SI	0/38		0/21		
Wright, 2004[56]	0/37		0/39		
Subtotal	3/241	1.2	1/233	0.4	
Case series					
Flören, 2006[39]	8/90				
Pipino, 2004[49]	2/331				
Siguier, 2004[50]	0/926				
Swanson, 2005[51]	21/1000				
Norwegian Arthroplasty Register, 2006[11b]	2/143				
Norwegian Arthroplasty Register (unpublished)[c]	0/57				
Subtotal	33/2547	1.3			

[a] Time to revision was not reported.
[b] Based on the 2005 data collection period.
[c] Based on the 2006 data collection period up to 19 December 2006 (Espehaug B, Norwegian Arthroplasty Register: personal communication, 5 January 2007).

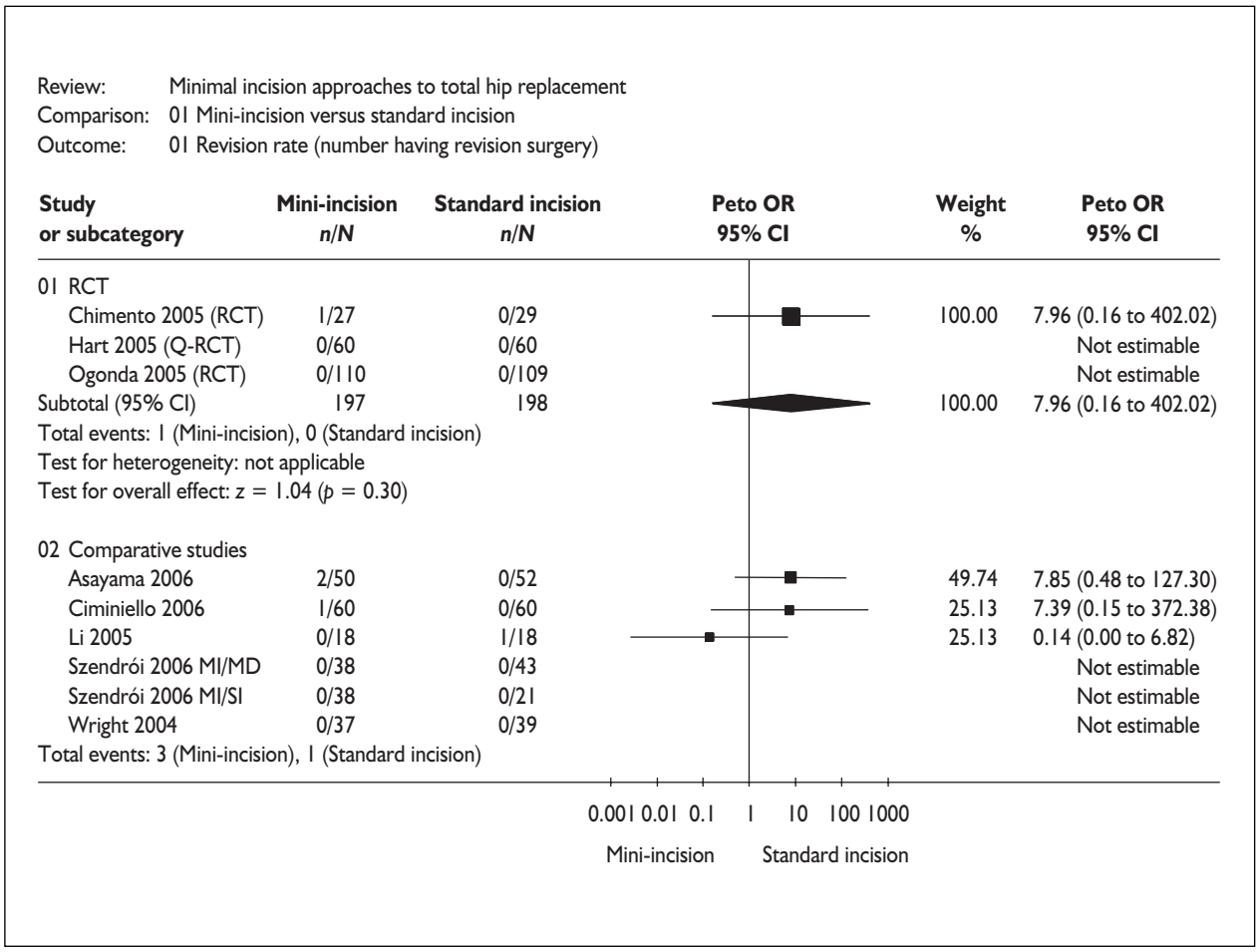

FIGURE 1 *Meta-analysis of revision rates*

incision group and the standard incision group by study type. Of the three trials (RCTs and quasi-RCTs) and six comparative studies reporting this outcome, the length of follow-up ranged from ⩽3 months[33,46,52] through <1 year[44] and 2 years[28,31] to >3 years.[40,56] In both trials and comparative studies, a total of only five participants had a revision surgery. Given the limited data available, the CIs are very wide and include differences that are not clinically plausible (Appendix 10, Comparison 01:01, Peto OR 7.96, 95% CI 0.16 to 402.02, $p = 0.30$). Overall, revisions occurred in between 0.5 and 1.2% of minimal incision cases depending on the source of data, with case series and registries showing a higher percentage, which probably reflects their relatively longer follow-up (between 1 and 10 years).

Postoperative dislocation rates

Dislocation was also uncommon, occurring in between 0.2 and 1.8% (the latter estimate being based on case series data) of minimal incision cases depending on the source of data (*Table 9* and *Figure 2*; Appendix 10, Comparison 01:02). The corresponding rates for standard THR were 0.9 and 1.1% based on data from trials and comparative studies, respectively. There were no clear differences between groups and the CIs were wide, including differences that are not clinically plausible. There was a tendency in favour of the mini-incision groups in the comparative studies, but this was not apparent in the randomised trials.

Surrogates for long-term outcomes

Implant position (cup and stem) Three trials and six comparative studies provided information describing poor placement of the acetabular component (cup) using various definitions (*Table 10* and *Figure 3*; Appendix 10, Comparison 01:03). Compared with standard incision THR, the proportion of cups poorly placed in

TABLE 9 *Postoperative dislocation rates*

Study	Mini-incision		Standard incision		Reported *p*-values
	n/*N*	%	*n*/*N*	%	
RCT and quasi-RCT					
Chimento, 2005[31]	2/28		0/32		0.2
Chung, 2004[32]	0/60		0/60		
Hart, 2005[40]	1/60		1/60		
Kim, 2006[43]	1/70		1/70		
Ogonda, 2005[46]	1/109		1/110		
Sharma, 2006[77]	0/20		0/20		
Subtotal	5/347	1.4	3/352	0.9	
Peto OR (95% CI)					1.72 (0.43 to 6.92), $p = 0.45$
Comparative studies					
Asayama, 2006[28]	0/52		1/50		
Berger, 2004[29]	0/99		0/100		
Chen, 2006[30]	0/51		0/95		
Ciminiello, 2006[33]	0/60		0/60		
DiGioia, 2003[35]	0/33		0/33		
O'Brien, 2005[45]	0/34		0/53		
Szendrói, 2006[52] MI/MD	0/38		0/43		
Szendrói, 2006[52] MI/SI	0/38		0/21		
Teet, 2006[54]	1/73		4/54		
Woolson, 2004[55]	0/50		1/85		
Wright, 2004[56]	0/42		1/42		
Subtotal	1/570	0.2	7/636	1.1	
Case series					
Flören, 2006[39]	0/90				
Hartzband, 2006[41]	0/100				
Siguier, 2004[50]	10/1037				
Swanson, 2005[51]	30/1000				
Subtotal	40/2227	1.8			

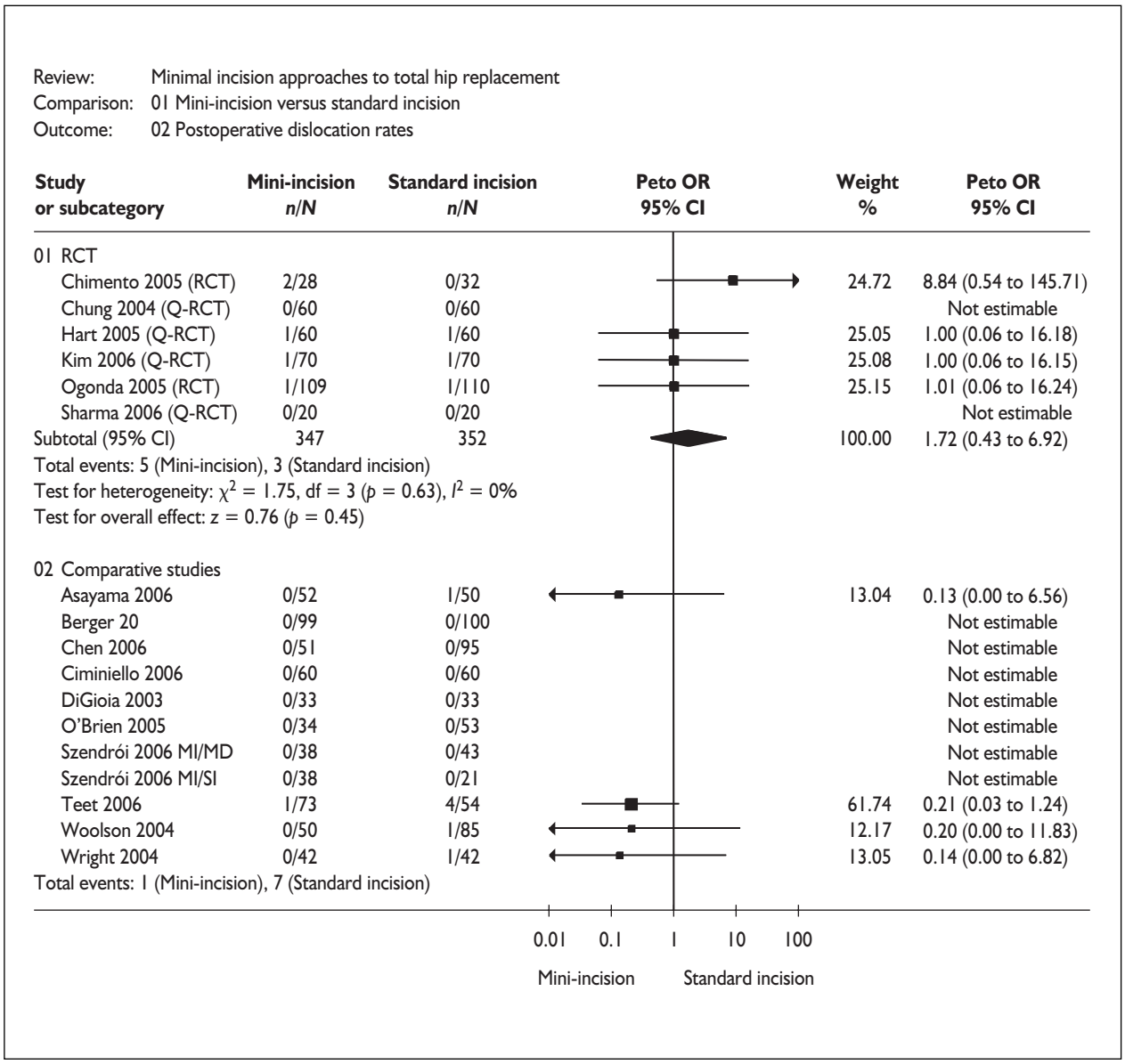

FIGURE 2 *Meta-analysis of postoperative dislocation rates*

mini-incision THR was similar based on the trial data [22/235 (9.4%) versus 24/239 (10%), Peto OR 0.93, 95% CI 0.50 to 1.74, $p = 0.83$] but slightly higher based on data from comparative studies [23/280 (8.2%) versus 18/301 (6%)]. There were marked differences between studies in their overall rates, which may be explained by the differences in definitions used.

Table 11 and *Figure 4* (Appendix 10, Comparison 01:04) show the results of studies reporting the number of (variously defined) femoral component (stems) that were poorly placed in mini- and standard incision THR. No trend was discernible favouring either treatment group and again there were wide differences between studies in their overall rates.

Implant migration One trial[40] and one comparative study[33] provided information on implant migration (Appendix 10, Comparison 01:05). There was no case of implant migration observed in the trial [mini-incision (MI) 0/60 versus standard incision (SI) 0/60] and the comparative study reported one case in the mini-incision group (MI 1/60 versus SI 0/60).

TABLE 10 *Implant position (cup, number poorly placed)*

Study	Mini-incision		Standard incision		Reported *p*-values
	n/N	%	*n/N*	%	
RCT and quasi-RCT					
Chung, 2004[32]	0/60		0/60	0	
Kim, 2006[43]	6/70		5/70		
Ogonda, 2005[46]	16/105		19/109		NS
Subtotal	22/235	9.4	24/239	10.0	
Peto OR (95% CI)					0.93 (0.50 to 1.74), $p = 0.83$
Comparative studies					
Asayama ,2006[28]	0/52		0/50		
Ciminiello, 2006[33]	0/60		0/60		
Szendrói, 2006[52] MI/MD	4/38		2/43		0.348
Szendrói, 2006[52] MI/SI	4/38		3/21		0.686
Woolson, 2004[55]	15/50		13/85		0.04
Wright, 2004[56]	0/42		0/42		
Subtotal	23/280	8.2	18/301	6.0	
Case series					
Pipino, 2004[49]	29/353				
Swanson, 2005[51]	30/1000				
Subtotal	59/1353	4.4			

NS, not significant.

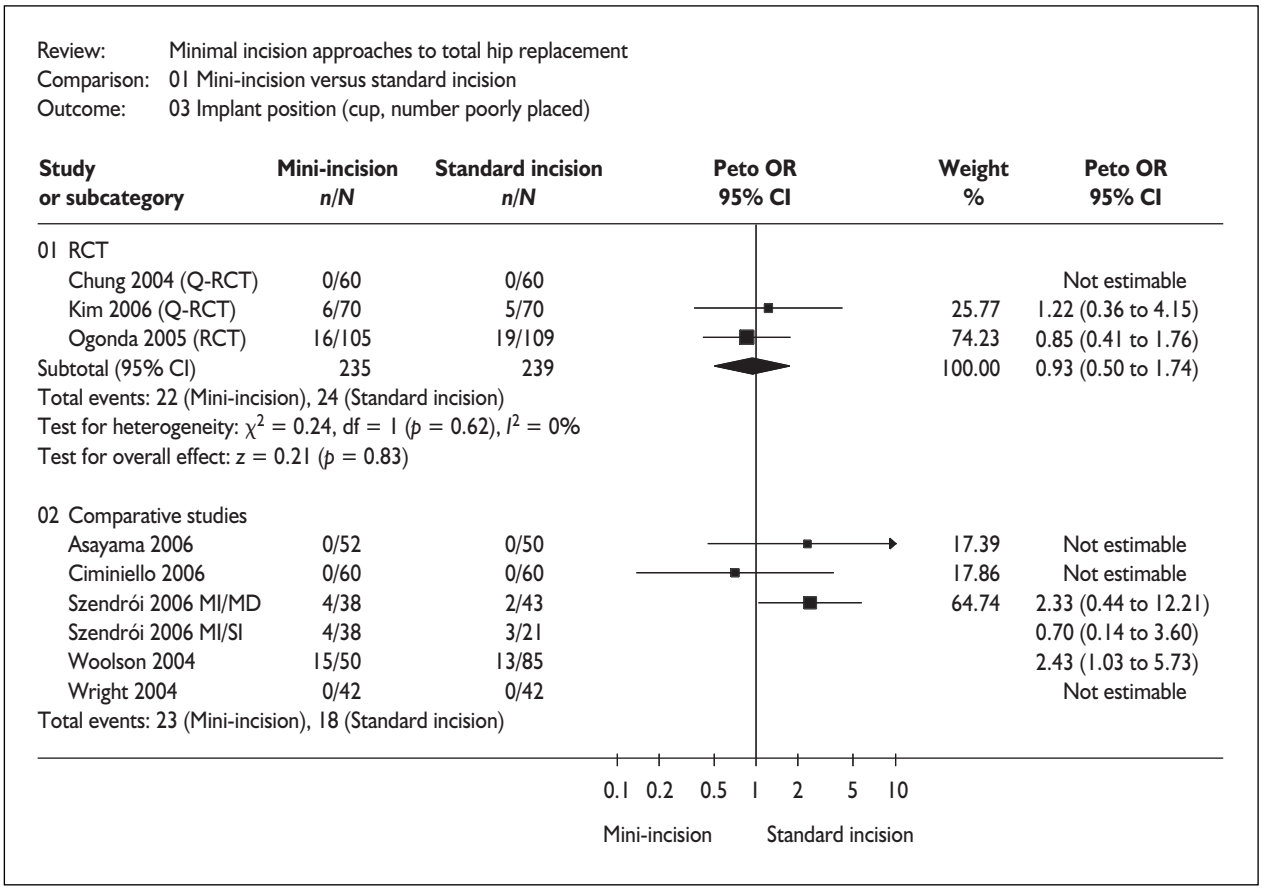

FIGURE 3 *Meta-analysis of implant position (cup, number poorly placed)*

TABLE 11 *Implant position (stem, number poorly placed)*

Study	Mini-incision		Standard incision		Reported *p*-values
	n/N	**%**	***n/N***	**%**	
RCT and quasi-RCT					
Chimento, 2005[31]	1/28		1/32		0.99
Chung, 2004[32]	0/60		0/60		
Hart, 2005[40]	6/60		7/60		
Kim, 2006[43]	4/70		4/70		
Ogonda, 2005[46]	3/105		8/109		
Subtotal	14/323	4.3	20/331	6.0	
Peto odds ratio [95% CI]					0.70 (0.35 to 1.40), $p = 0.31$
Comparative studies					
Asayama, 2006[28]	0/52		0/50		
Ciminiello, 2006[33]	0/60		0/60		
de Beer, 2004[34]	0/30		0/30		
O'Brien, 2005[45]	1/34		3/53		
Szendrói, 2006[52] MI/MD	2/38		2/43		0.568
Szendrói, 2006[52] MI/SI	2/38		1/21		0.682
Teet, 2006[54]	4/73		4/54		0.0009
Woolson, 2004[55]	6/50		3/85		0.056
Wright, 2004[56]	0/42		0/42		
Subtotal	15/417	3.6	13/438	3.0	
Case series					
Flören, 2006[39]	12/70				
Pipino, 2004[49]	21/353				
Swanson, 2005[51]	7/1000				
Subtotal	40/1423	2.8			

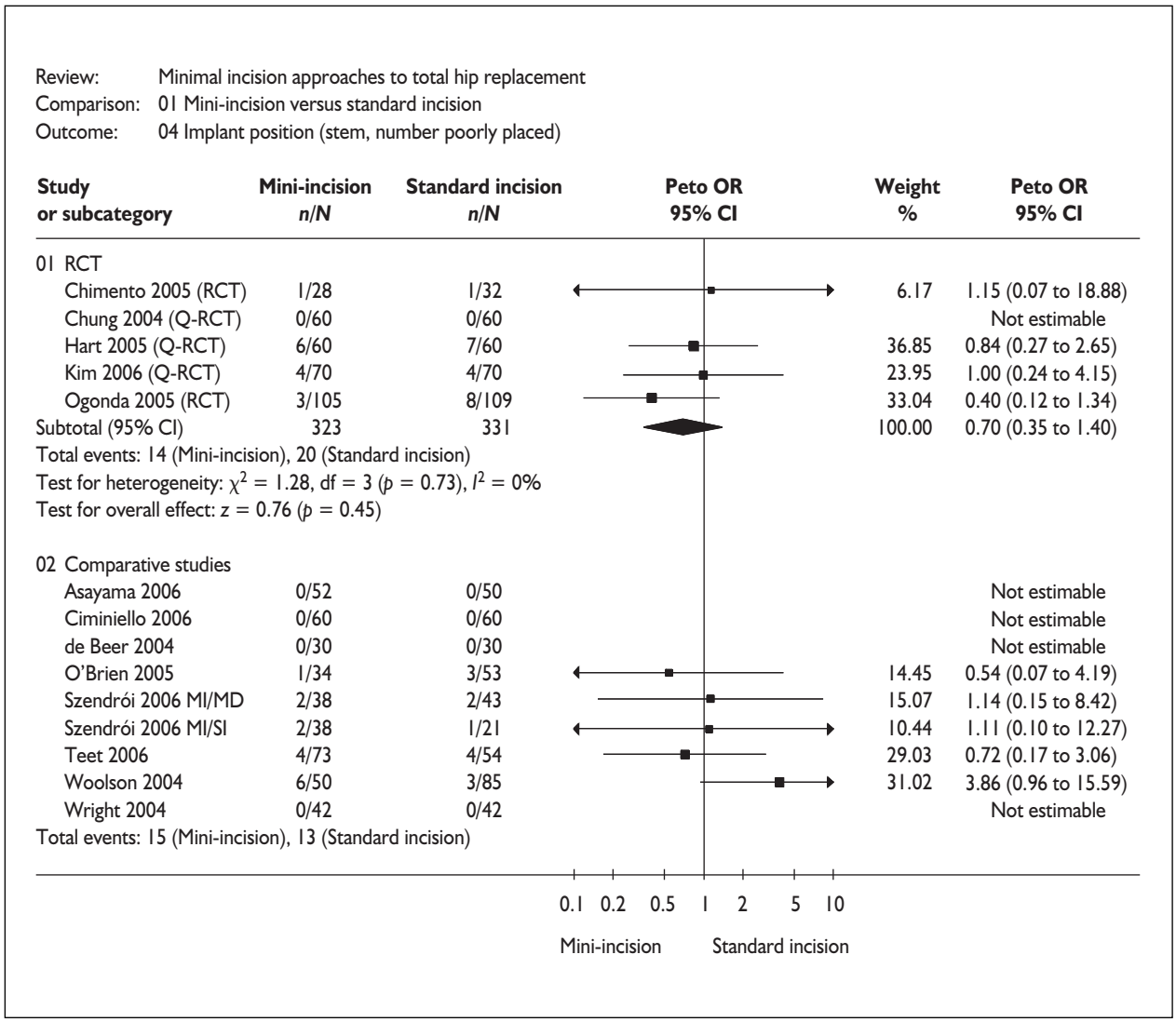

FIGURE 4 *Meta-analysis of implant position (stem, number poorly placed)*

Three further case series with 70, 100 and 331 participants, respectively, reported no case of implant migration.[39,41,49]

Heterotopic ossification Two comparative studies ($N = 86$) reported a total of four cases of heterotopic ossification, all occurring in the standard incision group (Appendix 10, Comparison 01:06).[35,78] Two further case series also provided information on heterotopic ossification. One of these studies with 926 participants[50] reported no incidents, whereas the other study[49] reported that it occurred in 44% (155/353) of the participants. The latter study is based on the Brooker's classification grades (grade I = 106, II = 28, III = 21, IV = 0, where grade IV is the worst).

Cement quality *Table 12* (Appendix 10, Comparison 01:07) shows the results of studies reporting the number of implants with poor cement quality (variously defined). The trial data show no statistically significant differences in the average number of implants with poor cement quality [MI 31/192 (16.1%) versus SI 27/197 (13.7%), Peto OR 1.26, 95% CI 0.70 to 2.27, $p = 0.45$]. None of the comparative studies reporting this outcome observed any implants with poor cement quality. One case series with 70 participants[39] reported that ten arthroplasties showed radiolucent lines in one or more zone.

Limb length inequality

One comparative study reported that there were no patients who had inequality in length across their limbs post-operation (MI 0/52 versus SI

TABLE 12 *Cement quality (number with poor quality)*

Study	Mini-incision		Standard incision		Reported *p*-values
	n/N	%	*n/N*	%	
RCT and quasi-RCT					
Chimento, 2005[31]	3/27		1/28		0.4
Hart, 2005[40]	0/60		0/60		
Ogonda, 2005[46]	28/105		26/109		0.93
Subtotal	31/192	16.1	27/197	13.7	
Peto OR [95% CI]					1.26 (0.70 to 2.27), $p = 0.45$
Comparative studies					
Szendrói, 2006[52] MI/MD	0/24		0/25		
Szendrói, 2006[52] MI/SI	0/24		0/11		
Woolson, 2004[55]	0/12		0/21		
Wright 2004[56]	0/42		0/42		
Subtotal	0/102	0	0/99	0	

TABLE 13 *Blood loss (intraoperative, ml)*

Study	Mini-incision		Standard incision		Reported *p*-values
	n/N	Value[a]	*n/N*	Value[a]	
RCT and quasi-RCT					
Charles, 2006[69]	20	460.0	20	462.5	0.966
Chimento, 2005[31]	28	127 (48)	32	170 (65)	0.003
Chung, 2004[32]	60	136.0 (41.1)	60	200.5 (65.2)	<0.01
Hart ,2005[40]	60	318.8 [200–460]	60	544.4 [390–880]	
Kim, 2006[43]	70	445.8	70	567.5	0.1687
Ogonda, 2005[46]	109	314.0 [90–1310]	110	365.8 [100–1100]	0.03
Rachbauer 2006[75]	60	Less	60	More	<0.01
Subtotal	407		412		
WMD (95% CI)[b]					–56.59 (–71.63 to –41.55), $p < 0.00001$
Comparative studies					
Asayama, 2006[28]	52	217.0 [50–600]	50	247.0 [100–550]	
Berger, 2004[29]	99	154	100	278	>0.05
Chen, 2006[30]	51	175.49 (51.9)	95	293.68 (84.5)	
Ciminiello, 2006[33]	60	201.67 [40–170]	60	191.73 [100–400]	0.812
de Beer, 2004[34]	30	180.0 (69)	30	246.7 (99)	0.04
Howell, 2004[42]	50	387 (155)	57	469 (147)	0.007
Pilot, 2006[48]	10	699	10	540	0.28
Szendrói, 2006[52] MI/MD	38	244 (100)	43	265(114)	0.399
Szendrói, 2006[52] MI/SI	38	244 (100)	43	304 (136)	0.098
Woolson, 2004[55]	50	603	85	507	0.12
Wright, 2004[56]	42	151.8 (53.9)	42	173.2 (57.5)	0.08
Subtotal	520		615		
Case series					
Pipino 2004[49]	368	150			
Swanson 2005[51]	1000	317.3 (230.6)			
Subtotal	1368				

[a] Values are reported as average (SD) [range].
[b] Based on the analysis using estimated SDs from *p*-values where relevant data were not reported.

0/50).[28] One case series reported that 8.5% (28/331) of participants had a change in limb length of up to 1 cm but none of the participants had a change in limb length more than 1 cm.[49] Another study reported that 8.8% (88/1000) of participants had inequality in limb length of more than 7 mm.[51] In a further study, limb length inequality was noted in 7% (7/100) of participants with a maximum discrepancy of 5 mm.[41]

Safety

Blood loss

Table 13 shows the results of studies that reported the amount of blood loss for patients during the operation. The reported blood loss varied widely across studies. Nevertheless, all seven trials, and eight of the 11 comparative studies favoured the mini-incision group. The data from the case series for mini-incision THR were consistent with data from the trials and comparative studies.

Only two trials[31,32] reported SDs and were therefore suitable for quantitative synthesis. The results show that there was significantly less blood loss in the mini-incision group than in the standard incision group (Appendix 10, Comparison 01:09, WMD –58 ml, 95% CI –74 to –42, $p < 0.00001$). This result is broadly consistent with further analyses supplemented with SDs on the basis of reported p-values (*Figure 5*; Appendix 10, Comparison 02:09, WMD –57 ml, 95% CI –72 to –42, $p < 0.00001$). When supplemented further with dummy SDs for the Hart study,[40] significant differences remained, although there was significant statistical heterogeneity (Appendix 10, Comparison 03:09, WMD –99 ml, 95% CI –112 to –86, $p < 0.00001$). Using a random effects model did not change this pattern (WMD –86 ml, 95% CI –162 to –10, $p = 0.03$).

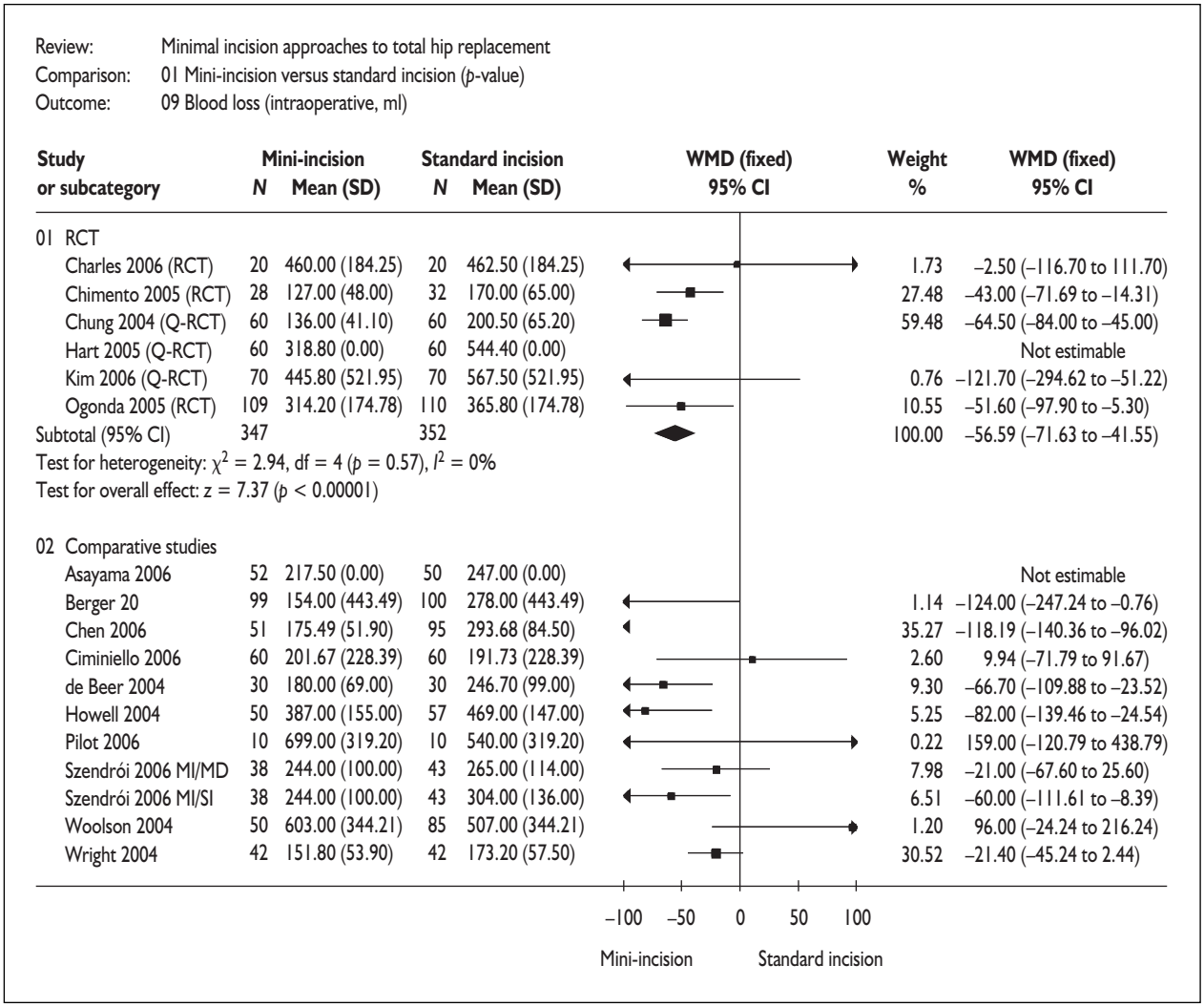

FIGURE 5 *Meta-analysis of blood loss estimated using trial data supplemented by calculated standard deviations from reported* p*-values*

Two further comparative studies reported on total (rather than intraoperative) blood loss, with one (N = 36) favouring mini-incision (318 versus 523 ml, reported p-value <0.05)[44] and the other (N = 20) slightly favouring standard incision (796 versus 772 ml, p-value unknown).[78]

Fractures

Intraoperative fractures occurred between 0 and 2.7% in the mini-incision group and between 0.5 and 1.2% in the standard group (*Table 14*; Appendix 10, Comparison 01:11). The rates varied depending on the source of data. Three trials (N = 339) reported no cases among 169 in the mini-incision group compared with the two among 170 in the standard incision group. In contrast, the comparative studies examining this outcome (N = 790) tended to favour the standard incision group.

With respect to postoperative fractures (*Table 14*; Appendix 10, Comparison 01:12), there were no cases reported in the trials examining this outcome (N = 160) but results from the comparative studies (N = 326) again favoured the standard incision group.

Other adverse effects

Infections Infections (including wound, superficial or deep infections) during the postoperative period appear to be uncommon in the included studies with less than 1% across all data sources and surgical techniques (*Table 15* and *Figure 6*) and

TABLE 14 *Intraoperative and postoperative fractures*

Study	Mini-incision		Standard incision		Reported *p*-values
	n/*N*	%	*n*/*N*	%	
Intra-operative fractures					
RCT and quasi-RCT					
Hart, 2005[40]	0/60		0/60		
Ogonda, 2005[46]	0/109		2/110		
Subtotal	0/169	0	2/170	1.2	
Peto OR (95% CI)					0.14 (0.01 to 2.18), p = 0.16
Comparative studies					
Asayama, 2006[28]	2/52		0/50		
Berger, 2004[29]	1/99		1/100		
Howell, 2004[42]	2/50		0/57		
O'Brien, 2005[45]	2/34		1/53		
Szendrói, 2006[52] MI/MD	0/38		0/43		
Szendrói 2006[52] MI/SI	0/38		0/21		
Takahira, 2006[78]	1/10		0/10		
Woolson, 2004[55]	2/50		0/85		
Subtotal	10/371	2.7	2/419	0.5	
Case series					
Swanson, 2005[51]	10/1000	1.0			
Post-operative fractures					
RCT and quasi-RCT					
Hart, 2005[40]	0/60		0/60		
Sharma, 2006[77]	0/20		0/20		
Subtotal	0/80	0	0/80	0	
Peto OR (95% CI)					Not estimable
Comparative studies					
Chen, 2006[30]	3/51		4/95		
Ciminiello, 2006[33]	0/60		0/60		
de Beer, 2004[34]	1/30		0/30		
Subtotal	4/141	2.8	4/185	2.2	
Case series					
Pipino, 2004[49]	3/331				
Siguier, 2004[50]	1/926				
Swanson, 2005[51]	3/1000				
Subtotal	7/2257	0.3			

TABLE 15 *Infections*

Study	Mini-incision		Standard incision		Reported *p*-values
	n/*N*	%	*n*/*N*	%	
RCT and quasi-RCT					
Chimento, 2005[31]	0/28		0/32		
Chung, 2004[32]	0/60		0/60		
Hart, 2005[40]	0/60		0/60		
Kim, 2006[43]	1/70		0/70		
Ogonda, 2005[46]	2/109		0/110		
Sharma, 2006[77]	0/20		0/20		
Zhang, 2006[58]	0/60		0/60		
Subtotal	3/407	0.7	0/412	0	
Peto OR (95% CI)					7.48 (0.78 to 72.16), $p = 0.08$
Comparative studies					
Asayama, 2006[28]	0/52		1/50		
Berger, 2004[29]	0/99		0/100		
Ciminiello, 2006[33]	0/60		0/60		
Howell, 2004[42]	0/50		1/57		
O'Brien, 2005[45]	0/34		0/53		
Szendrói, 2006[52] MI/MD	0/38		0/43		
Szendrói, 2006[52] MI/SI	0/38		0/21		
Woolson, 2004[55]	1/50		0/85		
Wright, 2004[56]	0/42		0/42		
Subtotal	1/463	0.2	2/511	0.4	
Case series					
Flören, 2006[39]	0/90				
Hartzband, 2006[41]	0/100				
Pipino, 2004[49]	1/331				
Siguier, 2004[50]	5/926				
Swanson, 2005[51]	8/1000				
Subtotal	14/2447	0.6			

TABLE 16 *Nerve injury*

Study	Mini-incision		Standard incision		Reported *p*-values
	n/N	**%**	***n/N***	**%**	
RCT and quasi-RCT					
Charles, 2006[69]	1/20		0/20		
Chimento, 2005[31]	0/28		0/32		
Chung, 2004[32]	0/60		0/60		
Hart, 2005[40]	0/60		0/60		
Kim, 2006[43]	1/70		1/70		
Zhang, 2006[58]	0/60		0/60		
Subtotal	2/298	0.7	1/302	0.3	
Peto OR (95% CI)					1.95 (0.20 to 18.89), $p = 0.56$
Comparative studies					
Asayama 2006[28]	0/52		0/50		
Chen 2006[30]	0/51		2/95		
DiGioia 2003[35]	0/33		0/33		
O'Brien 2005[45]	0/34		0/53		
Szendrói, 2006[52] MI/MD	2/38		3/43		
Szendrói, 2006[52] MI/SI	2/38		0/21		
Takahira, 2006[78]	1/10		0/10		
Woolson, 2004[55]	1/50		1/85		
Wright 2004[56]	0/42		0/42		
Subtotal	6/348	1.7	6/432	1.4	
Case series					
Hartzband, 2006[41]	0/100				
Pipino, 2004[49]	0/331				
Swanson, 2005[51]	6/1000				
Subtotal	6/1431	0.4			

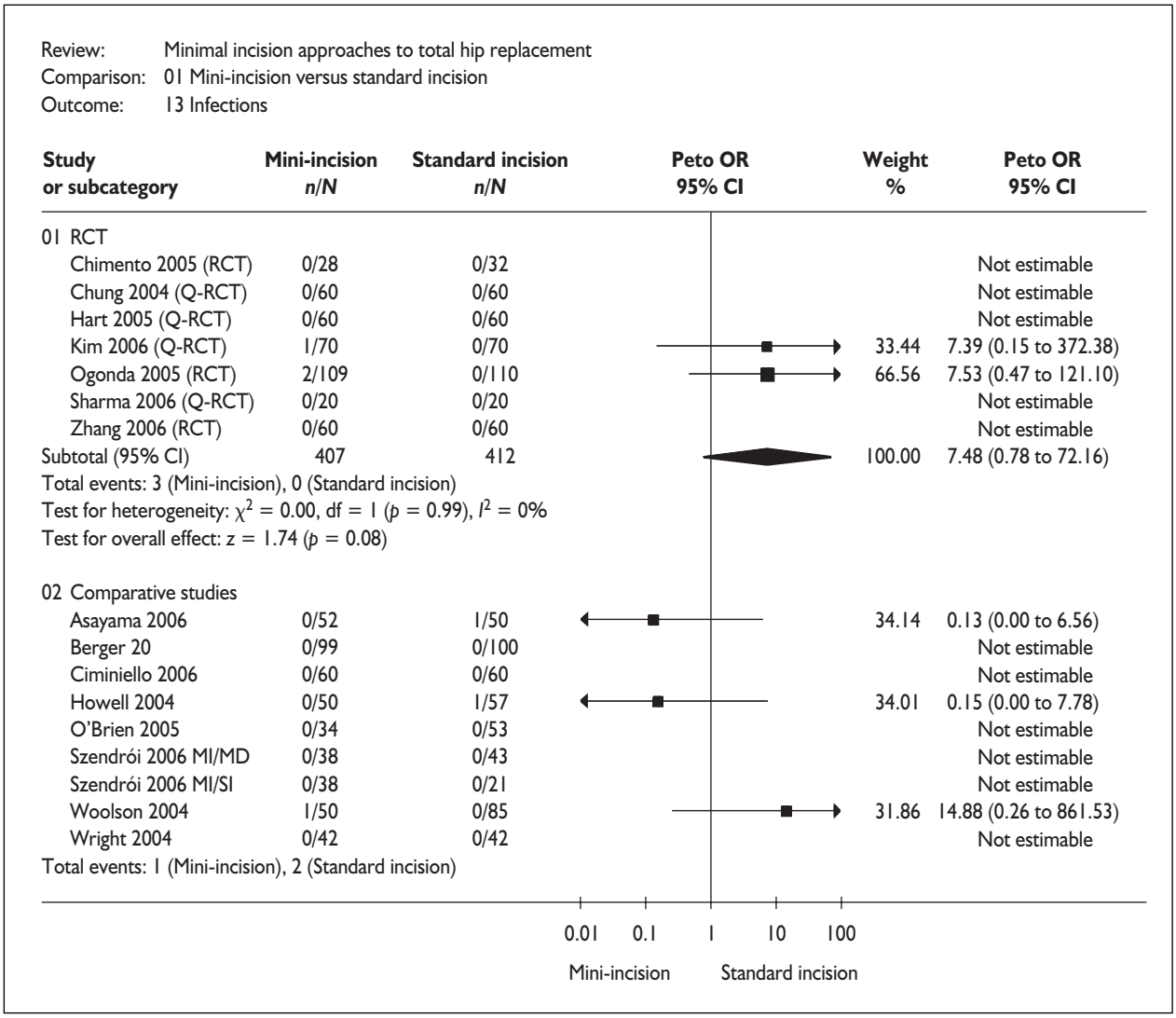

FIGURE 6 *Meta-analysis of infections*

hence with wide confidence intervals around estimates of differences between the two approaches which are not clinically plausible.

Nerve injury Reports of postoperative nerve injury were also rare. Data from the six trials and nine comparative studies that reported the number of postoperative nerve injuries (*Table 16*; Appendix 10, Comparison 01:14) showed no statistically significant differences between the mini-incision group and standard incision group, although with wide 95% CIs for the trials [*Table 16*; Appendix 10, Comparison 01:14, 2/298 (0.7%) versus 1/302 (0.3%), Peto OR 1.95, 95% CI 0.20 to 18.89, $p = 0.56$].

Two case series[49,51] also provided information on the number of nerve injuries following mini-incision surgery at a slightly lower rate (0.4%), compared with the data from the trials (0.7%) or the comparative studies (1.7%).

Vascular injury One trial with 120 participants reported that there were no events of vascular injury.[58] Also, one case series with 331 participants which provided information on vascular injuries reported no events following mini-incision surgery.[49]

Thrombosis Five trials and six comparative studies provided information on DVT (*Table 17* and *Figure 7*). In all studies where DVT occurred, there were slightly fewer events in the mini-incision groups than in the standard groups (0.9% versus 2.5% in the trial, 2.1% versus 4.3% in the comparative studies), although meta-analysis of the trial data found no statistically significant difference (Appendix 10, Comparison

TABLE 17 *DVT and PE*

Study	Mini-incision		Standard incision		Reported *p*-values
	n/N	%	*n/N*	%	
RCT and quasi-RCT					
Chimento, 2005[31]	0/28		0/32		
Chung, 2004[32]	3/60		5/60		
Hart, 2005[40]	0/60		0/60		
Ogonda, 2005[46]	0/109		1/110		
Zhang, 2006[58]	0/60		2/60		
Subtotal	3/317	0.9	8/322	2.5	
Peto OR (95% CI)					0.39 (0.12 to 1.30), $p = 0.12$
Comparative studies					
Asayama, 2006[28]	0/52		1/50		
De Beer, 2004[34]	0/30		1/30		
O'Brien, 2005[45]	0/34		3/53		
Szendrói, 2006[52] MI/MD	2/38		3/43		
Szendrói, 2006[52] MI/SI	2/38		2/21		
Woolson, 2004[55]	1/50		2/85		
Subtotal	5/242	2.1	12/282	4.3	
Case series					
Hartzband, 2006[41]	4/100	4.0			
PE					
RCT and quasi-RCT					
Hart 2005[40]	0/60		0/60		
Subtotal	0/60	0	0/60	0	
Peto OR (95% CI)					Not estimable
Comparative studies					
Berger, 2004[29]	0/99		0/100		
O'Brien, 2005[45]	1/34		0/53		
Subtotal	1/133	0.8	0/153	0	
Case series					
Swanson, 2005[51a]	12/1000	1.2			

[a] Includes both DVT and PE.

01:16, Peto OR 0.39, 95% CI 0.12 to 1.30, $p = 0.12$).

Three further studies reported on PE (*Table 17*). Of these, one comparative study[45] reported one episode of PE in the mini-incision group.

Resource utilisation

Duration of operation

All nine included trials provided information on the duration of operation (*Table 18*). Of these, three showed that the average duration was shorter in the mini-incision group,[32,43,46] four showed that it was shorter in the standard incision group,[31,40,58,69] one reported no difference but did not report any data[75] and the ninth only provided a (non-significant) *p*-value[77] (*Table 18*). In the comparative studies, eight[30,33,44,45,52,55,56] of the 15 studies reporting this outcome found the operation shorter on average in the mini-incision group compared with seven in the standard incision group.[28,29,34,35,42,48,78]

The trials reporting SDs tended to be those that favoured mini-incisions. For this reason, we chose to estimate SDs for the others using reported *p*-values (calculated SDs). The results suggested a small difference in favour of mini-incisions for this analysis (*Table 18* and *Figure 8*; Appendix 10, Comparison 02:18, WMD –3.70 minutes, 95% CI –5.67 to –1.74, $p = 0.0002$). Caution is required, as this analysis displayed statistical heterogeneity.

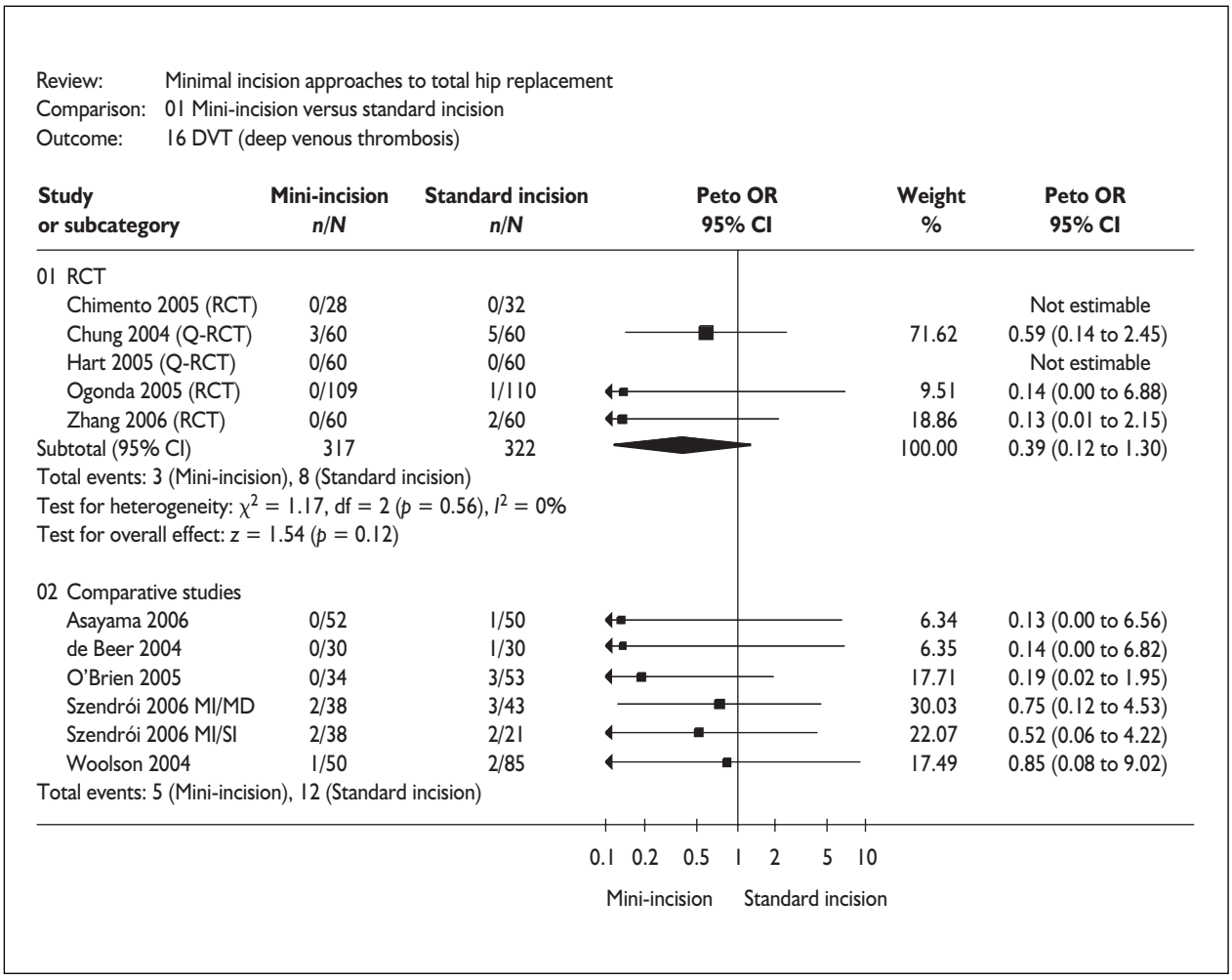

FIGURE 7 *Meta-analysis of DVT*

After applying random effects models, the differences between mini- and standard incision surgery were no longer statistically significant (WMD –2.35, 95% CI –6.86 to 2.16, p = 0.31). Analyses based on the published data and the data supplemented with the dummy SDs are reported in Appendix 10, Comparisons 01: 18 and 03:18.

On the assumption that the trials are least biased, overall, there may be a small difference of around 2–5 minutes in operating time favouring mini-incision. However, this is not certain and the difference may not have any practical significance.

Length of hospital stay

The reported length of hospital stay varied from 1 to 23 days (*Table 19*). Compared with the standard incision group, five[32,46,58,69,77] of the six trials and seven[29,30,35,42,45,74,78] of the 12 comparative studies that provided information on length of hospital stay reported shorter average hospital stay in the mini-incision group. The difference between the two groups tended to be small or for 1 or 2 days, except one trial by Zhang and colleagues reporting the largest difference of more than 6 days.[58] The length of stay reported in the case series was generally consistent with the data on length of stay for the mini-incision group in the trials.

Meta-analysis of the trial data supplemented by calculated SDs from reported p-values resulted in a mean length of stay that was statistically significantly shorter in the mini-incision group but there was significant statistical heterogeneity at the 10% level (*Figure 9*; Appendix 10, Comparison 02:19, WMD –0.50 days, 95% CI –0.83 to –0.18, p = 0.002). When a random effects model was applied, the difference between groups was no longer statistically significant (WMD –0.34 days, 95% CI –0.94 to 0.25, p = 0.26). Further analyses based on the published data and the data supplemented with the dummy SDs are

TABLE 18 *Duration of operation (minutes)*

Study	Mini-incision		Standard incision		Reported *p*-values
	n/N	Value[a]	*n/N*	Value[a]	
Study					
Charles, 2006[69]	20	95.2	20	87.7	0.315
Chimento, 2005[31]	28	70.3 (10.7)	32	70.0 (8.5)	0.4
Chung, 2004[32]	60	49.0 (9.4)	60	55.1 (17.9)	
Hart, 2005[40]	60	71 [55–84]	60	70 [51–86]	NR
Kim, 2006[43]	70	52 [48–70]	70	61 [51–80]	<0.001
Ogonda, 2005[46]	109	60.3 (9.2)	110	65.9 (13.2)	
Rachbauer, 2006[75]	60	No difference	60	No difference	NR
Sharma, 2006[77]	20	NR	20	NR	0.207
Zhang, 2006[58]	60	75	60	69	>0.05
Subtotal	487		492		
WMD (95% CI)[b]					–3.70 (–5.67 to –1.74), $p = 0.0002$
Comparative studies					
Asayama, 2006[28]	50	58.6 [32–89]	50	57.9 [36-90]	0.715
Berger, 2004[29]	99	72	100	66	NR
Chen, 2006[30]	51	88.41 (17.60)	95	90.85 (17.81)	
Ciminiello, 2006[33]	60	55.45 [40–170]	60	56.95 [35–90]	0.097
de Beer, 2004[34]	30	46.6 [24–90]	30	44.5 [17–75]	0.572
DiGioia, 2003[35]	33	120	33	100	NR
Howell, 2004[42]	50	97 (19)	57	84 (15)	0.001
Li, 2005[44]	18	91 (16.4)	18	97 (15.6)	>0.05
O'Brien, 2005[45]	32	74 (15)	51	80 (10)	
Pilot, 2006[48]	10	99.5	10	81.0	0.056
Szendrói, 2006[52] MI/MD	38	84 (16)	43	93 (18)	0.020
Szendrói, 2006[52] MI/SI	38	84 (16)	21	102 (12)	<0.001
Takahira, 2006[78]	10	126.5	10	119.9	NR
Woolson, 2004[55]	50	97	85	105	0.13
Wright, 2004[56]	42	71.4 (11.2)	42	77.7 (13.2)	0.02
Subtotal	611		705		
Case series					
Hartzband, 2006[41]	100	37.5 [27–90]			
Swanson, 2005[51]	1000	61.2 (24.2)			

NR, not reported.
[a] Values are reported as average (SD) [range].
[b] Based on the analysis using SDs estimated from *p*–values where relevant data were not reported.

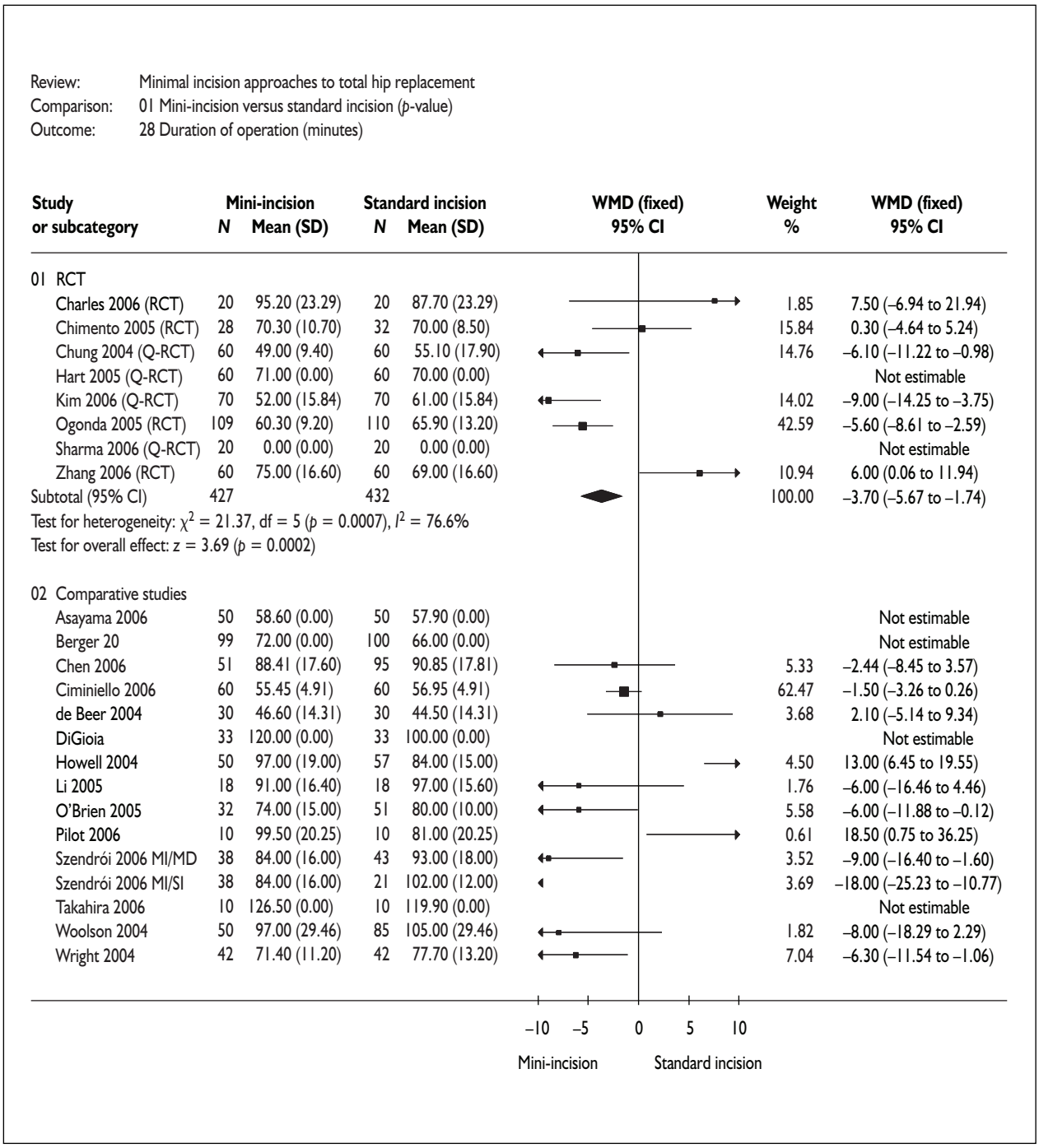

FIGURE 8 *Meta-analysis of duration of operation time estimated using trial data supplemented by calculated SDs from reported* p*-values*

TABLE 19 *Length of hospital stay (days)*

Study	Mini-incision		Standard incision		Reported *p*-values
	n/N	**Value[a]**	***n/N***	**Value[a]**	
RCT and quasi-RCT					
Charles, 2006[69]	20	5.35	20	5.70	0.501
Chimento, 2005[31]	28	5.8 [4–13]	32	5.5 [3–15]	0.6
Chung, 2004[32]	60	4.41 (1.1)	60	5.34 (1.4)	<0.01
Ogonda, 2005[46]	109	3.65 (2.04)	110	3.68 (2.45)	0.94
Sharma, 2006[77]	20	Shorter	20	Longer	0.042
Zhang, 2006[58]	60	7 [5–8]	60	13.5 [12–16]	NR
Subtotal	297		302		
WMD (95% CI)[b]					–0.50 (–0.83 to –0.18), $p = 0.002$
Comparative studies					
Asayama, 2006[28]	52	2.96 (1–6)	50	2.94 (2–4)	0.858
Berger, 2004[29]	100	1.9	100	3.5	>0.05
Chen, 2006[30]	51	11.16 (0.83)	95	12.83 (1.96)	
Ciminiello, 2006[33]	60	3.70 [2–7]	60	3.63 [2–5]	0.94
de Beer, 2004[34]	30	5.13 [3–8]	30	5.1 [4–8]	0.894
DiGioia, 2003[35]	33	3.8	33	3.9	0.6
Howell, 2004[42]	50	4.4 (2.9)	57	5.7 (3.1)	0.03
O'Brien, 2005[45]	35	5.4 (2.1)	53	6.2 (2.8)	
Panisello, 2006[74]	40	5.6	40	6.7	NR
Takahira, 2006[78]	10	22	10	23.4	NR
Woolson, 2004[55]	50	4.3	85	4.0	0.44
Wright, 2004[56]	42	6.12	42	6.07	0.92
Subtotal	553		655		
Case series					
Flören, 2006[39]	79	4.7 (2.0)			
Hartzband, 2006[41]	100	2.89 [3–5]			
Swanson, 2005[51]	1000	3.7 (1.8)			
Subtotal	1079				

NR, not reported.
[a] Values are reported as average (SD) [range].
[b] Based on the analysis using SDs estimated from *p*-values where relevant data were not reported.

reported in Appendix 10, Comparisons 01:19 and 03:19.

Caution is required, since these differences may reflect the clinical policy of each hospital for discharge rather than the clinical need of each patient. For this reason, it may not be appropriate to place much weight on these values.

Patient-centred measures

Deaths

Two trials[31,46] and two comparative studies[33,56] provided information on the number of participants who died during the first 30 days of the study period (30-day mortality) and also during the entire study period (long-term mortality) (*Table 20*). In terms of 30-day mortality, one trial reported that two of the 110 patients (1.8%) in the standard incision group had died in the early postoperative period (Appendix 10, Comparison 01:20).[46] No deaths were reported during the early phase of the comparative studies.[33,56]

In terms of long-term mortality, two of the 32 trial participants (6.3%) in the standard incision group had died during the 2-year period but these events were reported to be unrelated to surgery.[31] One comparative study reported two deaths (2%) in each of the mini-incision and standard incision groups over the period of 5 years but similarly reported that these were secondary to events

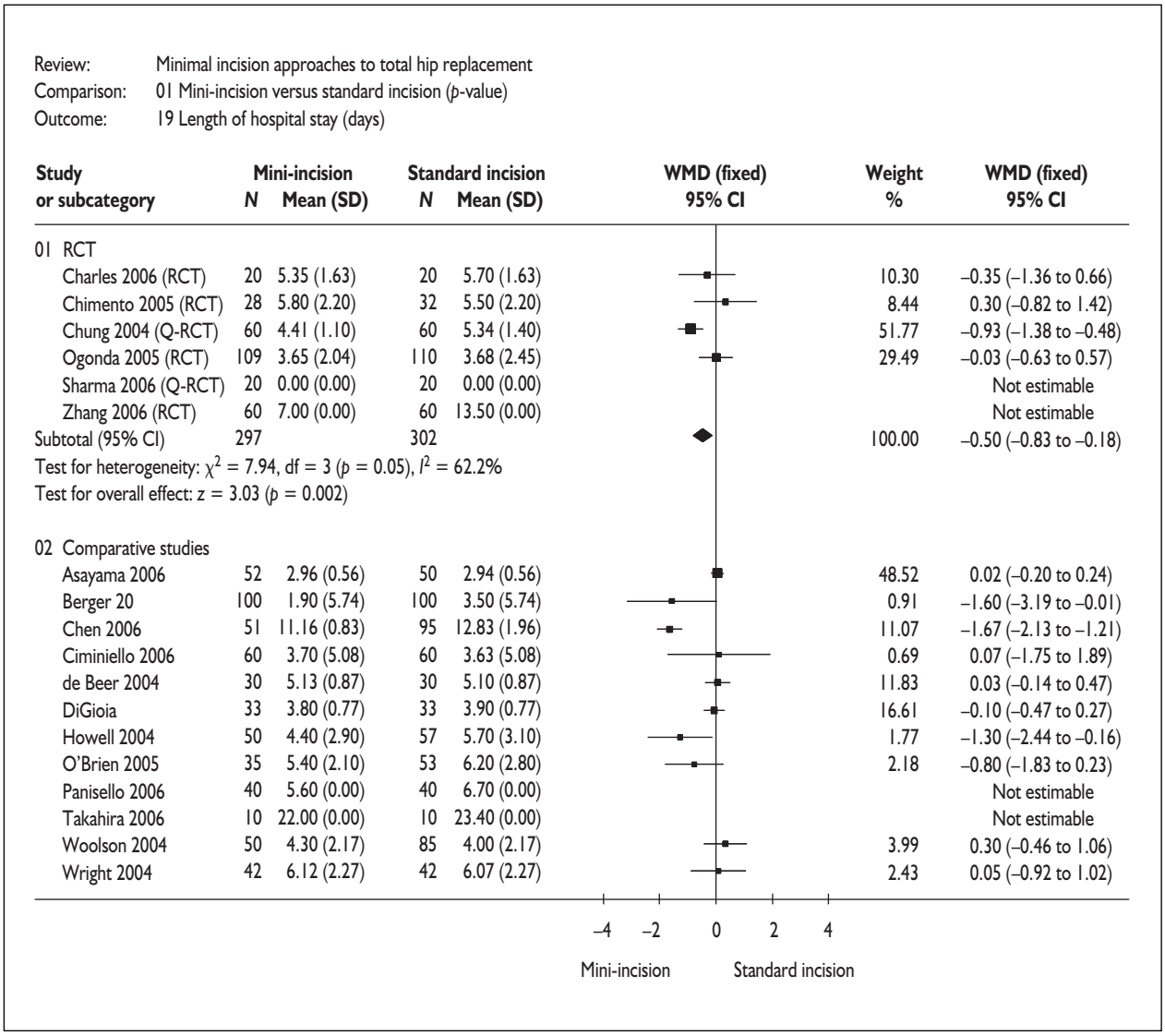

FIGURE 9 *Meta-analysis of length of stay estimated using trial data supplemented by calculated SDs from reported* p*-values*

unrelated to the hip arthroplasty.[56] No deaths were reported in another comparative study with a relatively short (6-week) follow-up (Appendix 10, Comparison 01:21).[33]

Pain

Postoperative pain was reported using various measures, including analgesic requirements, pain scores and the number of patients reporting pain (*Tables 21–23*). The available data were mostly derived from short-term (≤3 months) results. Five RCTs[31,32,46,69,75] and three comparative studies[28,33,34] reported data on analgesic needs (*Table 21*). In all but two[69,75] of these studies, the average analgesic usage was slightly less in the mini-incision groups but these differences were small. This difference was not found to be statistically significant in any of the studies which performed a statistical test. As the outcome measures varied between studies and not all studies reported data amenable to meta-analysis, only limited quantitative synthesis was possible. The meta-analyses that were conducted are reported in Appendix 10, Comparisons 01:22–01:24, and none of these provided any evidence of a difference between mini- and standard incision.

In terms of pain scores (short-term), results were similar with five[46,52,75,77] of the six studies with data favouring the mini-incision groups (*Table 22*; Appendix 10, Comparison 01:26). In three studies which performed a statistical test, this difference was found to be statistically significant. Results in terms of the number of patients reporting short-term pain, derived from three studies,[28,33,34] were

TABLE 20 *Mortality*

Study	Mini-incision		Standard incision		Reported *p*-values
	n/N	%	*n/N*	%	
30-day mortality					
RCT					
Ogonda, 2005[46]	0/109		2/110		
Subtotal	0/109	0	2/110	1.8	
Peto OR (95% CI)					0.14 (0.01 to 2.18), $p = 0.16$
Comparative studies					
Ciminiello, 2006[33]	0/60		0/60		
Wright, 2004[56]	0/42		0/42		
Subtotal	0/102	0	0/102	0	
Long-term mortality					
RCT					
Chimento, 2005[31]	0/28		2/32		
Subtotal	0/28	0	2/32	6.3	
Peto OR (95% CI)					0.15 (0.01 to 2.45), $p = 0.18$
Comparative studies					
Ciminiello, 2006[33]	0/60		0/60		
Wright, 2004[56]	2/42		2/42		
Subtotal	2/102	2.0	2/102	2.0	

TABLE 21 *Short-term pain – analgesic requirement*

Study	Measure	Mini-incision		Standard incision		Reported *p*-value
		N	Average (SD) [range]	*N*	Average (SD) [range]	
RCT and quasi-RCT						
Charles, 2006[69]	PCA narcotic consumption (mg)	18	22.8	19	19.5	0.105
Chimento, 2005[31]	Patient-controlled epidural anaesthesia (ml)	28	285 (185)	32	319 (177)	0.3
Chung, 2004[32]	Narcotic use (days)	60	2.20	60	2.64	NS
Ogonda, 2005[46]	Volume of morphine used (mg)	109	42.9 (97.4)	110	45.0 (96.8)	0.89
Rachbauer, 2006[75]	Use of analgesic	60	No difference	60	No difference	NR
Comparative studies						
Asayama, 2006[28]	Total intravenous narcotic received during hospitalisation[a] (mg)	52	92.7 [37–180]	50	94.9 [38–188]	NS
Ciminiello, 2006[33]	Equianalgesic requirement up to 6 weeks (mg)	60	118 [10.5–450.6]	60	121 [8.6–390.5]	0.77
de Beer, 2004[34]	Equianalgesic opioid consumption (mg)	30	147.70 [18–337.9]	30	169.3 [23.3–413.3]	0.336

NR, not reported; NS, not statistically significant; PCA, patient controlled analgesia.
[a] Equianalgesic equivalency to morphine.

TABLE 22 *Other short-term pain*

Study	Measure	Mini-incision		Standard incision		Reported *p*-value
		N	**Average (SD)**	***N***	**Average (SD)**	
Pain score						
RCT and quasi-RCT						
Charles, 2006[69]	Pain score[a]	18	3.9	19	3.7	0.129
Kim, 2006[43]	10-point analogous scale at 2 weeks and 3 months	70	NR	70	NR	>0.05
Ogonda, 2005[46]	100-mm visual analogue scale in first 7 days following discharge	109	33 (18.0)	110	33.6 (19.6)	0.82
Rachbauer, 2006[75]	Postoperative pain in the first week	60	Lower	60	Higher	Sig.
Sharma, 2006[77]	10-point visual analogue scale at day 1	20	4.05	20	6.25	0.0089
Comparative studies						
Szendrói 2006[52] (MI/MD)	Visual analogue scale at day 3	38	1.5 (1.15)	43	2.15 (1.2)	0.028
Szendrói, 2006[52] (MI/SI)	Visual analogue scale at day 3	38	1.5 (1.15)	21	2.1 (1.3)	0.112
Number of patients reporting pain						
Comparative studies						
Asayama, 2006[28]	Mild pain	52	2	49	3	
Ciminiello, 2006[33]	Thigh pain	60	0	60	0	
De Beer, 2004[34]	Subcutaneous hematoma, mild sciatica and thigh pain	30	0	30	1	
Case series						
Pipino, 2004[49]	Thigh pain	331	7			

NR = not reported; Sig, statistically significant.
[a] Details unavailable.

TABLE 23 *Long-term pain*

Study	Measure	Mini-incision		Standard incision		Reported *p*-value
		N	**Value**	***N***	**Value**	
RCT and quasi-RCT						
Kim, 2006[43]	10-point analogous scale at 6 months, 1 year and 2 years	70	NR	70	NR	>0.05
Case series						
Flören, 2006[39]	Slight or mild pain (no. of patients)	90	10			
Hartzband, 2006[41]	Significant thigh pain (no. of patients)	100	0			
Pipino, 2004[49]	Persistent thigh pain at 1 year (no. of patients)	331	1			

NR, not reported.

also slightly better for the mini-incision group (*Table 22*; Appendix 10, Comparison 01:25).

Only one trial[43] and three case series[39,41,49] included a measure of long-term pain (*Table 23*). The trial did not report the actual pain score values at 6–24 months postoperatively but suggested that the two groups did not differ significantly. The three case series recorded the number of patients reporting pain, although the degree of reported pain varied between the studies.

Return to usual activities

Only one trial[75] and one comparative study[30] provided information on time to return to usual or daily activities (*Table 24*; Appendix 10, Comparison 01:28). The average time in the mini-incision group was shorter in both studies. The one case series reporting this outcome reported a shorter time to return to usual activities than comparative study data. However, definitions and case mix may have differed.

Two further trials[31,32] and one comparative study[28] recorded the number of participants requiring a stick (cane) or other walking aid or the duration for which participants used such devices postoperatively (*Table 24*; Appendix 10, Comparisons 01:29 and 01:30). Results were generally more favourable for the mini-incision group. The number of patients with a limp in the mini-incision group within the first 3 months after operation was significantly fewer in one study[31] but non-significantly higher in another (*Table 24*; Appendix 10, Comparison 01:31).[28]

TABLE 24 *Return to usual activities*

Study	Measure	Mini-incision		Standard incision		Reported *p*-value
		N	Value (SD)	*N*	Value (SD)	
Time to return to usual activities						
RCT and quasi-RCT						
Rachbauer, 2006[75]	Time to return to daily activities	60	Shorter	60	Longer	NR
Comparative studies						
Chen, 2006[30]	Time to return to normal activities (days)	51	60 (12)	95	116 (11)	
Case series						
Pipino, 2004[49]	Return to a full normal lifestyle at 1–7 years (no. of patients)	331	318			
Swanson, 2005[51]	Time to begin unrestricted normal daily activities (days)	1000	29.4			
Use of walking aids: short-term						
RCT and quasi-RCT						
Chimento, 2005[31]	Required a cane at 6 weeks (no. of patients)	28	9	32	15	NS
Chung, 2004[32]	Use of walking aids (days)	60	21.4 (4.8)	60	24.8 (5.4)	
Comparative studies						
Asayama, 2006[28]	Use of walking aid at 3 months (no. of patients)	52	4	49	4	
Limp: short-term (no. of patients)						
RCT and quasi-RCT						
Chimento, 2005[31]	Persistent limp at 6 weeks	28	6	31	15	0.04
Comparative studies						
Asayama, 2006[28]	Very slight limp at 3 months	52	19	49	16	NS
Case series						
Siguier, 2004[50]	Limp	926	0			
Limp: long-term (no. of patients)						
RCT and quasi-RCT						
Chimento, 2005[31]	Persistent limp at 1 year	27	0	29	0	

NR, not reported; NS, not statistically significant.

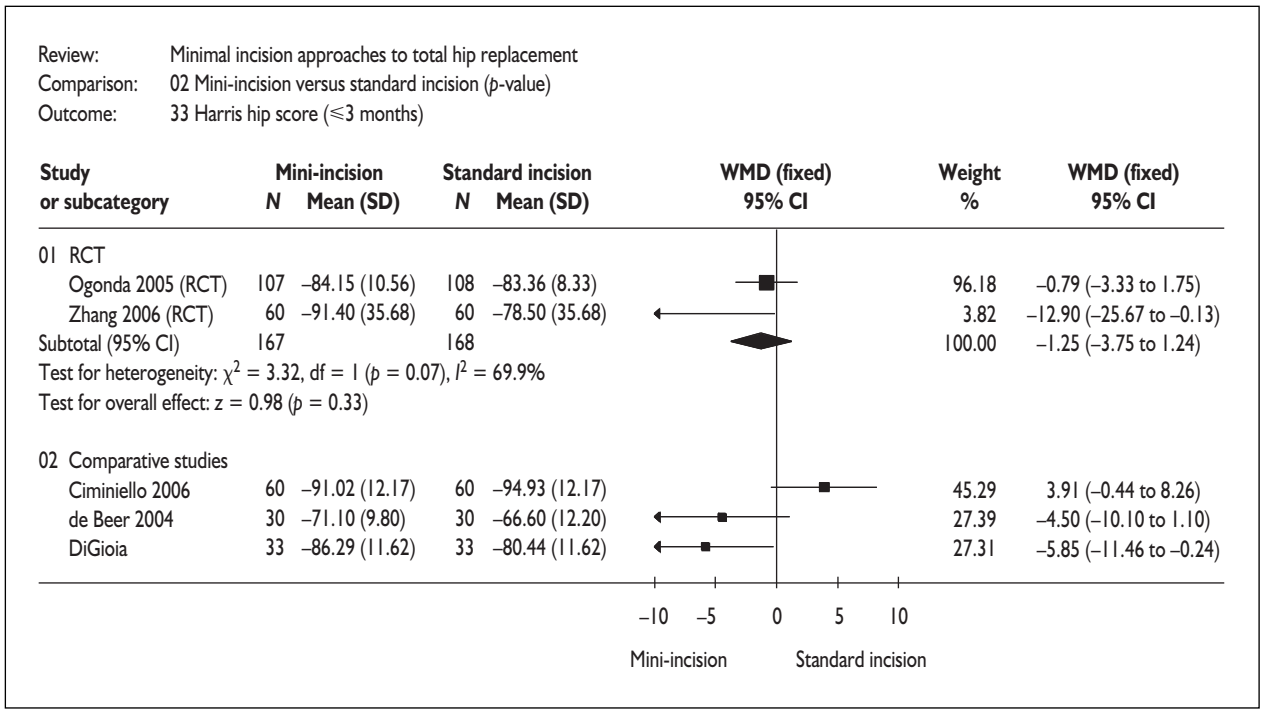

FIGURE 10 *Meta-analysis of Harris hip score (≤3 months) estimated using trial data supplemented by calculated SDs from reported* p*-values*

TABLE 25 *Condition-specific quality of life (≤3 months)*

Study	Mini-incision		Standard incision		Reported *p*-value
	N	**Value (SD) [range]**	***N***	**Value (SD) [range]**	
Harris hip score[a]					
RCT and quasi-RCT					
Ogonda, 2005[46]	107	84.15 (10.56)	108	83.36 (8.33)	0.54
Zhang, 2006[58]	60	91.4	60	78.5	<0.05
Comparative studies					
Ciminiello, 2006[33]	60	91.02 [60–100]	60	94.93 [70–100]	0.081
de Beer, 2004[34]	30	71.1 (9.8)	30	66.6 (12.2)	0.193
DiGioia, 2003[35]	33	86.29 [63–96]	33	80.44 [63–95]	0.045
WOMAC osteoarthritis index[b]					
RCT and quasi-RCT					
Charles, 2006[69]	16	91.99	19	89.60	0.690
Ogonda, 2005[46]	107	74.40 (13.88)	108	73.95 (12.90)	
Oxford hip score[b]					
RCT and quasi-RCT					
Ogonda, 2005[46]	107	24.97 (7.33)	108	25.88 (6.29)	
Comparative studies					
de Beer, 2004[34]	30	26.50 (8.40)	30	28.40 (7.50)	0.494
Merle d'Aubigné-Charnley Score[b]					
RCT and quasi-RCT					
Hart, 2005[40]	60	16.6	60	14.1	<0.02

[a] Higher scores reflect better quality of life.
[b] Higher scores reflect poorer quality of life.

TABLE 26 *Condition-specific quality of life (>3 months)*

Study	Mini-incision		Standard incision		Reported *p*-value
	N	**Value (SD) [range]**	***N***	**Value (SD) [range]**	
Harris hip score					
RCT and quasi-RCT					
Chimento, 2005[31]	27	94.5	29	94.5	NR
Chung, 2004[32]	60	95.5	60	93.5	NS
Kim, 2006[43]	70	93 [86–100]	70	91 [85–100]	0.7435
Zhang, 2006[58]	60	95.1	60	95.6	>0.05
Comparative studies					
Asayama, 2006[28]	52	96.2	50	96.2	NS
Chen, 2006[30]	51	89.71 (3.62)	95	83.78 (8.03)	
DiGioia, 2003[35]	33	96 [86–100]	33	94 [79–100]	0.08
Li, 2005[44]	18	92	18	90	>0.05
Woolson, 2004[55]	20	99 [89–100]	14	97 [65–100]	0.43
Wright, 2004[56]	37	86.9 (4.1)	39	84.2 (6.4)	0.042
Case series					
Flören, 2006[39]	79	92.3 (7.9)			
Swanson, 2005[51]	1000	92 (9)			
Merle d'Aubigné-Charnley score					
RCT and quasi-RCT					
Hart, 2005[40]	60	17.4	60	17.3	NS

NR, not reported; NS, not statistically significant.

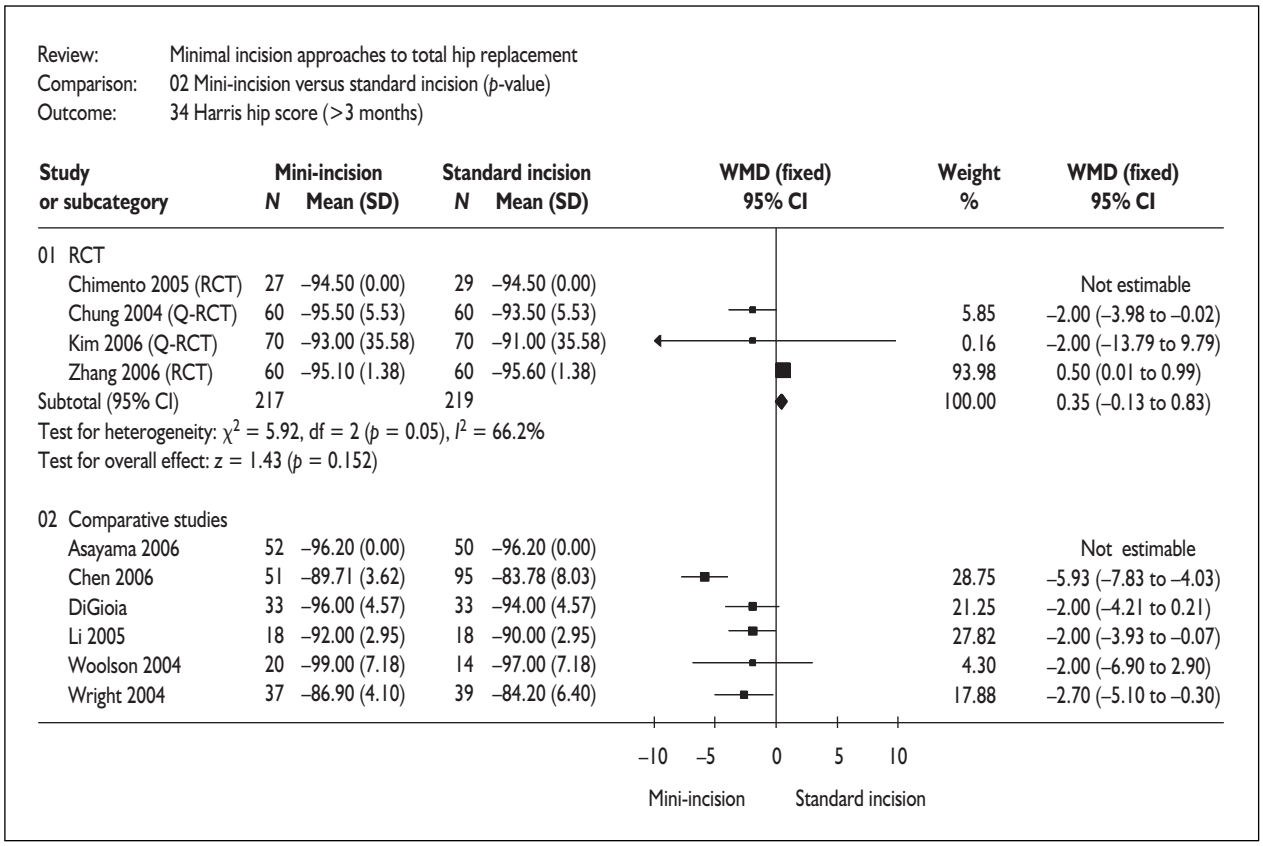

FIGURE 11 *Meta-analysis of Harris hip score (>3 months) estimated using trial data supplemented by calculated SDs from reported* p*-values*

No studies measured resumption of normal activities over a longer time span, except one study which reported no episodes of persistent limp at 1 year after mini- or standard incision surgery.[31]

Condition-specific quality of life

Measurement of condition-specific quality of life following surgery was assessed using a variety of instruments, including the Harris hip score, WOMAC (Western Ontario and MacMaster Universities Osteoarthritis Index), Oxford hip score and Merle d'Aubigné–Charnley score. In general, higher scores indicate better quality of life. However, for WOMAC and Oxford hip scores, higher scores indicate poorer quality of life.

The short-term (≤3 months) results are summarised in *Table 25*. Two trials[46,58] and three comparative studies[33–35] utilised the Harris hip score. All but one study[33] favoured the mini-incision group but only two found this to be statistically significant.[35,58]

Since only one trial[46] reported SDs, we estimated SDs for the other trial[58] using the reported *p*-value for the purpose of quantitative synthesis. The results showed no statistically significant difference between the mini- and standard incision groups (*Figure 10*; Appendix 10, Comparison 02:33, WMD –1.25, 95% CI –3.75 to 1.24, $p = 0.33$). The average Harris hip scores varied widely across studies, ranging from 67 to 95. Although not shown in the table, in one case series study 91% of the 353 participants had a Harris hip score of 90 or greater (the best possible score is 100).[49]

Other studies that examined short-term quality of life through the WOMAC index[46,69] and the Oxford hip score[34,46] found no significant differences between groups (*Table 25*; Appendix 10, Comparisons 01:35 and 01:36). However, one trial examining the Merle d'Aubigné–Charnley score reported statistically significantly higher quality of life in the mini-incision group compared with the standard incision group (*Table 25*; Appendix 10, Comparison 01:37).[40]

With respect to the long-term (>3 months) results related to condition-specific quality of life (*Table 26*), eight of the 10 studies that examined the Harris hip score tended to favour the mini-incision group, of which only one non-randomised study reported a statistically significant difference.[56] The average scores varied across studies, although compared with the short-term results the scores reported by studies with longer follow-up appeared to be higher (reflecting better quality of life), and the difference between groups was smaller. Only limited quantitative synthesis was possible due to insufficient data. The trial data did not provide any evidence of a difference between groups after supplementing with calculated SDs (*Figure 11*; Appendix 10, Comparison 02:34, WMD 0.35, 95% CI –0.13 to 0.83, $p = 0.15$) or calculated and dummy SDs (Appendix 10, Comparison 03:34, WMD 0.27, 95% CI –0.15 to 0.69, $p = 0.21$).

Using an alternative measure of condition-specific quality of life (the Merle d'Aubigné–Charnley score), one further trial again found no statistically significant difference between groups (*Table 26*).[40]

General quality of life

Three studies used components of Short Forms with 12 (SF-12) and 36 Items (SF-36) to ascertain general quality of life (*Table 27*; Appendix 10, Comparisons 01:39–01:43). Overall, quality of life scores were similar in both the mini-incision and standard incision groups. However, in one comparative study the standard incision group scored higher (better) in the longer term (6 months to 1 year) on one test score (SF-36 physical function).[36]

Although not analysed in the trial report by Charles and colleagues,[69] further patient-level analysis based on the completed SF-36 data collected as part of this RCT was performed (Coyle D, Coyle K, University of Ottawa: personal communication, May 2007). This analysis calculated Short Form with 6 Dimensions (SF-6D) scores using the algorithm from Brazier and colleagues.[80] Using an analysis of covariance and adjusting for baseline SF-6D scores, the results showed no significant differences in the mean values between the mini-incision group and the standard incision group at 3 months [0.79 (SD 0.08) versus 0.76 (SD 0.10)] or 2 years after operation [0.80 (SD 0.08) versus 0.82 (SD 0.09)]. A full description of these analyses is reported in Appendix 11, including analyses using different methods of handling missing values.

Patient satisfaction and scar cosmesis

Six studies using a variety of measures provided information on patient satisfaction and scar

TABLE 27 *General quality of life*

Study	Measure	Mini-incision		Standard incision		Reported *p*-value
		N	Value (SD) [range]	*N*	Value (SD) [range]	
Short-term (≤3 months)						
RCT and quasi-RCT						
Charles, 2006[69]	SF-36 physical component	16	40.8	19	40.4	0.583
Coyle[a]	SF-6D	18	0.79 (0.08)	18	0.76 (0.10)	
Ogonda, 2005[46]	SF-12 physical component	107	38.48 (10.20)	108	37.73 (9.48)	0.58
Ogonda, 2005[46]	SF-12 mental component	107	50.61 (11.05)	108	51.11 (10.54)	0.73
Long-term (>3 months)						
Comparative studies						
Coyle[a]	SF-6D	18	0.80 (0.08)	18	0.82 (0.09)	
Dorr, 2007[36]	SF-36 physical component	109	54.50 (4.29)	56	56.24 (3.87)	
Dorr, 2007[36]	SF-36 mental component	109	60.38 (3.84)	56	60.74 (3.42)	

[a] Coyle D, Coyle K, University of Ottawa: personal communication, May 2007.

cosmesis (*Table 28*; Appendix 10, Comparisons 01:44–01:46). One trial[69] reported that patient satisfaction scores (details unknown) were slightly lower in the standard incision group than in the mini-incision group, although the difference was not statistically significant.

Similarly, in three comparative studies[36,55,56] the number of patients dissatisfied with the scar appearance of incision was higher in the standard incision group, and one study which performed a statistical test found this to be significant. It is worth noting that one of the studies where no participants rated their scar as 'unacceptable'[55] reported that participants in the mini-incision group were significantly more likely to rate their scar as 'excellent' compared with the standard group (12/20 versus 3/14, $p = 0.026$), despite the fact that more scars in the mini-incision group in the same study were rated 'poor' by plastic surgeons (MI 6/20 scars versus SI 1/14 scars).

Although not shown in the table, one comparative study also reported that over 90% of patients were satisfied with the outcomes irrespective of incision length (<10, 10–14 or >14 cm), with the highest satisfaction in the shortest incision (<10 cm) group, possibly due to less postoperative pain and better cosmetic appearance.[52]

One trial examined scar cosmesis in terms of contraction.[46] The results were similar for both groups.

Two-incision THR versus single mini-incision or standard THR

Clinical performance

Revision rates

Table 29 shows the revision rate after two-incision operations compared with single standard incision or single mini-incision operations. One comparative study which examined this outcome reported no events after 1 year of follow-up.[38] In two case series with 1–1.5 years of follow-up, 0.6% of the participants received a revision surgery following a two-incision surgery (5/851;[27];1/200[37]).

Postoperative dislocation rate

One trial with 30 participants recorded no postoperative dislocations in either the two-incision group or single standard incision group.[57] Two case series with 1–1.5 years of follow-up reported that less than 2% of the participants had postoperative dislocations after a two-incision surgery (8/851;[27] 2/100[37]).

Surrogates for long-term outcomes

Two comparative studies[38,53] provided information on the number of acetabular components (cups) that were poorly placed. There was no significant difference between the two-incision group and the single mini-incision group (8/78 versus 8/78; Appendix 10, Comparison 04:03). In terms of the femoral component (stem), there were no differences between two-incision and single standard incision surgery based on one trial (0/15 versus 0/15)[57] or between two-incision and single

TABLE 28 *Satisfaction*

Study	Measure	Mini-incision		Standard incision		Reported *p*-value
		N	Value (SD) [range]	*N*	Value (SD) [range]	
RCT and quasi-RC						
Charles, 2006[69]	Satisfaction (score)	18	15.222	19	14.579	0.341
Ogonda, 2005[46]	Scar (cm)	107	8.44 (1.02)	108	13.95 (1.26)	
Ogonda, 2005[46]	Scar (mean contraction at 6 weeks as % of total wound length at the end of surgery)	107	11%	108	12%	0.70
Comparative studies						
Dorr, 2007[36]	Not happy with cosmesis (no. of patients)	109	0	56	21	0.000
Woolson, 2004[55] (Mow, 2005)[67]	Opinion of scar 'unacceptable' (no. of patients)	20	0	14	0	0.026
Wright, 2004[56]	Disappointed with appearance of incision (no. of patients)	37	0	37	5	

TABLE 29 *Revision rate (number having revision surgery)*

Study	Two incisions		Single incision		Reported *p*-values
	n/N	%	*n/N*	%	
Two-incision vs single standard incision					
No studies					
Two-incision vs single mini-incision					
Duwelius, 2007[38]	0/43	0	0/43	0	
Two-incision case series					
Archibeck, 2004[27]	5/851				
Duwelius, 2003[37]	1/200				
Subtotal	6/1051	0.6			

mini-incision surgery based on the results from two comparative studies (8/78 versus 7/78; Appendix 10, Comparison 04:04).[38,53]

Two comparative studies (N = 156) reported that there were no incidents of implant migration.[38,53] In one case series, implant migration was reported in two out of 175 (1%) and heterotopic ossification in two out of 80 (2.5%).[37]

Limb length inequality

Only one comparative study provided information on this outcome.[38] There was no significant difference in the proportion of participants who had inequality in limb length in the two-incision group compared with the single mini-incision group (6/39 versus 6/38; Appendix 10, Comparison 04:06).

Safety

Blood loss

One study[57] reported that there was significantly more intraoperative blood loss in the two-incision group than in the single standard incision group (*Table 30*). In two comparative studies comparing two-incision surgery with single mini-incision surgery, one reported significantly less blood loss in the two-incision group,[38] whereas the other reported significantly more blood loss in the two-incision group.[71] A further comparative study examining total blood loss reported that there was significantly more blood loss in the two-incision group compared with the single mini-incision group (699 versus 603 ml, p = 0.02).[53]

Fracture

Two comparative studies reported that there were

TABLE 30 *Blood loss (intraoperative, ml)*

Study	Two incisions		Single incision		Reported *p*-value
	N	**Value (SD) [range]**	***N***	**Value (SD) [range]**	
Two-incision vs single standard incision					
Yan, 2005[57]	15	760 [600–1200]	15	650 [500–800]	<0.05
Two-incision vs single mini-incision					
Duwelius, 2007[38]	43	366 (215)	43	247 (90)	0.001
Greidanus, 2006[71]	66	Less	99	More	<0.05
Two-incision case series					
No studies					

slightly more intraoperative fractures in the two-incision group than in the single mini-incision group based on the data from two comparative studies, but the difference was not statistically significant (5/78 versus 1/78; Appendix 10, Comparison 04:09).[38,53] In terms of postoperative fractures, one trial comparing two-incision with single standard incision surgery reported one case in each group (1/15 versus 1/15),[57] whereas in another study both postoperative fractures were in the two-incision group (2/35 versus 0/35) (Appendix 10, Comparison 04:10).[53]

Two case series also reported on fractures. Intraoperative fractures were reported in 6% of the samples (62/851;[27] 3/180[37]), whereas the proportion of postoperative fractures was less than 1% (2/851;[37] 3/200[27]).

Infections

One study reported that there were no incidents of infections following two-incision or single standard incision surgery (0/15 versus 0/15).[57] Two case series reported infections in 0.8% of the sample (7/851;[37] 1/100[27]).

Nerve injury

One trial reported one case of nerve injury in the two-incision group, compared with none in the single standard incision group (1/15 versus 0/15).[57] Two further studies reported a total of 10 cases of nerve injury in the two-incision group, compared with none in the single mini-incision group (10/78 versus 0/78; Appendix 10, Comparison 04:12).[38,53] All nerve injuries appeared to relate to the lateral cutaneous nerve of the thigh, producing a degree of thigh numbness which could be either temporary or permanent. Two case series reported that 5% of the participants having two-incision surgery had nerve injuries (27/851;[37] 18/75[27]).

Resource utilisation

Duration of operation

Duration of operation was reported by one trial comparing two-incision and single standard incision surgery[57] and two further studies comparing two-incision and single mini-incision surgery[38,79] (*Table 31*). Across all these studies the results were consistently less favourable (longer operation time) for the two-incision group and three studies found this to be statistically significant. Two case series (including one multi-centre study) also provided information on operation time, as shown in *Table 31*.

Length of hospital stay

Length of hospital stay was reported in one trial comparing two-incision and single standard incision surgery[57] and another three studies comparing two-incision and single mini-incision surgery[38,71,79] (*Table 32*). All studies reported shorter hospital stay for the two-incision group regardless of the comparator and in three studies this was found to be statistically significant. Although not shown in the table, in one multi-centre case series study where participants were managed with an accelerated critical pathway after having two-incision surgery, 69% (249/363) were discharged home within 24 hours after surgery.[37]

Patient-centred measures

Pain

Three studies comparing two-incision and single mini-incision surgery provided information on postoperative pain using various measures. One trial with 72 participants reported that time to discontinue narcotics was shorter for the two-incision group (details not available).[73] The second study with 165 participants reported that narcotic use was significantly less for the two-incision group ($p < 0.05$; no further details available).[71] However, the third study reported

TABLE 31 *Duration of operation (minutes)*

Study	Two incisions		Single incision		Reported *p*-value
	N	**Value (SD) [range]**	***N***	**Value (SD) [range]**	
Two-incision vs single standard incision					
Yan, 2005[57]	15	100 [90–220]	15	80 [60–150]	<0.05
Two-incision vs single mini-incision					
Duwelius, 2007[38]	43	93.7 (90)	43	61.7 (60)	0.002
Tanavalee, 2006[53]	35	168 [130–210]	35	113 [90–140]	<0.01
Yoon, 2005[79]	118	72 [50–115]	100	52 [35–75]	NR
Two-incision case series					
Archibeck, 2004[27]	851	148			
Duwelius, 2003[37] – C1	100	90			
Duwelius, 2003[37] – C2	100	62			
Duwelius, 2003[37] – C3a	12	150			
Duwelius, 2003[37] – C3b	88	101			
Duwelius, 2003[37] – C4	75	85			

C, study centre; NR, not reported.

TABLE 32 *Length of hospital stay (days)*

Study	Two incisions		Single incision		Reported *p*-value
	N	**Value (SD) [range]**	***N***	**Value (SD) [range]**	
Two-incision vs single standard incision					
Yan, 2005[57]	15	6	15	13	<0.001
Two-incision vs single mini-incision					
Duwelius, 2007[38]	43	1.25 [0.5–2.3]	43	1.9 [0.5–4.3]	<0.001
Greidanus, 2006[71]	66	Shorter	99	longer	<0.05
Yoon, 2005[79]	118	Shorter	100	longer	NR
Two-incision case series					
No studies					

NR, not reported.

that the number of patients using a prescription anti-inflammatory drug was significantly higher in the two-incision group (20/43 versus 10/43, $p = 0.04$).[38] The same study also reported that WOMAC pain scores were lower for the two-incision group compared with the single mini-incision group 6 weeks after operation (2 versus 2.5, from graph) but were the same between groups 1 year after operation (1.6 versus 1.6, from graph).[38]

Return to usual activities

Four studies comparing two-incision with single mini-incision surgery provided information on patients' return to usual activities (functional recovery) after surgery using various measures. One trial with 72 participants reported that time to return to normal activities and time to discontinue ambulatory aids were both longer for the two-incision group (details not available).[73] A comparative study with 52 participants reported that there were no significant differences between the groups in the duration of ambulatory aids use [28 (7–56) days versus 27 (5–49) days, $p = 0.75$] or time to return to driving [32 (8–49) versus 34 (20–56), $p = 0.38$].[47] However, another study with 86 participants reported that the two-incision group was significantly better in terms of time to resume driving [13 (2–31) days versus 24 (6–32) days, $p = 0.04$] or time to resume shopping [14 (3–24) days versus 26 (6–37) days, $p = 0.01$].[38] The fourth trial with 20 participants measured outcome at 1 year and reported that there was no significant difference between the groups in the results of gait analysis performed 1 year after surgery (details not available).[72]

TABLE 33 *Harris hip score*

Study	Two incisions		Single incision		Reported *p*-value
	N	**Value (SD)**	***N***	**Value (SD)**	
Short-term (⩽3 months)					
Two-incision vs single standard incision					
Yan, 2005[57]	15	89	15	86	<0.05
Two-incision vs single mini-incision					
Duwelius, 2007[38]	43	89	43	88	From graph
Two-incision case series					
No studies					
Long-term (>3 months)					
Two-incision vs single standard incision					
Yan, 2005[57]	15	93	15	93	>0.05
Two-incision vs single standard incision					
Duwelius, 2007[38]	43	94	43	88	From graph
Tanavalee, 2006[53]	35	94.5 (4.7)	35	94.6 (4.5)	0.95
Two-incision case series					
Duwelius, 2003[37]	100	90			

Condition-specific quality of life

Table 33 shows results from studies reporting on the Harris hip score. In terms of the short-term (⩽3 months) results, one study reported significantly higher scores (better health) for the two-incision group compared with the single standard incision group.[57] In another study, scores in the two-incision group were also better than in the single mini-incision group, although the difference appears to be relatively small.

In terms of the Harris hip scores over the longer terms (>3 months) (*Table 33*), the two-incision group did not differ from the single standard incision surgery[57] or single mini-incision surgery,[53] whereas in one study the two-incision group appeared to be better than the single mini-incision group.[38]

General quality of life

Only one study with 86 participants measured general quality of life.[38] This study used the SF-36 physical function and reported that the score in the two-incision group was higher than that in the single mini-incision group 6 weeks postoperation (80 versus 70, estimated from a graph within the study report), although slightly lower at 1 year after operation (80 versus 85, estimated from a graph within the study report).

Patient satisfaction

One comparative study carried out a self-administered questionnaire survey to ascertain perceptions of 26 patients who underwent staged bilateral THRs with two-incision THR on one hip and single mini-incision THR (posterior) on the other hip.[47] At a minimum of 6 months after the second operation, 62% (16/26) of the patients preferred the single mini-incision approach to the two-incision approach with their reasons being a better early recovery (8/16 participants), better cosmetic results (4/16) or both (4/16). Eight patients preferred the two-incision approach because of a better early recovery. None preferred the cosmetic appearance of two-incision THR, as they were not satisfied with the presence of the anterior incision, which was clearly visible during simple daily activities such as bathing and changing clothes.

Important subgroup differences for minimal incision versus standard techniques

One trial reported subgroup analysis for grossly obese patients and muscular male patients, for whom a mini-incision was thought to be more difficult.[46] The mean operative time was 7.5 minutes longer for patients with a BMI of >35 (69.5 ± 11.2 minutes) than that for patients with a BMI of <30 (62.0 ± 11.3 minutes). The difference was statistically significant ($p < 0.001$), irrespective of the incision length. For the muscular male patients with a mid-thigh circumference of >55 cm, the mean operative time (61.4 ± 11.0 minutes) was not found to be significantly different from that for the less

muscular male patients (66.9 ± 13.2 minutes) ($p = 0.17$). Caution is required, however, as the number of patients was small.

One case series of the two-incision procedure also reported that the incidence of key complications (fractures, nerve deficits and dislocations) was nearly two times higher for patients with a BMI of ⩾30 (16.3%) than that for patients with a BMI of <30 (8.3%) ($p = 0.05$).[27]

The same case series of the two-incision procedure examined the possible effect of surgeon experience on operative time, blood loss and the prevalence of key complications.[27] This study was a prospective survey of trainee surgeons who attended corporate-sponsored training on the two-incision THR. Results from 851 procedures performed by 159 surgeons following training show that the mean operative time was significantly decreased, as the surgeons progressed from their first case (168 ± 49.6 minutes) to their tenth case (130 ± 47.1 minutes) ($p < 0.05$). Blood loss also decreased non-significantly from the first (547 ± 377 ml) to tenth (427 ± 260 ml) cases ($p > 0.05$). No significant relationship was found between complication rates and surgeon experience. Nevertheless, the prevalence of complications was significantly higher for surgeons who reported performing less than 50 operations per year (26.5%), compared with surgeons performing 50 or more operations per year (7.1% for surgeons performing 50–100, 8.6% for surgeons performing 100–150 and 7.1% for surgeons performing over 150 operations, $p = 0.0003$).

Summary and conclusions of the evidence for and against the intervention

Despite the number of studies identified, there was little evidence of any longer term differences between incision length. This is primarily due to the lack of data available. Surrogates for longer term outcomes also did not provide sufficient information with which to make judgements about longer term performance.

Overall, it appears likely that the mini-incision approach offers some perioperative advantages in terms of less blood loss and shorter operative time, although these may be of limited practical significance. The mini-incision approach may also offer a shorter recovery period as identified by the shorter length of hospital stay and time to return to usual activities. This quicker recovery is a key issue in the economic evaluation, the methods of which are discussed in Chapter 5, where the impact of this earlier recovery is measured using QALYs. Patients also appear to be more satisfied with the operation and the appearance of the scar (although this latter finding may be more influenced by the scar's location than its size). As indicated above, limited data are available for other outcomes and the level of uncertainty is such that clinically important differences may exist favouring either treatment. Nevertheless, until new data become available, it may be sensible to assume that the two methods are comparable. A summary of the effect sizes based on meta-analyses of trial data is given in *Table 34*.

With respect to the two-incision procedure, it is not possible to draw firm conclusions due to the small number of studies identified from our searches and also the poor quality of the data reported. At best, the data suggest that the two-incision procedure may offer a possible short-term benefit in terms of earlier discharge from hospital and better quality of life (Harris hip score) (*Table 35*). Although there were more cases of nerve injuries with the two-incision operation, the CIs were wide and did not rule out clinically important differences that could favour either two-incision or single incision procedures. It is also worth noting that blood loss and operation time tended to favour single incision rather than two-incision surgery. As is the case for single mini-incision THR, any observed differences in operation duration following the two-incision procedure, compared with standard THR, are not likely to be large and may be of limited practical significance. For longer term outcomes, there was no discernible difference by the type of surgical procedures within the available data.

TABLE 34 *Summary of the effect size from meta-analysis of the trial data for single mini-incision THR versus standard THR*

Outcome (WMD and Peto OR based on trials) [95% CI]	No. of trials (No. of comparative studies)
Favours mini-incision	
Blood loss[a]	
WMD –56.59 [–71.63 to –41.55], $p < 0.00001$	7 (11)
Duration of operation[a]	
WMD –3.70 [–5.67 to –1.74], $p = 0.0002$	9 (15)
Length of hospital stay[a]	
WMD –0.50 [–0.83 to –0.18], $p = 0.002$	6 (12)
Return to usual activities after operation	
Time to return to normal activities: no trial data	0 (1)
Use of walking aids (days): WMD –3.40 [–5.23 to –1.57], $p = 0.0003$	1 (0)
Use of walking aids (*N* of patients): Peto OR 0.55 [0.20 to 1.53], $p = 0.25$	1 (1)
Limp: Peto OR 0.31 [0.11 to 0.91], $p = 0.03$	1 (1)
Patient satisfaction	
WMD not estimable	1 (3)
No evidence of a difference or insufficient information	
Revision rates	
Peto OR 7.96 [0.16 to 402.02], $p = 0.30$	3 (6)
Postoperative dislocation rates	
Peto OR 1.72 [0.43 to 6.92], $p = 0.45$	6 (11)
Surrogates for long-term outcomes	
Implant position (cup): Peto OR 0.93 [0.50 to 1.74], $p = 0.83$	3 (6)
Implant position (stem): Peto OR 0.70 [0.35 to 1.40], $p = 0.31$	5 (9)
Implant migration: Peto OR not estimable	1 (1)
Heterotopic ossification: no trial data	0 (2)
Cement quality: Peto OR 1.26 [0.70 to 2.27], $p = 0.45$	3 (4)
Limb length inequality (number of patients with unequal length)	
No trial data	0 (1)
Intraoperative fractures	
Peto OR 0.14 [0.01 to 2.18], $p = 0.16$	2 (3)
Postoperative fractures	
Peto OR not estimable	2 (3)
Infections	
Peto OR 7.48 [0.78 to 72.16], $p = 0.08$	7 (9)
Nerve injury	
Peto OR 1.95 [0.20 to 18.89], $p = 0.56$	6 (9)
Vascular injuries	
Peto OR not estimable	1 (0)
DVT	
Peto OR 0.39 [0.12 to 1.30], $p = 0.12$	5 (6)
Pulmonary embolism	
Peto OR not estimable	1 (2)
30-day mortality	
Peto OR 0.14 [0.01 to 2.18], $p = 0.16$	1 (2)
Long-term mortality	
Peto OR 0.15 [0.01 to 2.45], $p = 0.18$	1 (2)
Analgesic use	
Narcotic (days): WMD not estimable	1 (0)
Patient-controlled anaesthesia (mg): WMD –4.41 [–29.18 to 20.36], $p = 0.73$	3 (0)
Total narcotic received (mg): no trial data	0 (3)

continued

TABLE 34 *Summary of the effect size from meta-analysis of the trial data for single mini-incision THR versus standard THR (cont'd)*

Outcome (WMD and Peto OR based on trials) [95% CI]	No. of trials (No. of comparative studies)
Short-term pain	
Pain (no. of patients): no trial data	0 (3)
Pain score: WMD –0.06 [–0.56 to 0.44],$p = 0.81$	4 (2)
Long-term pain	
Pain score: WMD not estimable	1 (0)
Long-term difference in usual activities	
Limp: Peto OR not estimable	1 (0)
Short-term condition-specific quality of life	
Harris hip score[a]: WMD –1.25 [–3.75 to 1.24], $p = 0.33$	2 (3)
WOMAC: WMD 0.45 [–3.13 to 4.03], $p = 0.81$	2 (0)
Oxford hip score: WMD –0.91 [–2.74 to 0.92], $p = 0.33$	1 (1)
Merle d'Aubigné–Charnley score: WMD not estimable	1 (0)
Long-term condition-specific quality of life	
Harris hip score[a]: WMD 0.35 [–0.13 to 0.83], $p = 0.15$	4 (6)
Merle d'Aubigné-Charnley score: WMD not estimable	1 (0)
Short-term general quality of life	
SF-12 physical component: WMD –0.75 [–3.38 to 1.88], $p = 0.58$	1 (0)
SF-12 mental component: WMD 0.50 [–2.39 to 3.39], $p = 0.73$	1 (0)
SF-36 physical function WMD: not estimable	1 (0)
Long-term general quality of life	
SF-36 physical function: no trial data	0 (1)
SF-36 mental function: no trial data	0 (1)
Favours standard incision	
No outcomes	

[a] Based on published data supplemented with calculated standard deviations. All other values (WMD and Peto OR) are based on published data.

TABLE 35 *Summary of evidence for two-incisions THR versus single mini-incision or standard THR*

Outcome	No. of studies
Favours two incisions	
Length of hospital stay	
2MI vs SI: 1 favours two incisions (significant difference)	1
2MI vs MI: 3 favour two incisions (2 significant difference)	3
Short-term condition-specific quality of life (Harris hip score)	
2MI vs SI: 1 favours two incisions (significant difference)	1
2MI vs MI: 1 favours two incisions (no significant difference)	1
No evidence of a difference or insufficient information	
Revision rates	
2MI vs SI: no studies	1
2MI vs MI: no events	1
Postoperative dislocation rates	
2MI vs SI: no events	1
2MI vs MI: no studies	0
Surrogates for long-term outcomes	
Implant position (cup):	
2MI vs SI: no studies	0
2MI vs MI: 8/78 cases vs 8/78 cases	2

continued

TABLE 35 *Summary of evidence for two incisions THR versus single mini-incision or standard THR (cont'd)*

Outcome	No. of studies
Implant position (stem):	
2MI vs SI: no events	1
2MI vs MI: 8/78 cases vs 7/78 cases	2
Implant migration:	
2MI vs SI: no studies	0
2MI vs MI: no events	2
Limb length inequality	
2MI vs SI: no studies	0
2MI vs MI: 6/39 cases vs 6/38 cases	1
Intraoperative fractures	
2MI vs SI: no studies	0
2MI vs MI: 5/78 cases vs 1/78 cases	2
Postoperative fractures	
2MI vs SI: 1/15 cases vs 1/15 cases	1
2MI vs MI: 2/35 cases vs 0/35 cases	1
Infections	
2MI vs SI: no events	1
2MI vs MI: no studies	0
Short-term pain	
Narcotics use:	
2MI vs SI, no studies	0
2MI vs MI: 2 favour 2MI (1 significant difference), 1 favours MI (significant difference)	3
Pain score:	
2MI vs SI, no studies	0
2MI vs MI, 1 favours two incisions (no significant difference)	1
Long-term pain (pain score)	
2MI vs SI: no studies	0
2MI vs MI: no significant difference	1
Return to usual activities after operation (various measures)	
2MI vs SI: no studies	0
2MI vs MI: 1 favours 2MI (significant difference), 1 favours SI (no significant difference), 1 no difference	3
Long-term difference in usual activities (gait analysis)	
2MI vs SI: no studies	0
2MI vs MI: no significant difference	1
Long-term condition specific quality of life (Harris hip score)	
2MI vs SI: no significant difference	1
2MI vs MI: no significant difference	2
Short-term general quality of life (SF-36)	
2MI vs SI: no studies	0
2MI vs MI: 1 favours 2MI (no significant difference)	1
Long-term general quality of life (SF-36)	
2MI vs SI: no studies	0
2MI vs MI: 1 favours MI (no significant difference)	1
Favours single incision	
Blood loss	
2MI vs SI: 1 favours SI (significant difference)	1
2MI vs MI: 1 favours 2MI (significant difference); 1 favours MI (significant difference)	2
Nerve injury	
2MI vs SI: 1/15 cases vs 0/15 cases	1
2MI vs MI: 10/78 cases vs 0/78 cases	2
Duration of operation	
2MI vs SI: 1 favours SI (significant difference)	1
2MI vs MI: 3 favour MI (2 significant difference)	3

Chapter 4

Systematic review of economic evaluations

Methods

Search strategies

Studies that reported both costs and outcomes of single mini-incision and/or two mini-incision techniques compared with standard THR surgery for the treatment of arthritis of the hip were sought from a systematic review of the literature. No language restrictions to searches were imposed.

Databases searched were MEDLINE (1996–February Week 3 2007), EMBASE (1980–Week 8 2007), MEDLINE In-Process (1 March 2007), Science Citation Index (1985–2 March 2007), NHS Economic Evaluation Database (NHS EED) (December 2006), HTA Database (December 2006) and Health Management Information Consortium (1979–March 2006). In addition, recent conference proceedings and reference lists of all included studies were scanned to identify additional potentially relevant studies. Other sources of information consulted included references in relevant articles and selected experts in the field. Full details of the search strategies used are documented in Appendix 1.

Inclusion and exclusion criteria

To be included, studies had to compare, in terms of both costs and outcomes, strategies involving single and/or two mini-incision surgical techniques with standard THR for the treatment of arthritis of the hip. Studies were included even if they made no formal attempt to relate cost to outcome data in a cost-effectiveness or cost–utility analysis. One reviewer assessed all abstracts for relevance and full papers were obtained for those that appeared potentially relevant.

Data extraction strategy

The following data were extracted for each included primary study using the framework provided for abstracts prepared for the NHS EED:[81]

1. *Study identification information*
   (a) Author and year.
   (b) The interventions studied.
   (c) The type of economic evaluation.
   (d) The country of origin and currency reported.
2. *The intervention, study design and main outcomes*
   (a) Fuller description of treatment.
   (b) Numbers receiving or randomised to each intervention.
   (c) Outcomes studied.
3. *Sources of data*
   (a) Effectiveness data.
   (b) Mortality and co-morbidity (if measured).
   (c) Cost data.
   (d) Quality of life (if measured).
4. *Methods and study perspective*
5. *Results*
   (a) Costs.
   (b) Benefits.
   (c) Incremental cost-effectiveness ratio (ICER)/cost–utility.
   (d) Sensitivity analyses.
6. *Additional comments relating to the design and reporting of the economic evaluation*
   For reviews of economic evaluations, data were extracted on the nature of the review methodology used, the inclusion criteria for studies, the number of studies identified, the method of quality assessment for individual economic evaluations and the conclusions drawn on the relative efficiency of the alternative methods.

Quality assessment strategy

One economist assessed included studies using the NHS EED guidelines for reviewers.[81]

Data synthesis

No attempt was made to synthesise quantitatively the primary studies that were identified. Data from all included studies were instead summarised and appraised in order to identify common results, variations and weaknesses between studies.

Results

Number of studies identified

The results of the literature search are presented in *Table 36*. The number of reports retrieved from the search in the Science Citation Index is the total after deduplication against the results of the MEDLINE/EMBASE multi-file search.

TABLE 36 *Results of searching for studies on cost-effectiveness*

Database	Hits screened	Selected for full assessment
MEDLINE/EMBASE/MEDLINE In-Process multi-file search (after deduplication in Ovid)	56	16
SCI	12	1
NHS NEED	5	5
HTA database	35	1
HMIC	10	0
Selected from conference abstracts	0	0
Total	**118**	**23**

Twenty-three papers were selected from the searches, four of which were assessed for the systematic review. The remaining 19 papers were selected for background information or for possible utilities data. Of the four studies, one[82] met the inclusion criteria. One additional unpublished paper was obtained from a manufacturer of hip prostheses (Duwelius and colleagues, Providence St Vincent Medical Center, Portland, OR, 2006) (henceforth Duwelius, 2006). Reasons for exclusion of the remaining three were that one contained no cost information,[62] in the second the procedures followed a care pathway dissimilar to usual care in the UK NHS (standard THR was treated as an inpatient procedure, whereas minimal incision THR was an outpatient procedure)[83] and the final study compared standard THR with a 'do nothing' approach and not a minimal incision THR technique.[84]

Study identification and key elements

Comparators, type of study, dates for collection and prospective study from sample

The unpublished paper by Duwelius and colleagues compared single mini-incision and two mini-incision THR with standard THR on a group of non-randomised patients in the USA. The study by Straumann and colleagues, set in Switzerland, used a model based analysis to assess consequences to Switzerland of MIS THR compared with standard THR at the aggregate level. For the Swiss study, MIS THR was assumed to include both the single mini-incision and two mini-incision surgical techniques.[82]

The unpublished study was classified as a cost–utility analysis, that is, when the consequences of programmes are adjusted by generic health state preference scores to allow the QALYs gained to be assessed as opposed to the crude number of years.[85] The Swiss study was classified as a modelling study with a retrospective costing exercise of standard THR. Effectiveness data and cost difference between standard and MIS THR were based on the unpublished US study by Duwelius and colleagues. Both papers took a societal perspective, that is, in addition to hospital and community costs they both took into account the cost of productivity losses. The characteristics of the included studies are presented in *Table 37*.

The unpublished US study collected effectiveness data prospectively over the period from 2002 to 2005. The costing was undertaken retrospectively on the same sample as that used for the effectiveness study (Duwelius, 2006). In relation to the Swiss study, the baseline costs were estimated for the year 2003.

TABLE 37 *Characteristics of the included studies*

Study	Design	Sample	Follow-up	Perspective
Duwelius, 2006 (unpublished) (USA)	Multi-centre prospective non-randomised, unmatched cohort study	Two-incision THR: 235 Mini-incision THR: 325 Standard THR: 31	6 weeks	Societal
Straumann, 2006[82] (Switzerland)	Modelling with retrospective costing exercise of standard THR	13,101 primary THRs performed in Switzerland in 2003	NA	Societal

NA, not applicable.

Patient group, study sample and study design

The sample size of the US study was 591 patients, although patients were not distributed equally between the three interventions: 235 patients were treated using the two mini-incision technique, 325 using the single mini-incision technique and 31 using standard THR. The study was a multi-centre unmatched cohort study. Fourteen surgeons at 10 hospitals provided data on the 591 patients. It appears that no eligibility criteria were specified and patients were recruited to each intervention based on surgeon preference. As a consequence, significantly different ($p \leq 0.05$) demographic characteristics between groups at time of operation were identified. That is, a trend in patient selection tending towards younger and healthier patients was apparent for the two mini-incision and single mini-incision techniques (Duwelius, 2006). Patients were followed up for a maximum of 6 weeks.

In terms of patient groups and study sample, the paper by Straumann and colleagues is difficult to quantify.[82] This study was a simple model-based analysis which utilised a retrospective costing exercise of standard THR. It is assumed, from published literature, that 13,101 primary THR operations were performed in Switzerland in 2003. The average hospital cost of a primary THR was estimated from a single hospital in Zurich. From the total number of primary THRs performed, it was assumed that, potentially, 30% (conservative) or up to 50% (optimistic) of these might have been performed as an MIS technique. Therefore, the costs (and potential cost savings) of the MIS techniques were calculated at the aggregate level, for rates of 30 and 50%, by multiplying the cost difference in percentage terms between standard and MIS THR from the unpublished US study with the cost of standard THR (Duwelius, 2006).

The main clinical outcome measures for the included studies are presented in *Table 38*.

Methods of economic analysis

Both papers provided details on which items were included in cost calculations, although no unit cost data were presented for either. What is not clear is whether a consistent base-year has been applied to all costs (Duwelius, 2006). Indirect costs were calculated for both studies using the human capital approach (time off paid work). In terms of summary measures of health benefits, none were presented for the study by Straumann and colleagues, which assumed that outcomes were equal,[82] whereas the unpublished US paper presented QALYs as its main measure of health benefit (Duwelius, 2006).

Two-way sensitivity analysis was performed in the paper by Duwelius and colleagues for all costs and utility values. Further, community costs such as the cost of an inpatient rehabilitations facility, skilled nursing facility, home health care, home only (no rehabilitation) and physician costs were all varied by +30% and –30% of the base-case values. Wages and hospital cost-to-charge ratios were also varied by +10% or –10% of base-case values. Inflation rates were varied by +5% to –5% of base-case values to see what effect this might have on results (Duwelius, 2006). The only sensitivity analysis performed in relation to the Swiss paper was changes to the indication rate of minimally invasive techniques from 30% (assumed to be conservative) to 50% (optimistic).[82]

Results

The results of the included studies are shown in *Table 39*. In the unpublished US study by Duwelius and colleagues, total costs including productivity costs were lowest for the two mini-incision technique and highest for the standard technique (two mini-incision, $16,085; single mini-incision, $16,615; and standard incision, $21,705) (Duwelius, 2006). When the total cost was broken down into hospital costs, rehabilitation costs and indirect costs, the cost for the two mini-incision and single mini-incision techniques were consistently lower than standard THR with two

TABLE 38 *Outcome measures used in the included studies*

Study	End-points
Duwelius, 2006 (unpublished) (USA)	Time to walking without support (WWOS) Psychometric health status (SF-36) Postoperative recovery (approximated by WWOS, Harris hip score and health-related quality of life) Various complications
Straumann, 2006[82]	None specified (assumed equal)

mini-incision remaining the least costly option. It is unclear whether the differences in costs were tested for significance and no CIs were reported. In terms of benefits, 6-week QALYs were calculated for the three interventions and the reported incremental effectiveness of the two mini-incision and single mini-incision techniques compared with standard incision were 0.037 and 0.023 QALYs gained respectively. The authors reported that the same patterns of outcomes and costs were observed after varying input parameters to test the sensitivity of the base-case assumptions.

No measure of health benefit was included in the study by Straumann and colleagues.[82] Average hospital costs per patient were higher for standard THR compared with MIS THR (€13,511 versus €11,534.40 per patient). At the aggregate level, it was assumed that by employing MIS in place of standard THR for 30 or 50% of cases, hospital and rehabilitation costs would reduce dramatically and that many millions of euros would be saved over the 1-year time horizon. In terms of indirect costs, it was assumed that 36 fewer work days were lost per employed patient with MIS THR as opposed to standard THR. From this, it was estimated that the effective reduction of productivity losses ranged between €23.8 million and €39.7 million.

Summary of results and discussion

The two studies that met the inclusion criteria of the review of economics estimated that MIS THR (including both single and double mini-incision) is likely to be less costly than standard THR. This is due to the fact that the unpublished US study found that length of stay was statistically significantly shorter for the MIS procedures ($p \leq 0.05$). The study also found that the need for community rehabilitation was also reduced for the MIS procedures in comparison to standard THR.

TABLE 39 *Cost and outcome data reported in the included studies*[a]

Study	Finding	Two mini-incision	Single mini-incision	Standard
Duwelius, 2006 (unpublished) (USA)	Total cost	$16,085 [£8,042.50]	$16,615 [£8,307.50]	$21,705 [£10,852.50]
Price year 2003	Total costs, excluding productivity losses	$14,651 [£7,325.50]	$14,825 [£7,412.50]	$19,451 [£9,725.50]
	6-week QALYs	0.053	0.039	0.016
		MIS (both single and two mini-incision)		
Straumann, 2006[82] Switzerland	Total cost per patient	€13,511 [£9,187.48]		€11,534.40 [£7,843.39]
Price year not stated	Aggregate hospital cost *savings* assuming 30% MIS indication rate	€7.8 million saving [£5.3 million saving]		NA
	Aggregate hospital cost *savings* assuming 50% MIS indication rate	€12.9 million saving [£8.8 million saving]		NA
	Aggregate community cost *savings* assuming 50% MIS indication rate	€10.9 million saving [£7.4 million saving] for two mini-incision and €10.1 million saving [£6.9 million saving] for single mini-incision		NA
	Aggregate community cost *savings* assuming 50% MIS indication rate	€18.1 million saving [£12.3 million saving] for and two mini-incision and €16.9 million saving [£11.5 million saving] for single mini-incision		NA
	Aggregate indirect cost *savings* assuming 30% MIS indication rate	€23.8 million saving [£16.2 million saving]		NA
	Aggregate indirect cost *savings* assuming 50% MIS indication rate	€39.7 million saving [£27 million saving]		NA

NA, not applicable.
[a] Figures in brackets are conversions in UK £ sterling using rates of US$1 ≈ £0.5 and €1 ≈ £0.68.

Furthermore, it was reported that short-term outcomes were improved for the MIS techniques in comparison with standard THR, although differences in 6-week QALYs were not statistically significant (Duwelius, 2006). It should be noted that a statistically significant difference in terms of case mix between the groups in the unpublished US study was found, that is, a trend in patient selection saw younger and healthier patients being selected for the two mini-incision and single mini-incision approaches compared with standard THR. The authors attempted to compensate for this bias by using propensity scoring (Duwelius, 2006). As the relative differences in costs and effects were taken from the unpublished US paper (Duwelius, 2006) and applied to Swiss data in the study by Straumann and colleagues,[82] it is unsurprising that the same conclusions in terms of costs were found. Both studies concluded that the adoption of MIS techniques in the field of THR would likely reduce healthcare costs and provide better short-term outcomes.

There are numerous issues that should be taken into account when interpreting the results of the two described studies, which are, at best, contentious. In relation to the unpublished US study, the single most important limitation related to the case mix of patients recruited to the three surgical approaches. Patients were non-randomised and unmatched and, as a result, all reductions in necessity for postoperative care and improved outcomes are likely to be affected by the fact that younger and healthier people were consistently selected to receive the MIS techniques. As a result, the fact that these patients were discharged from hospital sooner, were less likely to use rehabilitation facilities in the community and had higher quality of life in terms of QALYs gained is what one might have expected if the same patient group were treated using the standard method. The authors used propensity scoring when calculating health-related quality of life to counteract the potential biases that might arise from differences in case mix, although it is unclear if this approach would have corrected possible selection biases. Further limitations of this study related to the costing method. A retrospective costing exercise took place which estimated surgeon costs from the Medicare unadjusted national average rates for primary THR, hospital costs from charge data converted to costs using a hospital cost-to-charge ratio and rehabilitation costs from inpatient hospital discharge and Medicare reimbursement schedules. Bearing in mind the methods used to collect cost data, it is unknown whether such costs would be appropriate to the UK and, indeed, to THR surgery, as charges were converted using hospital-level cost-to-charge ratios. Furthermore, no attempt was made to correct for possible selection biases and it is unclear whether a consistent base year was applied to all costs as is usual good practice when conducting an economic evaluation.

In relation to the paper by Straumann and colleagues,[82] little useful information is presented and this study is not a typical costing exercise. The paper assumes equal effectiveness in terms of outcomes and only considers the potential cost savings from the introduction of minimally invasive techniques. By applying the definitive cost difference between minimally invasive THR and standard THR to the average cost of a standard THR in Switzerland, the authors are making several extremely strong assumptions. First, the authors assume that data from the unpublished US study are valid, even for the US, and that MIS THR is likely to have equal or better outcomes than standard THR. The authors also assume that US data are likely to be applicable to Switzerland, despite the vast difference in standard surgical practice across healthcare systems.

Conclusions

This chapter presents the overall evidence available on the cost-effectiveness of single mini-incision and two mini-incision THR compared with standard THR in the treatment of arthritis of the hip, based on a systematic review of the literature. The two cost studies that met the inclusion criteria for the review of economic evaluations add little, if any, value to the current evidence base. Although results claim that MIS techniques are likely to be cost saving and provide better outcomes in the immediate postoperative period, the strong assumptions made by the authors of the two included studies have probably produced biased, unreliable results with limited applicability to the UK. The conclusions drawn within the two studies are very strong given their limitations in quality. The measurement and inclusion of such costs (indirect costs) in an economic evaluation, however, are contentious. A well-designed UK-based economic evaluation with long-term follow-up of costs and outcomes is warranted to answer questions over the potential cost-effectiveness of single and two mini-incision THR in the NHS (even after we consider the addition to the evidence base of the economic evaluation conducted as part of this report).

Chapter 5

Economic evaluation

Economic model

In this chapter, the data available on costs and effects are combined in an economic model to estimate the cost-effectiveness of minimal incision THR compared with standard THR for the treatment of arthritic disease of the hip. The results should be treated with caution, as the model is constrained by the paucity of data available for estimating some model parameters. It was not possible to include the two mini-incision technique in the model analysis owing to the limited and poor-quality data available. Conceivably, expert opinion might have been used to provide some estimates of the necessary parameters to guide an economic analysis of the two incision method. This approach was not adopted, however, as it is believed that the two mini-incision technique has fallen out of favour within the orthopaedic community (Hutchison JD, Department of Surgery, University of Aberdeen and Munro N, NHS Grampian: personal communication, April 2007).

The economic evaluation was conducted using a Markov Model (constructed in TreeAge Pro 2007). The model estimated the short-term (1-year) long-term costs and benefits of a cohort of typical patients for the different surgical procedures. The long-term model followed a cohort of patients from their initial operation through their convalescence (operation state) to their return to usual activities (defined in the model as a 'Successful THR state'). The patients may remain in this state until they die or they suffer a complication and therefore have a revision operation or some other form of long-term patient management if surgery is no longer considered a viable option. Conceptually, the patients could move between states within the model until they all eventually die. For the purposes of the analysis, however, the cohort of patients was modelled for a maximum of 40 years following the initial operation, which represents the maximum survival for the majority of the patients. An illustrative representation of the Markov model can be seen in *Figure 12*. Deterministic sensitivity analysis to explore changes in parameter values or threshold values was conducted. Many of these deterministic analyses were combined with partial probabilistic sensitivity analyses where many, but not all, parameters within the model were described by a

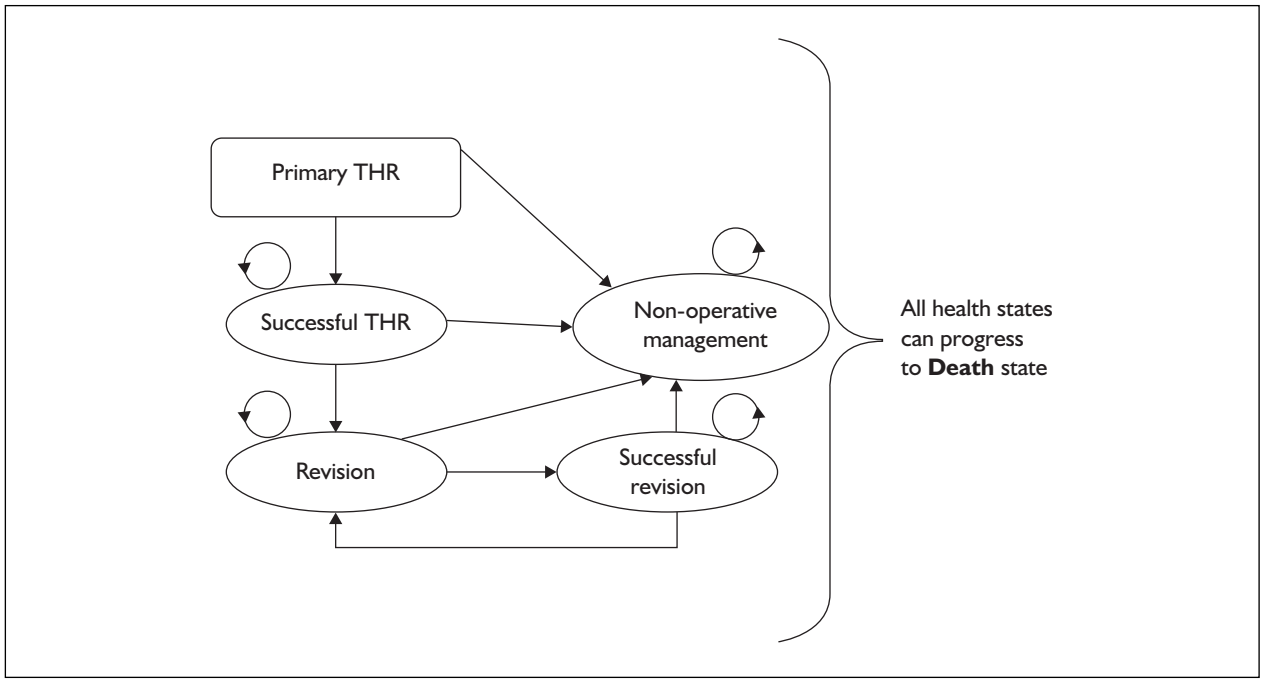

FIGURE 12 *Markov model for standard and mini-incision THR*

probability distribution. The methods used to assign these distributions are described below. Where no distribution was attached to a parameter, this was because the estimates were relatively precise or a standard value was used or insufficient information was available to estimate a distribution.

Following their initial surgery, patients could move into one of following states:

- Successful THR state.
- Revision state: where a patient has revision surgery.
- Successful THR revision state: where patients following a successful revision operation remain until they die or have further complications warranting surgery and/or non-operative management.
- Non-operative management state: resulting in long-term non-operative management of the disease, as surgery is no longer a viable option.
- Death.

A cost per patient for each health state in the Markov model was calculated using the methods outlined below. The main cost components in the model are the initial operative procedure and the costs of any subsequent revision operation or long-term non-operative management. It was assumed that if a patient suffered a complication requiring a revision procedure, the patient would be operated on using standard THR regardless of the method of THR they originally received. Death is the only state within the model that a patient cannot leave (i.e. it is an absorbing state). As all orthopaedic surgical procedures carry some risk of complications, the costs of postoperative complications were included where it was felt likely that the impact on quality of life or costs would be substantial.

The cycle length (the minimum period between transitions) of the model was set at 1 year, and the model was run for a maximum of 40 cycles although analyses using a 1-year time horizon are also presented as a base case as the most reliable data related to this period. For the base-case analysis, it is only the costs and consequences that patients incur in the first cycle of the model that were estimated. An outline of the tree structure is shown in Appendix 13. It was assumed that the starting age for the model cohort is 68 years based on the mean age of patients undergoing primary THR from the National Joint Registry for England and Wales.[3]

Estimation of model parameters

Baseline parameters

All baseline parameter values are given in *Table 40* and their source and methods used to derive them are described below. Although many analyses were conducted for a 1-year time horizon, it is necessary to explain the methods used in relation to those analyses where a 40-year time horizon was considered. For the remainder of this section, therefore, all model inputs for both the 1- and 40-year analysis are described. Where quantitative synthesis was possible, the outputs of the systematic review of effectiveness (Chapter 3) were

TABLE 40 *Baseline parameter values used in the model*

Baseline parameter	Value	Distribution	Values of distribution
Transition probabilities			
Operative mortality	0.0091	Log-normal	95% CI 0.0055 to 0.0142
All-cause mortality	See sex and age-adjusted UK life table in Appendix 13		
Revision rate	See 24-year risk of revision in *Table 41*		
Rate of non-operative management following failed THR	0		
Other probabilities			
Re-operation rate for dislocation	0.01	No distribution	
Re-operation rate for deep infection (risk only included for first 5 years postoperation)	0.011	No distribution	
DVT rate	0.0189	Normal	95% CI 0.0111 to 0.0276
PE rate	0.012	Log-normal	95% CI 0.0065 to 0.0202
Operation duration	120 minutes	No distribution	
Length of stay	8.7 days	Log-normal	Mean 8.7 days, median 7 days

presented as Peto ORs for dichotomous variables and WMDs for continuous variables. For these data to be incorporated into the model they needed to be combined with estimates of baseline rates for one of the interventions. Furthermore, although it might be argued that such relative effect sizes are transferable between settings,[86] it was important to ensure that they were applied to baseline rates that are applicable to the UK, so that the resultant absolute differences between interventions were more likely to be applicable to the UK.

The baseline annual rate of revision following standard THR was taken from data provided by the Swedish National Joint Registry database.[87] These data were utilised, as opposed to data from the UK National Joint Registry database, as they provided the most precise estimates of long-term survival of prostheses with the greatest number of observations. Estimation of the risk of revision was based on the survival curve for 'all implants'. These data provided estimates of the survival of hip implants up to 24 years post-surgery. The overall survival of the hip prostheses for standard THR for each 1-year time period up to 24 years was estimated from these curves. From these data, a revision rate for each 1-year cycle length was calculated. Details of the revision risks for each year are shown in *Table 41*. It should be noted that for those sensitivity analyses that used a 40-year time horizon, an assumption was made that the risk of revision after year 24 is constant for the remaining years at 1.802% per year, the transition probability at 24 years. For the 1-year time horizon analysis, it is only the baseline risk of revision at one year post-surgery and the relative effectiveness at 1 year that are considered.

No distribution was assigned to the baseline risk of revision as the number of observations used to calculate this risk is taken from a very large national database and the CIs around the point estimates were narrow.

In the event that a patient's THR failed, the model allowed patients to be treated non-operatively for the rest of their lives if further revision surgery is deemed inappropriate. For the base-case model, however, it was assumed that all failed THRs will receive revision surgery. The impact of relaxing this assumption was explored in later sensitivity analyses. It should be noted that when patients do enter the non-operative management state, they are unable to leave this state unless they die.

As with all surgical procedures requiring general anaesthetic, death due to complications in the intraoperative period is a potential risk. The risk of operative mortality was based on data from the Trent regional replacement register[88] shown in *Table 40*. Based on these data, a mortality rate of 0.91% was assumed. The CIs around the point estimate reported by Fender and colleagues[88] assumed a log-normal distribution; therefore, these data were used to estimate a similar distribution around this baseline risk.

As patients progress through the model over time, annual rates of age-specific general or all-cause mortality were required. These were taken from published UK life tables for the years 2003 to 2005.[89] The National Joint Registry reports that 60% of all primary THRs are performed on women; therefore, the all-cause mortality for the model cohort was weighted to reflect this. Data relating to the rate of all-cause mortality can be seen in Appendix 14. As the number of observations used to calculate this risk is very large, no distribution was assigned to these rates.

Certain postoperative complications other than revision have been allowed for within the model owing to their importance in terms of resource use and quality of life. These complications have been subsumed within the initial operation and successful THR states and, once rectified, patients would still be classed as successful. The following

TABLE 41 *Cumulative risk of revision estimated from survival curves*

Time (years)	Absolute rate of revision	Time (years)	Absolute rate of revision	Time (years)	Absolute rate of revision	Time (years)	Absolute rate of revision	Time (years)	Absolute rate of revision
0	0	5	0.028	10	0.073	15	0.136	20	0.197
1	0.007	6	0.035	11	0.085	16	0.147	21	0.204
2	0.013	7	0.042	12	0.097	17	0.163	22	0.211
3	0.017	8	0.05	13	0.113	18	0.174	23	0.218
4	0.02	9	0.06	14	0.124	19	0.186	24	0.222

complications have been explicitly included in the model: risk of re-operation (i.e. not revision) due to dislocation or wound infection, risk of DVT and risk of non-fatal PE. The risks of DVT and non-fatal PE are only factored into the initial operation and revision states as these complications are only relevant in the immediate postoperative period. The Swedish National Joint Registry provided data on the rate of re-operations and revisions due to various complications.[87] From this, it was possible to calculate the rate of re-operations on the hip joint (not including revision procedures). Two of the most important complications which might require a re-operation are dislocation and deep infection. From the Swedish Registry data, an annual constant risk of re-operation for dislocation was estimated as the yearly rates remained similar over time. Similarly, a constant rate of re-operation for infection was calculated from the Swedish data, although this risk was only included for the first 5 years postoperatively, as the data suggested that this risk became negligible after this time point. Again, as with the risk of revision, no distribution was assigned to these risks due to the large number of observed events in the registry data.[87] The associated probability, cost and disutility associated with these complications were factored into the 'Initial operation', 'Revision' and 'Successful THR' states.

The risks of DVT and non-fatal PE were included in the model's operation states (primary THR and revision) as it was felt that these risks might differ between standard and mini-incision THR surgery. The baseline risks of DVT and PE were taken from the Scottish Intercollegiate Guidelines Network (SIGN) guidelines for the prophylaxis of venous thromboembolism (see *Table 40*).[90] From this, a baseline risk of 1.9% for DVT and a risk of 1.2% for non-fatal PE were assumed. The CIs around the point estimate for DVT were based on a normal distribution and a similar distribution around this baseline risk was used in the model. For the PE rate, the CIs suggested a log-normal distribution, which was therefore used to express the uncertainty around this point estimate.

Other baseline parameters required for the model related to operation duration and length of stay. For standard THR, the baseline length of operation was assumed to be 120 minutes based on a previous HTA monograph.[91] Average length of hospital stay was taken from the Hospital Episodes Statistics Database for the operation code W37.1 and was assumed to be 8.7 days based on 'Total prosthetic replacement of the hip joint using cement, Primary total prosthetic replacement of hip joint using cement'. This particular operation code was chosen as it is the most frequently recorded operation code for THR (*Table 40*).[92] A distribution for this parameter was constructed using the median and mean length of stay for this operation code. Using these two items of data, the use of alternative distributions was investigated and a log-normal distribution was chosen, as it provided a plausible lower estimate of length of stay and also allowed the possibility of substantially greater length of stay.

Derivation of relative effect sizes

Data on the relative effect sizes were derived from the systematic review of effectiveness where possible. All relative effect sizes are given in *Table 42*. It was assumed that the relative effect size of operative mortality and of all-cause morality for mini-incision THR compared with standard THR

TABLE 42 *Relative effect sizes used in the model*

Parameter	Point estimate	Limits of 95% CI		Distribution
		Lower	Upper	
Transition probabilities				
Operative mortality	1	1	1	
All-cause mortality	1	1	1	
Revision rate	1	0.1	1.9	Uniform
Rate of non-operative management following failed THR	1	1	1	
Other probabilities				
Re-operation rate for dislocation	1	0.1	1.9	Uniform
Re-operation rate for deep infection	1	0.1	1.9	Uniform
DVT rate	1	0.1	1.9	Uniform
PE rate	1	0.1	1.9	Uniform
Operation duration (minutes)	–3.70	–5.67	–1.74	Normal
Length of stay (days)	–0.5	–0.83	–0.18	Normal

was one (*Table 42*). This assumption was made as it is unlikely that these risks would differ between the two operative techniques (Hutchison JD, Department of Surgery, University of Aberdeen and Munro N, NHS Grampian: personal communication, February 2007).

The conclusions that can be drawn from the meta-analysis reported in Chapter 3 are tenuous, as data for some outcomes were sparse and the CIs were implausibly wide. For the base-case model, therefore, the relative effect sizes from the meta-analysis were not utilised for several model parameters. Reliable data relating to the annual risk of revision, rate of re-operation for both dislocation and deep infection and risk of DVT and non-fatal PE were not available but interpretation of the few data from Chapter 3 suggests a relative effect size of one but with considerable uncertainty, which was reflected by the adoption of a uniform distribution for these parameters (*Table 42*). This assumption was based on the interpretation of the findings of the review of effectiveness and on advice of the methodological and clinical members of the research team. The approach was deemed more appropriate than surveying expert opinion as such data are themselves arbitrary and may reflect the biases of those surveyed.

Other relative effect sizes required for the model relate to operation duration and length of stay, which were obtained from data reported in Chapter 3 (*Table 42*). Data were suggestive of a statistically significant reduction in operation time and length of stay and this was therefore reflected in the initial operation costs for the two procedures. For both parameters, a normal distribution was assigned to represent statistical uncertainty of the point estimates based on the 95% CIs.

Resource use and costs

The derivations of selected individual resource use parameters are shown in *Tables 43* and *44*. A summary of all resource use parameter values included in the model can be found in *Table 45*. The main cost component included in the model is the costs associated with the primary THR operation and the costs of any subsequent revision operations or re-operations for complications (i.e. dislocation and/or infection). It is likely that the main cost differences between standard and mini-incision THR might result from any extra specialist equipment or instrumentation required for mini-incision techniques, any difference in the duration of surgery and as the possibility of a shorter hospitalisation period which may be associated with the mini-incision technique.

For the primary operation, the cost of a cemented prosthesis, assumed to be used for both procedures, was estimated from a number of manufacturers' price lists. A cemented prosthesis was chosen, as data from the Hospital Episodes Statistics showed that a greater number of THRs were performed with cemented rather than uncemented prostheses.[92] In relation to instrumentation costs, it was assumed for standard THR that this cost would be subsumed in the cost of the prosthesis based on usual NHS practice. To perform mini-incision THR, however, an extra additional instrumentation kit would be necessary. The one-off cost of this was taken from manufacturers' price lists and an estimate of the lifespan of the instruments, and also an approximation of the number of times these instruments would be used in a year was determined following expert opinion (Hutchison JD, Department of Surgery, University of Aberdeen and Munro N, NHS Grampian: personal communication, March 2007). An annual equivalent cost was estimated using a discount rate

TABLE 43 *Cost of management of DVT during initial hospitalisation period*

Management	Cost (£)	Dose	Source
Tests			
Ultrasound	38		NRC banding code RBB3 Other ultrasound
Fibrin D-dimer	1		NRC Speciality code DAP 841 – biochemistry test
Drugs			
Heparin	0.36	5000 units/ml	BNF
	13.68	1000 units/ml/hour for 72 hours	BNF
Warfarin	0.11	10 mg on first day	BNF
	8.10	6 mg warfarin for a further 3 months	BNF
Total	**61.25**		

TABLE 44 *Cost of non-operative management for patients following failed THR*

Area of resource use	Quantity of resource use	Unit cost (£)	Annual cost per patient (£)	Source
Physiotherapy sessions – outpatient	Eight sessions per annum	32	256.00	PSSRU
Physiotherapy in the community	Three sessions per annum	14	42.00	PSSRU
Medication (assume 270 days per year): ibuprofen	1.2 g daily	0.6 g × 84 tablets = 3.79	24.36	BNF
GP visits	Two per annum	18	36.00	PSSRU
NSAID events			385.00	
Total			**743.36**	

NSAID, non-steroidal anti-inflammatory drug; PSSRU, Personal Social Services Research Unit.

of 3.5% which, given expected annual usage, gave a cost per patient of £12.58. Other costs associated with the initial operation related to staffing, overheads (length of stay and theatre costs), consumables and capital costs. The staff mixes for both methods of replacement were estimated and assumed to be the same for the base-case analysis following clinical opinion (Hutchison JD, Department of Surgery, University of Aberdeen and Munro N, NHS Grampian: personal communication, 2007). The various staff unit costs were estimated from published sources,[93] as were the unit costs of theatre time and a stay on an orthopaedic ward.[94]

The cost of surgery would be incurred in the first cycle of the model. Other costs would also be incurred in this cycle related to follow-up visits and the cost of complications which may occur following discharge.

Following guidance from the British Orthopaedic Association, a patient would attend a consultant outpatient appointment at 8 weeks and at 1 year. At this time, both antero-posterior and lateral X-rays would be performed.[95] Following consultation with clinical experts, the same follow-up for mini-incision patients was assumed for the base-case analysis (Hutchison JD, Department of Surgery, University of Aberdeen and Munro N, NHS Grampian: personal communication, March 2007). The cost of an outpatient appointment was assumed to be £103, taken from published sources.[94] The costs of antero-posterior and lateral X-rays were assumed to be the same and were taken from the NHS reference costs. A triangular distribution was defined for this cost based on the interquartile range of costs reported for this imaging modality.[96]

The costs of complications which might have a large impact on resource use and quality of life were also allowed for within the first cycle of the model. These include the cost of re-operation for dislocation and deep infection as well as admissions to hospital as a result of a DVT and/or PE. Costs for a re-operation (i.e. not revision), for both dislocation and infection, and the cost of treatment for PE were taken from NHS reference costs and, using the methods outlined above in relation to the cost of an X-ray, triangular distributions assigned to these costs.[96] For a DVT, it was assumed, based on clinical opinion, that approximately 5% of those suffering from DVT would be readmitted to hospital for further treatment (Hutchison JD, Department of Surgery, University of Aberdeen and Munro N, NHS Grampian: personal communication, April 2007). For these patients, the cost of management was based on NHS reference costs and a triangular distribution was defined around the point estimate to reflect statistical uncertainty.[96] For the remaining patients with a DVT, it was assumed that they would principally be treated using the treatment regime recommended by SIGN (*Table 43*).[97] The cost of tests and medications required were estimated from NHS reference costs and the BNF (*Table 43*).[96,98]

Following a successful THR operation, regular reviews past 1 year would be performed. These include consultant-led outpatient visits including X-rays (as described above for outpatient appointments within the first year after surgery) at 5 years following surgery and every subsequent 5 years thereafter.[95] These follow-up visits are assumed to cost the same as those incurred in the first cycle. The risk and management cost of complications which may impact on resource use and quality of life (not including revision) were subsumed within the relevant states. As described above for the operation state, these included the costs of re-operation for both dislocation and deep infection.

TABLE 45 *Cost estimates for each element of total cost*

Parameter	Value	Distribution	Values for distribution	Source
Estimation of theatre costs (per minute)				
Consultant surgeon	£1.30	NA	NA	PSSRU
Consultant anaesthetist	£1.32	NA	NA	PSSRU
Specialist registrar	£0.57	NA	NA	PSSRU
Nurse – Grade F	£0.40	NA	NA	PSSRU
Nurse – Grade F	£0.40	NA	NA	PSSRU
Nurse – Grade E	£0.32	NA	NA	PSSRU
Theatre overheads	£19.47	NA	NA	ISD
Duration of operation for standard (minutes)	120	NA	NA	Hip resurfacing HTA review
Equipment and instrumentation				
Cost cemented prosthesis	£558.13	NA	NA	Manufacturer
Cost for MI instrumentation per patient	£12.58			Manufacturer
Cost of standard instrumentation	Subsumed in prosthesis cost	NA	NA	
Follow-up cost				
Cost of inpatient hospital stay per day	£411.79	NA	NA	ISD Scotland
Cost of outpatient visit	£103.00	NA	NA	ISD Scotland
Cost of X-ray	£19.00	Triangular	IQR: £15–23	NRC Band A (RBA1)
Cost of complications				
Revision	£7858.00	Triangular	IQR: £6129–9121	NRC HRG H71 – Revisional procedure to hip
Re-operation for dislocation	£1925.00	Triangular	IQR: £1263–2304	NRC HRG H40 – Closed upper limb fractures or dislocation
Re-operation for infection	£3365.00	Triangular	IQR: £1034–4352	NRC HRG H30 – Infections of bones or joints
Cost of non-admitted DVT	£61.25			
Cost of admitted DVT	£789.00	Triangular	IQR: £612–1610	NRC HRG E21 – Deep vein thrombosis <70 without complications
Cost PE	£1326.00	Triangular	IQR: £979–2090	NRC HRG D11 – Pulmonary embolism without complications
Cost of non-operative management	£743.36	NA	NA	Hip resurfacing HTA review

HRG, Healthcare Resource Group; HTA, Health Technology Assessment; IQR, interquartile range; ISD, Information Services Division; NA, not applicable; NRC, National Health Service reference costs; PSSRU, Personal Social Services Research Unit.

The cost of care for patients who might have a failed operation would, of course, be dependent upon the nature of the failure. For those patients who require a revision surgery, the cost of this was taken from the NHS reference costs for Healthcare Resource Group (HRG) H71 (a revisional procedure to hip). A distribution for this cost was defined using the same methods described above. The follow-up of patients after a revision would be similar to follow-up following primary THR. It was assumed, however, that during the first year following revision surgery, an extra outpatient appointment including X-rays would be performed. Again, the risk and costs of complications were factored into the revision state and were assumed to be the same as after primary THR.

In addition to the cost of revision, a patient might receive medications and non-operative treatments for the control and management of hip disease if, after a failed primary or revision surgery, further revision surgery is no longer viable, for example as a result of being unfit for surgery. The cost for a typical regime of care was defined based on a previous HTA monograph,[91] which identified the management cost for those people who were waiting for a THR. The resource usage was used and costs were updated to 2006 prices (*Table 44*). No distributions were assigned to these costs and this represents a caveat of the costs associated with the non-operative management state. It should be noted, however, that the number of patients entering this state is likely to be extremely small; therefore, failing to assign distributions to each component is unlikely to alter the conclusions between mini-incision and standard THR.

Table 45 outlines cost estimates for each element of resource use used in the model.

Estimation of quality-adjusted life-years (QALYs)

This section and *Table 46* describe the source and methods used to obtain utility values. All utility values used for the base-case model are shown in *Table 47*. No suitable utility data, required to estimate QALYs, were identified in either of the economic evaluations reported in Chapter 4. Potential utility data were sought from focused searches of the Harvard Cost Utility Database and of the literature of quality of life estimates

TABLE 46 *Main findings from papers in relation to quality of life following THR*

Study	Type of THR	Baseline	Scores for treatment success	
			3 months	1 year
Dawson, 2001[99]	Revision	0.32 (95% CI 0.29 to 0.36)		0.62 (95% CI 0.59 to 0.65)
Robinson, 1999[100]	Primary	NR		0.99 (IQR 0.006)
Malchau, 2005[101]	Primary	0.38 (no SD reported)		0.75 (no SD reported)
Ostendorf, 2004a[102]	Primary	0.35 (SD 0.31)		0.76 (SD 0.27)
Ostenforf, 2004b[103]	Primary	0.33 (SD 0.32)	0.71 (SD 0.26)	0.75 (SD 0.28)

IQR, interquartile range; NR, not reported; SD, standard deviation.

TABLE 47 *Utility values used in the model to estimate QALYs*

Utility scores used in the economic model	Utility value (SD)	Distribution
Primary THR		
Preoperative	0.33 (0.32)	Beta
Success at 3 months	0.71 (0.26)	Beta
Success at 1 year	0.75 (0.28)	Beta
Successful THR		
Success at 1 year	0.75 (0.28)	Beta
Revision		
Failure of THR up to 3 months	0.33 (0.32)	Beta
Successful revision at 1 year	0.62 (0.015)	Beta
Successful THR after revision		
Success at 1 year	0.62 (0.015)	Beta
Non-operative management	0.33 (0.32)	Beta
Dead	0	None

following standard THR. From these searches, a number of studies with potentially relevant utility values which could be used to estimate QALYs were found. Five European studies with relevant data were identified as having potentially useful quality of life data. The results of these studies are summarised in *Table 46*.

Results at baseline and 1 year for utility scores following standard THR were similar across all the studies apart from one study which based its sample on revision THR patients.[99] Based on the above data, utilities data were taken from two papers.[99,103]

The data reported by Ostendorf and colleagues[103] was chosen because preoperative and 1-year utility scores were similar to results from other studies and also because this was the only study that reported a utility value at 3 months following surgery. This paper analysed a prospective cohort of patients in The Netherlands (n = 161) whose quality of life was measured at the time when the patient was placed on a waiting list for THR, preoperatively and at 3 and 12 months after surgery. The values used in the model are reported in *Table 47*. For the 40-year model, the utility associated with success post-1 year (for the successful THR and successful THR after revision states, respectively) were assumed to be equal to the 1-year values reported in *Table 47*. It should be noted that the disutility associated with a failed THR requiring revision and also the disutility associated with re-operations for dislocation were allowed for within the model. It was assumed that patients suffering any of these complications would have a utility score equal to the preoperative score for 3 months before progressing to the quality of life score associated with the successful THR or successful THR after a revision. Following successful revision surgery, patients were assumed to have a utility score equal to 0.62 at 1 year (for the revision state and successful THR after revision state) (*Table 47*). This figure was obtained from a paper by Dawson and colleagues,[99] which analysed the outcomes of 601 revision patients in the UK using the EQ-5D. For those patients who progress to the non-operative management state in the model following failed surgery, it was assumed that they would have a utility score equal to the pre-operative quality of life estimate. All utility scores defined in the model were assigned a beta distribution in order to reflect uncertainty of the point estimate (*Table 47*).

Within the base-case analysis, the above utilities were applied to both mini-incision THR and standard THR. The results presented in Chapter 3 indicate that mini-incision THR is associated with a shorter recovery. Therefore, it was assumed that patients would return to a utility of 0.71 at 2 months rather than the 3 months assumed for standard THR. This assumption of a 1-month earlier recovery represents analyst assumption as it was not possible to quantify the available data in relation to 'time to return to usual activities'. A 1-month quicker recovery was a reasonable starting point given findings from the review of effectiveness (see *Table 24*, p. 36) and the implication of this assumption has been addressed in a threshold analysis around this estimate (see the section 'Results', p. 65).

Finally, utilities data were also sought from the Harvard Cost Utility Database in relation to the disutility associated with DVT and non-fatal PE following surgery. No suitable data were found and the effects of these complications on quality of life, therefore, have not been factored into the estimation of QALYs.

Assessment of cost-effectiveness

The base-case analysis is based on the costs and outcomes faced by a cohort of 68-year-old THR patients (the mean age of patients receiving THR as stated in the most recent National Joint Registry for England and Wales report)[3] over two time horizons (1 year and 40 years). For the 40-year model, costs and effects were discounted at a rate of 3.5% following current national guidelines.[104] Within the economic model, outcomes are presented as incremental cost per QALY. Data on these outcomes are presented in two ways. First, mean costs and QALYs for the alternative interventions are presented and incremental cost per additional QALYs calculated where appropriate. The second way in which the cost-effectiveness of the alternative interventions is presented is in terms of cost-effectiveness acceptability curves (CEACs).[105] CEACs have been used to illustrate the effect of statistical uncertainty caused by the statistical variability in the model's parameter estimates. These curves illustrate the likelihood that an intervention is cost-effective at various threshold values for society's willingness to pay for a QALY.

Sensitivity analysis and subgroup analysis

Sensitivity analysis focused on varying assumptions or parameter values in the base-case model.

Increased resource use associated with mini-incision THR (1-year time horizon)

It was assumed for the base-case analysis that the management of patients following mini-incision

THR would be similar to that for standard THR patients. Following consultation with clinical experts, it is possible that mini-incision patients might be followed up more closely than standard THR patients (Hutchison JD, Department of Surgery, University of Aberdeen and Munro N, NHS Grampian: personal communication, March 2007). This sensitivity analysis assumes that an extra Grade E nurse would be required for the duration of surgery for mini-incision patients and also assumes that patients would have an extra consultant-led outpatient appointment during the first year after surgery. At this time the usual antero-posterior and lateral X-rays would be performed.

For the base-case analysis, the impact on cost associated with a shorter hospitalisation period and reduced operation time was included in the model. As these differences are very small and their relevance is uncertain, this sensitivity analysis also makes the assumption that any differences were not economically important.

Use of Peto ORs for dislocation and DVT reported in review of effectiveness (1- and 40-year time horizons)

Differences in short- and long-term outcomes following the two forms of surgery are assumed to be the same for the base-case analysis (but with wide CIs) due to the limited data around estimates produced in the meta-analysis reported in Chapter 3. Estimates surrounding the odds of dislocation and DVT following mini-incision THR compared with standard THR, although not statistically significant, were not wholly implausible, so these were included in this sensitivity analysis to relax slightly the assumptions of equal outcomes. The meta-analysis reports a Peto OR of 1.72 (95% CI 0.43 to 6.92) in relation to the risk of postoperative dislocation and a Peto OR of 0.39 (95% CI 0.12 to 1.30) in relation to DVT (a Peto OR <1 can be interpreted as a lower odds of a particular event occurring for mini-incision THR and, conversely, a Peto OR >1 represents a greater likelihood of an event occurring for mini-incision THR). Log-normal distributions were assigned to these risks to reflect uncertainty of point estimates. The analysis was conducted for a 1- and 40-year time horizons.

Use of alternative utilities data to estimate QALYs (1- and 40-year time horizons)

Alternative utilities data were identified to estimate QALYs from a study conducted by Charles and colleagues.[69] Details of the reanalysis that was performed on the trial results can be found in detail in Appendix 11. Three analyses were performed on the data to account for missing values. For this sensitivity analysis, the reported utility scores using the 'last value carried forward' approach to missing data was used. Utilities data at baseline, 3 months, 6 months and 1 year were used to estimate QALYs for standard THR patients. For mini-incision THR, the mean scores at each time point for standard THR were compared in an analysis of covariance adjusting for baseline SF-6D scores. *Table 48* shows the data used for this analysis, as required by the model. To estimate results for a 40-year time horizon, it was necessary to consider the utility that might apply for revision THR as the utilities data were for primary THR only. It was assumed for the 40-year model, therefore, that patients who underwent revision surgery would have 76% of the utility of primary THR patients (based on the difference between a successful primary and revision THR at 1 year from the base-case utility values used). As for the base-case models, the disutility associated with re-operations for dislocation was also allowed for within the model. In the calculation of QALYs, all utility values were given a beta distribution to reflect uncertainty of the point estimates and the reported coefficients of difference for mini-incision compared with standard THR were assigned normal distributions to reflect uncertainty (*Table 48*).

Assumption that all failed primary THRs go to non-operative management state and are not allowed the chance of revision surgery (40-year time horizon)

This sensitivity analysis assumed that all patients who failed their initial primary surgery would not be allowed the opportunity for further surgical management. These patients were instead treated non-operatively for the rest of their lives.

50% of failed THRs (primary and revision) go to non-operative management state and are not allowed the chance of revision surgery (40-year time horizon)

Similarly to the above, 50% of those patients who failed their THR surgery would not be allowed the opportunity for further surgical management. These patients were instead treated non-operatively for the rest of their lives.

25% of failed THRs (primary and revision) go to non-operative management state and are not allowed the chance of revision surgery (40-year time horizon)

This sensitivity analysis assumed that 25% of all patients who failed their THR surgery would not

TABLE 48 *Alternative utility values*

Time period	Group	Mean	SD	Adjusted difference (SE)
Preoperation	Standard	0.61235	0.15764	
	Mini-incision	0.61235	0.15764	
3 months postoperation	Standard	0.7632	0.10304	
	Mini-incision	0.7924	0.08298	
	Difference			0.045 (0.31)
6 months postoperation	Standard	0.8014	0.09470	
	Mini-incision	0.8001	0.07565	
	Difference			0.001 (0.030)
1 year postoperation	Standard	0.8139	0.11936	
	Mini-incision	0.7895	0.06912	
	Difference			–0.011 (0.033)

SE, standard error.

be allowed the opportunity for further surgical management. These patients were instead treated non-operatively for the rest of their lives.

Threshold analysis for revision rates for a 40-year time horizon

A threshold analysis in the form of an implied valuation was performed around the relative effect size associated with revision following mini-incision THR for a 40-year time horizon. The range of values of the relative effect size for revision following mini-incision THR were varied from 1.0 (no difference in relative difference in revision) to 1.2 (20% relative increase in revision following mini-incision THR in comparison with standard THR). In this way, it is possible to determine the relative increase in revision rates that mini-incision THR would have to be associated with to make it the least cost-effective alternative.

Subgroup analysis

There were no data available on which to conduct a subgroup analysis.

Results

The results of the deterministic analysis which reports incremental cost per QALY for the 1-year analysis are shown in *Table 49* and *Figure 13*.

The ICER is not reported in *Table 49* because standard THR is dominated by mini-incision THR over a 1-year time horizon (*Table 49*). To give an indication as to the flow of the patients through the model, in a cohort of 1000 patients, for both standard and mini-incision THR, 967 patients would move to the successful THR states at the end of the first cycle whereas seven would move to the revision states and a total of 26 deaths would occur within the 1-year time horizon. The results are the same for both forms of replacement given the assumptions made around the rates of complications for the base-case analysis. A cohort analysis showing how patients move through the model over the 40-year time horizon for the base-case analysis is shown in Appendix 15. When examining the deterministic results for the 1-year time horizon analysis displayed in *Table 49*, the point estimates of the incremental cost-effectiveness do not provide any indication of the uncertainty that surrounds the model parameters. The uncertainty surrounding the precision of many of the parameter estimates is reflected in the likelihood that the two surgical interventions are cost-effective at different threshold values for society's willingness to pay for a QALY. *Figures 13* and *14* report the CEACs comparing standard and mini-incision THR in terms of QALYs and the associated cost-effectiveness plane, respectively.

TABLE 49 *Results of the deterministic model for a 1-year time horizon (QALYs)*

Scenario	Procedure	Cost (£)	QALYs	Incremental cost (£)	Incremental QALYs	Incremental cost per QALY
Base-case (1 year)	Mini-incision THR	7064	0.695			
	Standard THR	7345	0.677	281	–0.018	Dominated

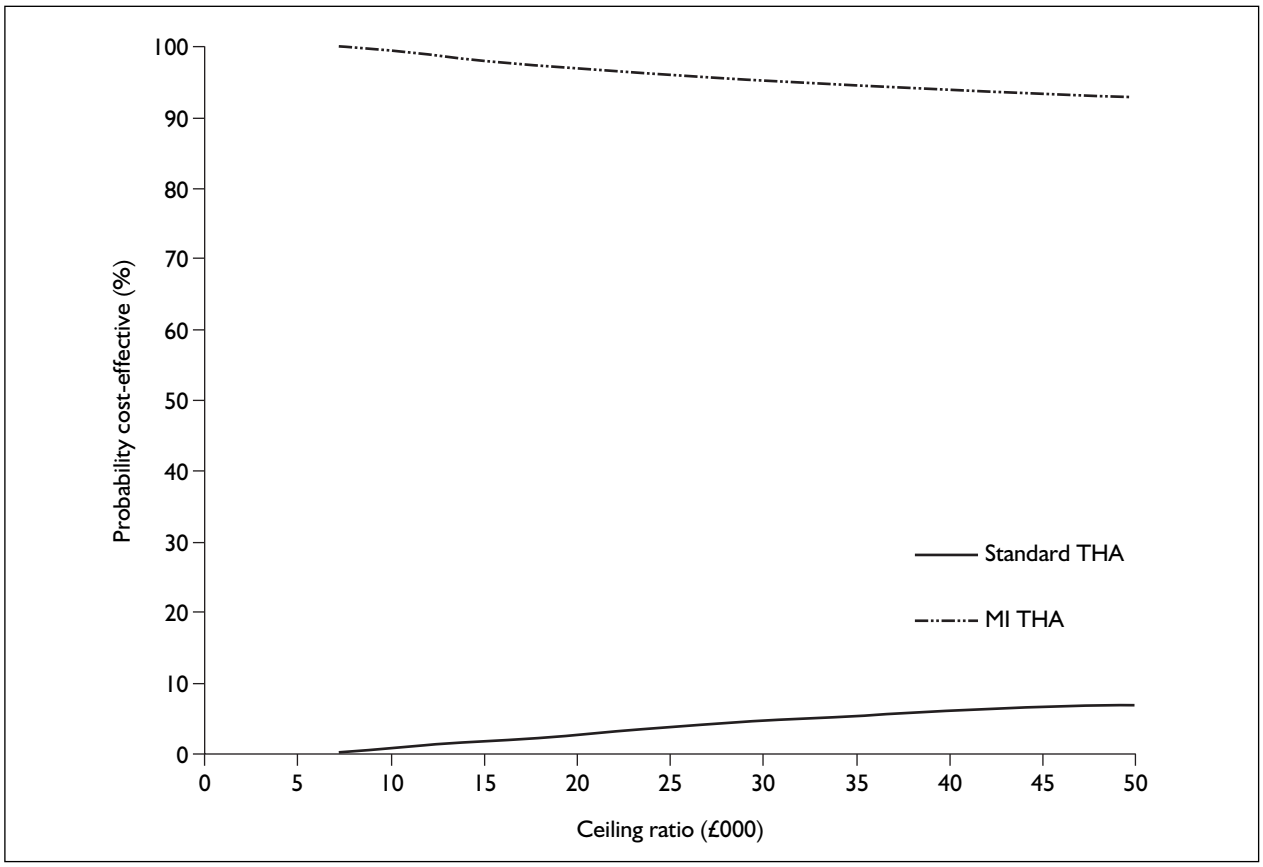

FIGURE 13 *CEAC showing society's willingness to pay for a QALY for the comparison of mini-incision with standard THR surgery (base-case analysis)*

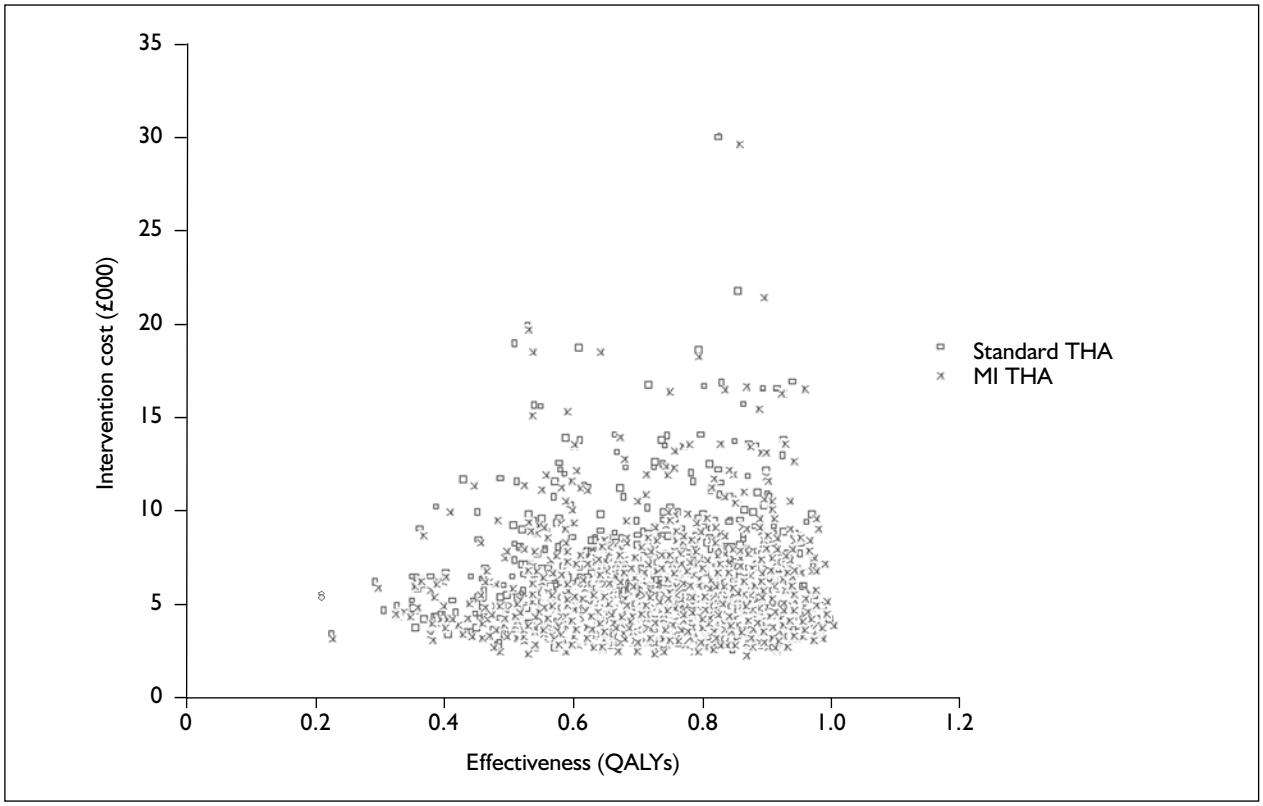

FIGURE 14 *Cost-effectiveness plane for base-case analysis*

Although patients flow through the model in the same way, it is the decreased cost of mini-incision THR in comparison with standard THR and the utility associated with a 1-month quicker recovery that drives the results. As can be seen from *Figure 13*, for the 1-year time horizon analysis mini-incision THR has >90% chance of being considered cost-effective for every willingness to pay threshold presented. The base-case results show that the reduced cost associated with the shorter operation and duration of hospital stay is enough to offset the cost of the extra instrumentation required for mini-incision THR. The difference in QALYs is also caused by the assumption that mini-incision THR patients would recover from surgery 1 month earlier than standard THR patients. This is expanded on further in the sensitivity analyses in the next section.

Table 50 shows the deterministic results of the base-case model when it was repeated for a 40-year time horizon. As can be seen, the results are similar to those for the 1-year analysis. It is only when we look at the stochastic analysis, however, that the importance of the 40-year analysis becomes apparent. The 40-year analysis allows a greater amount of uncertainty into the model and, although many outcomes assume no difference in effects, the extremely wide CIs around the point estimates reduce the probability that mini-incision THR is the most cost-effective alternative from around 95% to 55% for all threshold values considered.

Sensitivity analyses

Threshold analysis around time to return to usual activities (base-case model)

The base-case analysis assumed a 4-week quicker recovery following mini-incision THR, although the absolute difference is unknown. A threshold analysis was performed to explore the impact of quicker return to usual activities following mini-incision THR (*Table 51*). From *Table 51*, it can be seen that even if there was no difference in time to return to usual activities following mini-incision THR in relation to standard THR, standard THR is still dominated because of the higher cost associated with it.

Increased resource use associated with mini-incision THR (1-year time horizon)

The first sensitivity analysis focused on increasing the hospital resource usage of mini-incision surgery in comparison with standard THR surgery and by relaxing assumptions on cost savings in relation to the slightly shorter length of stay and operation time estimates (*Figures 15* and *16*). Here mini-incision THR is, again, more effective then standard THR, due to the assumption of earlier recovery for these patients, but is also more costly by approximately £200 with an ICER of approximately £11,000.

Threshold analysis around time to return to usual activities (1-year time horizon and increased resource use model)

In a further sensitivity analysis, for the scenario where mini-incision THR is associated with increased resource use, a threshold analysis around time to return to usual activities was performed. This analysis showed that if mini-incision THR was associated with a 2-week reduction in time to return to usual activities, as opposed to the 4-week quicker recovery assumed for the base-case analysis, then the ICER is approximately £22,000. When time to return to usual activities is reduced further to 1 week, the ICER increases to £44,000 (*Table 52* and *Figure 17*).

TABLE 50 *Results of the deterministic model for a 40-year time horizon (QALYs)*

Scenario	Procedure	Cost (£)	QALYs	Incremental cost (£)	Incremental QALYs	Incremental cost per QALY
Base-case (40 years)	Mini-incision THR	11,618	8.480			
	Standard THR	11,899	8.463	281	–0.017	Dominated

TABLE 51 *Threshold analysis of impact of earlier return to usual activities following mini-incision THR (base-case analysis)*

	Reduction in time to return to usual activities following minimal-incision THR (weeks)						
	0	1	2	3	4	5	6
Change in QALYs	0	0.00436	0.0087	0.0131	0.0175	0.0218	0.0262
Change in costs (£)	–281	–281	–281	–281	–281	–281	–281
ICER	Dominated	Dominated	Dominated	Dominated	Dominated	Dominated	Dominated

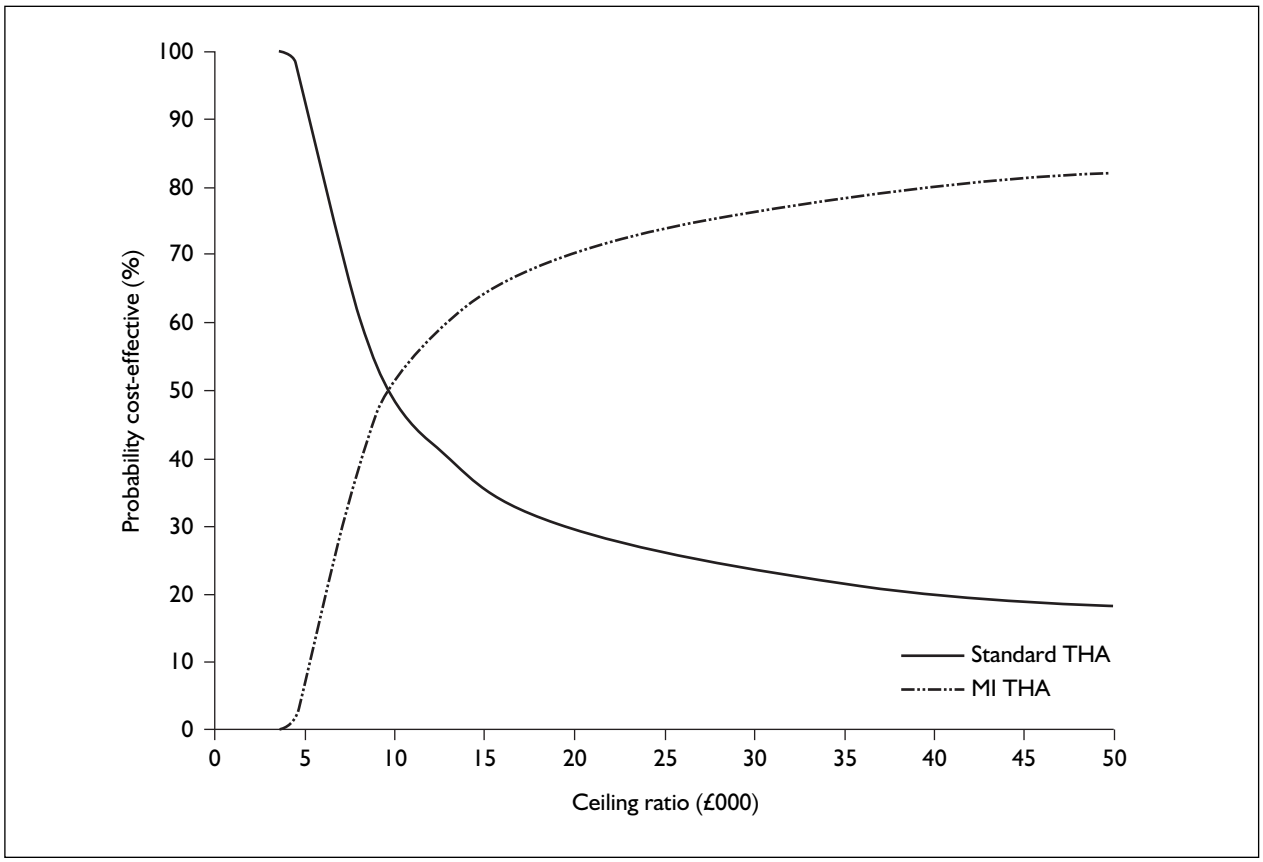

FIGURE 15 *CEAC showing society's willingness to pay for a QALY for the comparison of mini-incision with standard THR surgery (increased resource use with mini-incision THR, 1-year time horizon)*

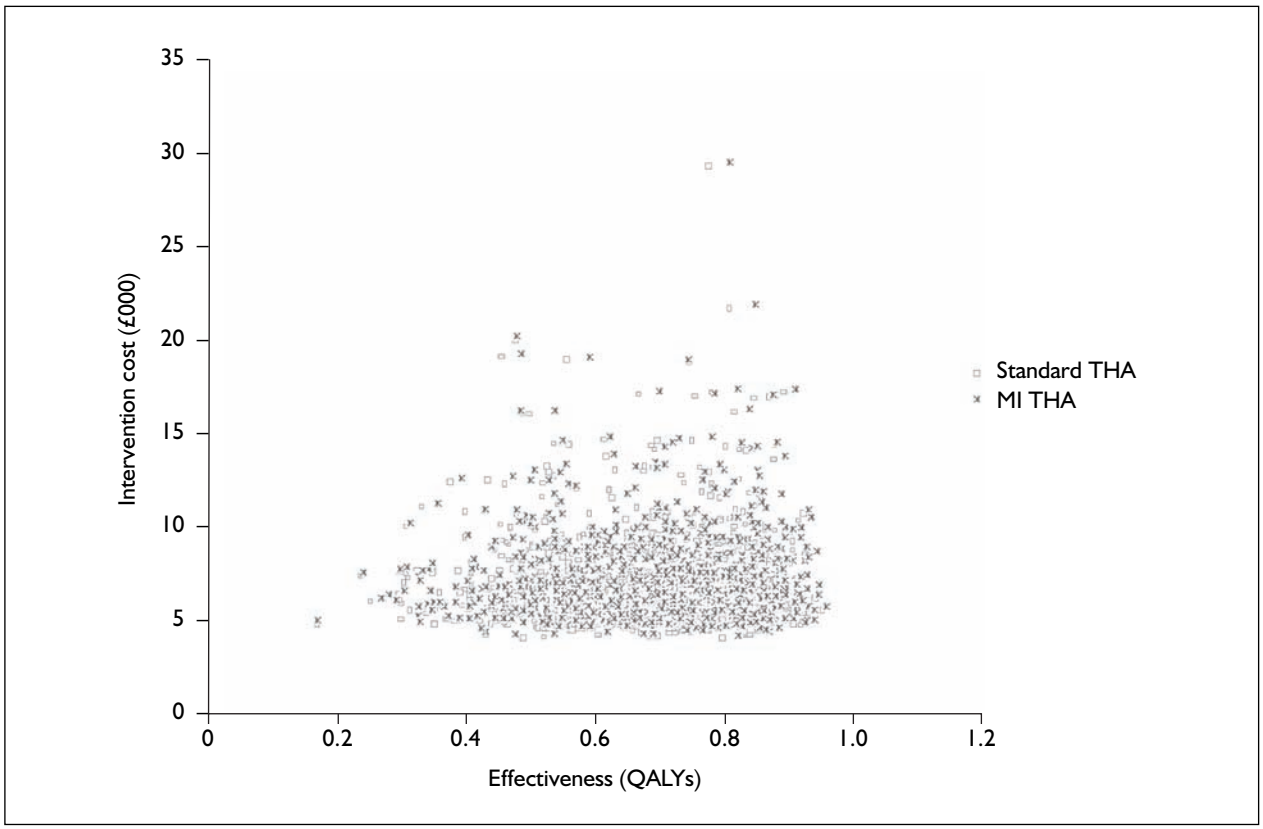

FIGURE 16 *Cost-effectiveness plane for increased resource usage analysis*

TABLE 52 *Threshold analysis of impact of earlier return to usual activities following mini-incision THR (increased resource usage analysis)*

	Reduction in time to return to usual activities following minimal-incision THR (weeks)						
	0	**1**	**2**	**3**	**4**	**5**	**6**
Change in QALYs	0	0.00436	0.0087	0.0131	0.0175	0.0218	0.0262
Change in costs (£)	192	192	192	192	192	192	192
ICER (£)	Dominated	43,991	21,996	14,664	10,998	8,798	7,331

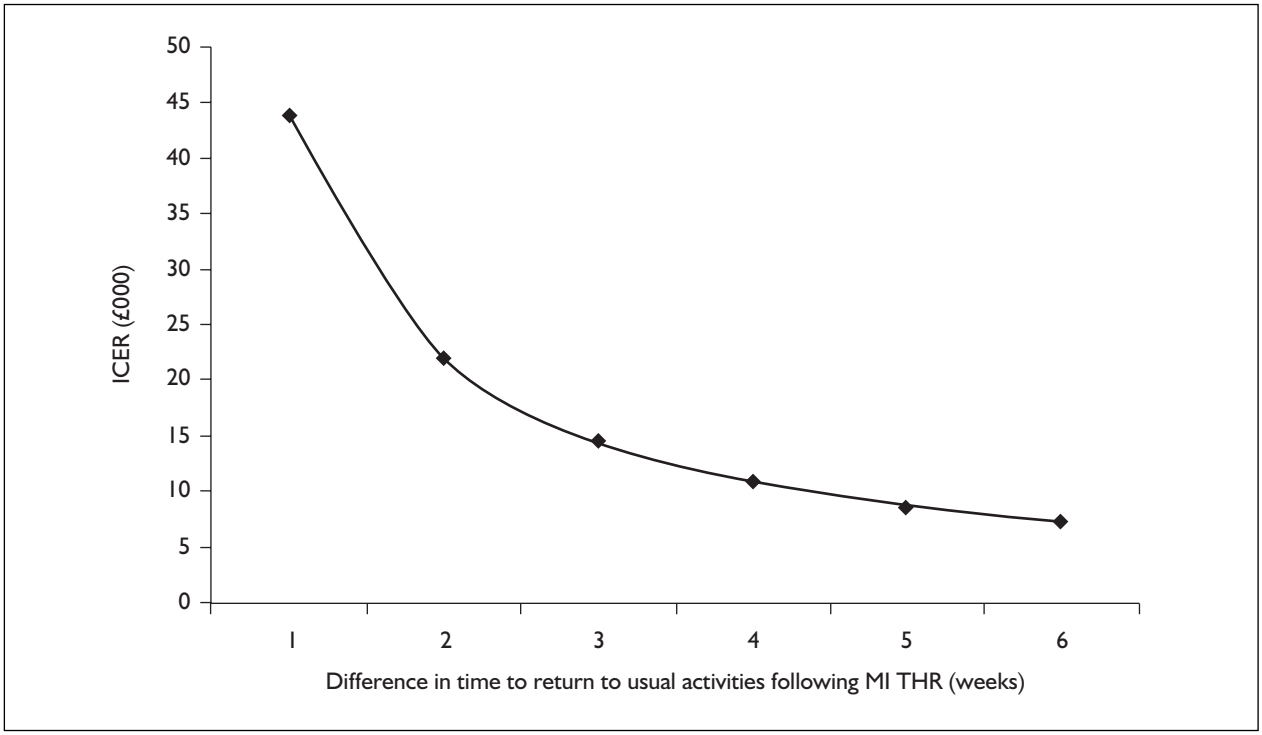

FIGURE 17 *Threshold analysis of impact of earlier return to usual activities (increased resource usage analysis)*

Use of Peto ORs reported for dislocation and DVT from review of effectiveness

This analysis used the point estimates of the Peto OR for DVT and re-operation due to dislocation from the meta-analysis conducted as part of the systematic review of effectiveness in Chapter 3. As is apparent in *Table 53*, the results did not differ greatly from the base-case analysis. Although there is a high management cost associated with dislocation, the baseline risk is small, hence the increase in the rate of dislocation apparent for mini-incision THR patients impacts little on results. Further, as the Peto OR for DVT favoured mini-incision THR, some of the increased cost associated with an increase in re-operations for dislocations would be offset by the reduction in cost for the treatment of patients suffering from DVT. As would be expected, the QALY gain following mini-incision surgery is slightly reduced due to the assumptions made around quality of life following a dislocation. Again, this reduction in quality of life is small because of the low baseline risk of dislocation and because of the short time horizon of this analysis. At all threshold values for society's willingness to pay for a QALY, mini-incision THR still has >95% chance of being considered cost-effective.

When this analysis was repeated for the 40-year time horizon, standard THR is still dominated by mini-incision THR (*Table 54*) but the magnitude of the difference in cost and QALYs is reduced. This is because the longer time horizon allows more uncertainty into the model and also allows a greater number of mini-incision patients to suffer the costs and consequences associated with a re-operation for dislocation in comparison with standard THR. This would be as expected given the point estimates of the OR for re-operation due to dislocation used for this analysis which slightly

favours standard THR. As the baseline risk of dislocation is low, however, it is not enough to offset the benefits of mini-incision surgery in terms of earlier return to usual activities in the immediate postoperative period, the driver of QALY results. The important point to note in relation to the probabilistic sensitivity analysis results for the 40-year model is that the probability that mini-incision THR would be considered cost-effective is approximately 55% for all threshold values (markedly reduced from the 95% chance in the 1-year analysis). This is because this model allows a much greater amount of uncertainty into the analysis.

Use of alternative utilities data to estimate QALYs (1- and 40-year analysis)

Alternative utilities data were identified from a study by Charles and colleagues.[69] Again, standard THR is dominated by mini-incision THR in this analysis which differs little from the base-case results (*Table 53*). The difference in cost between the two interventions remained the same as the base-case analysis; however, QALYs following mini-incision THR were slightly higher at 1 year. This is because the utility scores reported at 3 and 6 months were slightly higher for mini-incision THR than standard THR (*Table 48*) and the net effect of this was that QALYs at 1 year following mini-incision THR were higher.

This analysis was repeated for the 40-year time horizon and is one of the few analyses where standard THR is not dominated by mini-incision THR, although the ICER reported is extremely high (approximately £259,000). The difference in cost between the two interventions remained the same as in the base-case analysis; however, on average, QALYs following standard THR were very slightly higher at 40 years. This is because the difference in utilities at 1 year reported in the data from Charles and colleagues[69] (*Table 48*) was slightly lower for mini-incision and it was this difference in utility that was applied to the successful THR and successful THR after revision states, the states in the model in which patients would likely spend the most amount of time. The mean utility for standard THR was, therefore, higher than that for minimally invasive THR, leading to a greater number of QALYs following standard THR over the 40-year time horizon. Finally, the point estimate of QALYs for both standard and mini-incision THR for the 40-year analysis using alternative utility data are higher than those reported in the 1-year base-case analysis because the utility score associated with failure from the alternative utilities data was higher than (approximately double) that of the base-case utility score for failed THRs (*Table 54*).

Assumptions around the number of failed THR patients (primary and revision) moving to the non-operative management state and not being allowed the chance of revision surgery (40-year time horizon)

Results of the sensitivity analyses that made assumptions around the number of failed THR patients going to the non-operative management state for the rest of their lives, as opposed to being given the chance of revision surgery, did not differ greatly from those of the base-case analysis. As would be expected, patients in both arms of the model experienced reduced QALYs over the 40-year time horizon, compared with the 1-year time horizon base-case analysis, for each of the three sensitivity analyses that were performed (one assuming all failed patients went to the non-operative management state, one assuming 50% and one assuming 25%). This is as would be expected given the low quality of life associated with the model's non-operative management state. Similarly in relation to cost, although patients incurred costs in terms of long-term pain and non-operative management over the 40-year period, the high costs associated with revision surgery were more likely to be avoided and, as a result, reduced the cost estimates for both forms of surgery for each of the analyses (*Table 54*).

Threshold analysis for revision rates for a 40-year time horizon

A threshold analysis was conducted on the relative difference in revisions following mini-incision THR compared with standard THR. This analysis showed that if society were willing to pay £30,000 for a QALY, mini-incision THR would have to be associated with a 7.5% increase in revisions for it to be no longer considered cost-effective.

Summary of evidence on cost-effectiveness

Available data on the effectiveness of single mini-incision THR in comparison with standard THR were explicitly synthesised in an economic model. Synthesised data from the systematic review of effectiveness in relation to revision, risk of dislocation and infection and the risks of DVT and PE were extremely tenuous and were therefore not included in the model owing to the implausibly wide CIs reported. In general, however, the results suggested a relative effect size of one. It was assumed, therefore, that these outcomes would be

TABLE 53 *Base-case and sensitivity analysis results (1-year time horizon)*

Sensitivity analysis	Procedure	Cost (£)	QALYs	ICER (£)	Probability cost-effective for different threshold values for society's willingness to pay for a QALY (%)			
					£10,000	£20,000	£30,000	£50,000
Base-case (1-year time horizon)	Mini-incision	7,064	0.695		99.4	97.2	95.3	93.0
	Standard	7,345	0.677	Dominated	0.6	2.8	4.7	7.0
High mini-incision cost	Standard	7,345	0.677		48.5	29.8	23.7	17.9
	Mini-incision	7,537	0.681	10,998	51.5	70.2	76.3	82.1
Peto OR for dislocation and DVT taken from meta-analysis	Mini-incision	7,076	0.694		99.2	96.9	94.7	92.7
	Standard	7,345	0.677	Dominated	0.8	3.1	5.3	7.3
Alternate utilities values	Mini-incision	7,064	0.792		93.2	87.3	84.7	81.0
	Standard	7,345	0.771	Dominated	6.8	12.7	15.3	19.0

TABLE 54 *Base-case and sensitivity analyses conducted using a 40-year time horizon*

Sensitivity analysis	Procedure	Cost (£)	QALYs	ICER (£)	Probability cost-effective for different threshold values for society's willingness to pay for a QALY (%)			
					£10,000	£20,000	£30,000	£50,000
Base-case (40-year time horizon)	Mini-incision	11,618	8.480		59.0	57.5	56.3	56.1
	Standard	11,899	8.463	Dominated	41.0	42.5	43.7	43.9
OR for dislocation and DVT taken from meta-analysia	Mini-incision	11,735	8.476		55.8	54.9	54.9	54.3
	Standard	11,899	8.463	Dominated	44.2	45.1	45.1	45.7
Alternate utility values	Mini-incision	11,618	9.123		52.5	51.8	51.6	51.7
	Standard	11,899	9.124	258,609	47.5	48.2	48.4	48.3
All failed THR patients go to non-operative management state	Mini-incision	9,819	7.671		55.8	54.7	54.1	53.8
	Standard	10,101	7.654	Dominated	44.2	45.3	45.9	46.2
50% failed THR patients go to non-operative management state	Mini-incision	10,604	8.045		56.2	54.6	54.2	54.0
	Standard	10,885	8.027	Dominated	43.8	45.4	45.8	46.0
25% failed THR patients go to non-operative management state	Mini-incision	11,080	8.254		57.0	54.8	54.5	54.2
	Standard	11,361	8.237	Dominated	43.0	45.2	45.5	45.8

equal but with considerable uncertainty around the point estimates. In the base case of this model, and most of the sensitivity analyses, standard THR was dominated (i.e. no more effective but more costly by approximately £300) by mini-incision THR (with approximately a 95% likelihood of being cost-effective depending on the cost per QALY threshold considered for the 1-year base-case analysis). Standard THR only appeared to be less costly when it was assumed that follow-up after mini-incision THR would be more intensive than after standard THR. Nevertheless, if society were willing to pay £30,000 for an additional QALY, the likelihood that mini-incision surgery would be the most cost-effective alternative was still high at approximately 75%. The use of alternative utility values were explored for both a 1- and 40-year time horizons. The analysis conducted over a 40-year time horizon was one of the few analyses where standard THR was not dominated by mini-incision THR. The slight added effectiveness of standard THR in relation to mini-incision THR did not, however, alter the probabilistic sensitivity analysis results significantly. Relaxing assumptions with regard to equal long- and short-term complications following surgery, and increasing the time horizon of the analysis to 40 years, did not alter the deterministic results significantly but did make results of the stochastic analyses more uncertain as, when employing the 40-year time horizon, the likelihood that mini-incision THR would be considered cost-effective varied between 50 and 60% for threshold values for society's willingness to pay of up to £50,000. The exception to this was the analysis that used alternative utility values, where standard THR was more costly but more effective than mini-incision THR. The incremental cost per QALY for standard THR compared with mini-incision THR, however, was nearly £260,000. Furthermore, the likelihood that mini-incision THR would be considered cost-effective was over 50% for all threshold values for society's willingness to pay for a QALY up to £50,000. A threshold analysis around revisions for the 40-year time horizon model showed that if society were willing to pay £30,000 for a QALY, mini-incision THR would have to be associated with a 7.5% increase in revisions for it to be no longer considered cost-effective.

Results of the economic evaluation should be treated with caution because very few useable and reliable data were available in relation to costs for the two modes of surgery and the risk of long-term complications following mini-incision THR in comparison with standard THR.

Chapter 6

Implications for other parties

Quality of life for the family and carers

Quality of life issues related to THR relate to pain, mobility (e.g. limp, use of walking aids) and return to normal activities. There are a number of specific scores which measure condition-specific quality of life, encapsulating a range of issues, such as the Harris hip score. Finally, there are general quality of life measures such as the SF-12, the SF-36 and the EQ-5D.

The information on pain (either short-term within 3 months of the operation or long-term pain resulting in disability) was not well reported, but there were no overall differences between patients receiving a mini-incision or a standard incision. There were either no differences in mobility or time to return to normal activities or the data favoured mini-incision.

Similarly, few studies reported significant differences between the two groups in condition-specific measures, but where there were such differences, they favoured the mini-incision group both in the short term (less than 3 months) and over a longer period (e.g. 1–5 years). Measures of general quality of life did not favour either group. Patients also preferred the shorter scars resulting from MIS.

In summary, it seems reasonable to conclude that patients had a marginally better quality of life after MIS, but long-term information is not available. This conclusion might also be overturned if there was evidence of a higher need for revision surgery in the long term.

Although no information was available on the quality of life of family and carers, better quality of life for the individual with hip disease would most likely reduce the burden of care for their carers and hence improve their own quality of life.

Financial impact for the patient and others

An earlier return to mobility and normal activity following MIS would be expected to result in economic benefits both for themselves (e.g. earlier return to work) and for carers in reducing the need for time spent caring for the patient. However, there were no data available to support this inference.

It is unlikely that minimal incision approaches will be employed in all patients due to variations in individual patients' habitus, the variable complexity of reconstruction between cases and the variable experience of different surgeons.

Chapter 7
Implications for the NHS

Training

Relatively few orthopaedic surgeons in the UK are currently undertaking formal mini-incision THR. However, there is a trend to reduce incision size, which could be seen as a development of standard practice rather than a new technique which requires specific training.

Nevertheless, it would be prudent to advise that widespread adoption of this technique should be in the context of ongoing quality assurance processes relating to individual surgeons' practices. These might include audit and feedback from the National Joint Registry/Scottish Arthroplasty Project. Several studies addressed the issue of a learning curve for surgeons not familiar with this technique,[32,42,48,52,55] whereas others only included patients from surgeons who were considered to be experienced.[31,40,46,56] However, there was no consensus as to how many procedures would be sufficient to ensure a reasonable level of skill. It seems reasonable to propose, however, that initial training in mini-incision operations should occur in high-volume orthopaedic centres, and that surgeons performing THRs should perform a minimum number annually to maintain their expertise.

A further point to note is that if the use of MIS increases, this may reduce the number of cases of standard THRs available for the training of junior surgeons. Proficiency in mini-incision is achieved by performing the procedure and is, generally, not amenable to being taught on a training course (Hutchison JD, Department of Surgery, University of Aberdeen and Munro N, NHS Grampian: personal communication, April 2007). Generally, an orthopaedic surgeon would need to be proficient in the standard technique before modifying it to a mini-incision technique. We estimate that around two in five patients may be suitable for the mini-incision procedure (see the next section) and therefore not available for training in standard THR techniques. In addition, training in computer-aided navigation and robotic guidance might further reduce the necessary number of standard THRs available for the training of junior surgeons.

Training may also be provided by companies who are commercially motivated to sell their own THR appliances, and who may also supply THR 'kits' consisting of specially adapted retractors, light sources and so on in order to boost their sales. The desirability of this for the NHS is unclear.

Fair access and equity issues

Currently, MIS is variably utilised within the NHS, due to uncertainty about its safety and efficacy and the potential need for special training. However, it should be remembered that this operation is not suitable for all patients, particularly those who are obese, very muscular or with severe osteoporosis. This is for technical reasons related to operative difficulty, need for adequate operative access and a higher chance of complications in certain populations.

Estimates of the proportion of THR patients who might be suitable for this operation are not available, but around 6% of all THRs are currently performed via a mini-incision. Three studies included information about the proportions of patients potentially suitable for MIS. In one study, patients were selected for MIS based on their upper thigh or hip girdle girth:[45] 32/51 patients (63%) were considered to be small enough to be suitable for mini-incision THR. In another study,[55] where patients were selected for mini-incision THR based on body habitus (lower BMI), 50/135 patients (37%) received mini-incision THR. Finally, in a third study,[52] where the surgeons intended to use mini-incision THR, but then extended the incision length if required during the operation, 38/102 (37%) were successfully restricted to an incision of less than 10 cm, 43/102 (42%) had an intermediate incision length of 10–14 cm and 21/102 (21%) finally had an incision length of more than 14 cm. Interestingly, the final incision length correlated with increasing body habitus (mean BMI 26, 28 and 29.5, respectively). Hence, in an unselected population, just under 40% might be found to be suitable for mini-incision THR.

Second, the need for training and a need to maintain professional competence by performing a minimum number of operations may restrict the centres providing this technique to those with specialised hip surgeons. This may limit access to mini-incision operations by patients served by other centres.

Budgetary impact on the NHS

Given that the NHS operation costs of a mini-incision THR may be similar to those of standard incision, it would seem likely that increasing the numbers of THRs carried out via mini-incisions would not result in any appreciable change in NHS costs. However, this would depend on there being no significant increase in the need for revision surgery: long-term data for this outcome are lacking. It would be important to obtain long-term follow-up data for all THRs performed in the NHS, for example through the National Joint Registry.[3]

The use of two-incision approaches

Little evidence was available on the effectiveness of the two-incision approaches to minimal incision THR and it was not possible to estimate cost-effectiveness or budget impact of adopting these approaches. The generally accepted view among surgeons is that they have never been widely used and the conflicting evidence from the current report supports this stance.

Chapter 8
Discussion

Minimal incision THR continues a general trend towards the use of less invasive approaches in other surgical specialities. This study aimed to examine the clinical and cost-effectiveness of single mini-incision and two mini-incision procedures for THR compared with standard THR. The rationale behind the need for this research is that shorter incisions (usually 10 cm or less) may result in less muscle dissection, which may in turn lead to reduced morbidity and quicker recovery. On the other hand, shorter incisions may reduce visualisation at operation, leading to a potential risk of suboptimal placement of the prostheses, which may then lead to a higher rate of revisions than might be expected with standard THR. Failure of THR requiring replacement (revision) carries serious implications and so longer term performance is a major factor in the choice of method for THR. In addition to uncertainty about the relative effectiveness (including their effect on complication rates) of these minimally invasive techniques, there is also uncertainty about the relative costs of these procedures. In particular it was unclear whether the potential reduction in length of hospital stay would compensate for any increased cost of equipment.

Main results

The results of the review of clinical effectiveness suggest that single mini-incision procedures appear comparable to single standard incision procedures in terms of safety and quality of life following surgery. Single mini-incision surgery appeared to be associated with a small reduction in the loss of blood and operation time. The clinical and economic relevance of these results is uncertain and a matter for judgement. Recovery appears more rapid after MIS (although the magnitude of the reduction in time to return to usual activities is uncertain). This is reflected in a reduced hospital stay and quicker return to usual activities.

However, comparisons of longer term data and, in particular, revision rates, were inconclusive because of the small amount of data available and the limited duration of follow-up. The number of revisions observed during the follow-up periods was very small. For example, revision rates derived from the trial data were 0.5% (1/197) for mini-incision procedures compared with 0% (0/198) for standard incision procedures. The corresponding Peto OR was, as a result, 7.96 (95% CI 0.16 to 402.02). Clearly, such a wide CI is beyond the limits of clinical plausibility.

With respect to the two-incision procedure, the results are inconclusive and conflicting. Two-incision surgery is technically more complex than single-incision surgery and this may be reflected in a higher mean intraoperative blood loss and longer operation time (two of the three studies reporting on blood loss and all four studies reporting on operation time, found this difference to be statistically significant). On the other hand, the procedure may offer a shorter hospital stay and higher postoperative quality of life, compared with single mini-incision or standard incision procedures. However, data are sparse so these findings must be treated with caution. This operation has not been taken up with any enthusiasm by orthopaedic surgeons in the UK (Hutchison JD, Department of Surgery, University of Aberdeen and Munro N, NHS Grampian: personal communication, May 2007). After a further focused search of the most recent literature, there is little sign that the two-incision approach is being taken up any further than the current very small proportion in the UK. Further, there appears to be a decreasing trend in enthusiasm in the international literature.

Only two economic evaluations were identified that considered a comparison of minimally invasive approaches (Duwelius, 2006).[82] One of these, the unpublished US study, involved a comparison of two mini-incisions with single mini-incision and standard THR (Duwelius, 2006). The second study was a crude modelling exercise based on the results of the first study.[82] Neither study was methodologically robust and their results are unlikely to inform decision-makers.

Results of the economic evaluation conducted suggest similar costs and effects for mini-incision THR and standard incision THR. On average, mini-incision THR was found to be slightly less

costly than standard incision THR. This result is driven by the assumption that operation time and, more importantly, length of stay, are reduced and that little additional specialised equipment and instrumentation are required. In addition, an assumption around quicker return to usual activities following mini-incision THR results in the new intervention being slightly more effective than standard THR. Analyses were conducted over two time horizons (1 and 40 years). For both the short- and long-term analyses, the deterministic results were similar. It is only when we look at the stochastic analysis, however, that the importance of the 40-year analysis becomes apparent. The 40-year model allows a greater amount of uncertainty into the models' input parameters and when this is translated into the probability that mini-incision THR might be cost-effective, a reduction is seen in this rate from 95% to approximately 55% for all threshold values considered for society's willingness to pay for a QALY. Only here does the current huge level of uncertainty in relation to long-term outcomes become apparent. It was not possible to incorporate data to estimate the cost-effectiveness of two mini-incision THR as data are too sparse to allow any meaningful analysis to be conducted. Furthermore, no analysis by subgroup was performed due to the lack of data available. *Table 50* (p. 67) shows the deterministic results of the base-case model when it was repeated for a 40-year time horizon. As can be seen, the results are similar to those of the 1-year analysis.

The published results on subgroup differences do appear to indicate longer operation time for grossly obese patients (BMI >35) compared with patients with a BMI of <30 for the single incision procedures (irrespective of incision length).[46] Another study for the two-incision procedure also appears to indicate higher complication rates for obese patients (BMI >30) and also a training effect whereby operative time, blood loss and complication rates are higher with low-volume surgeons.[27]

Assumptions, limitations and uncertainties

The relatively small differences found between minimal and standard incision THR may be explained by a number of factors. First, THR with standard-length incision (usually 25–40 cm) has already been proved to be very successful in relieving pain and disability.[106] Moreover, some surgeons may have been using a progressively shorter incision in standard THR for many years.[107] Indeed, most of the included studies reported using average incision length of around 20 cm or less for the standard incision group. Hence measurable improvements with further shortening of incisions to less than 10 cm might be expected to be relatively small.

Nevertheless, given that minimal incision THR is a relatively new technique compared with standard THR, it is possible that the number of complications may increase, as minimal incision THR is generalised from surgeons with a special interest in this area to the wider community of surgeons who have a relatively low annual activity level for THR. It may also be possible that clinical performance of minimal incision THR will improve, as more surgeons gain proficiency in this technique. Further consideration is therefore required regarding the potential impact of this learning effect. Our searches identified 14 ongoing trials (of which four had been abandoned) and their results would represent a significant contribution to the area (Appendix 6).

Second, there is no consensus as to what constitutes a minimally invasive THR. The National Joint Registry has used a definition of incision length of ⩽10 cm. However, it has been argued by some that reduction in the dissection of soft tissue is more important with the less invasive approaches rather than incision length itself.[107,108] Yet it is not always clear within the included studies whether the deep dissection was sufficiently different between the mini-incision and standard incision groups. Of note, the cadaver study by Mardones and colleagues[109] comparing the two-incision technique with a single mini-incision technique reported that the degree of damage to the abductor muscle was actually greater with the two-incision incision technique.

Third, for most of the complications specified in the review, events were rare, while the sample size of the trials tended to be relatively small. Therefore, there was little information available. Most often, there were no clear differences, but confidence intervals were wide.

There is little research into the predictors of long-term success from short-term measures. We chose implant position (poor placement of cup or stem) and cement quality. It is possible that radiostereometry may be useful in this respect, but long-term research will be required to assess its value. The hypothesis is that if radiostereometry shows that the implant is stable at 2 years, it

should remain so. If the implant is moving, long-term surveillance may be required. If this hypothesis is proven, radiostereometry could be used to identify those patients whose implants are unstable (and hence require long-term surveillance) and discharge the rest from follow-up. This is a researchable question.

The study has largely been concerned with THR for patients with osteoarthritis. Since the incidence of osteoarthritis increases with age, the majority of participants in the studies included in the systematic review of effectiveness were in the older age groups. Therefore, the applicability of findings to younger age groups is uncertain. Although it might be expected that apart from younger patients possibly being more muscular or having previous trauma or childhood hip disease with subsequent deformity, and hence being less suitable for minimal incision approaches, there is no reason to expect the relative performance of the two approaches to be different in younger patients. The study also did not consider hip resurfacing. This operation is gaining popularity and is more commonly performed on a younger population.[3] The review also excluded studies that focused solely on patients with trauma and osteoporosis, who are also likely to have significantly different characteristics.

Because minimally invasive THR may be contraindicated in some patients (e.g. obese, muscular or having severe osteoporosis), it is plausible to expect a difference in the outcome of the THR on the basis of the type of patients. We had therefore planned analysis within subgroups as specified in Chapter 2. In the event, this was not performed due to the lack of data available. This is a common problem with any subgroup analyses and we acknowledge that the initial specification of subgroups represents an ideal. Indeed, amongst six[31,32,40,46,58,75] of the nine included trials that reported inclusion and exclusion criteria, patients were excluded from the trials for reasons such as weight, BMI, age, anaemia, neurological deficits and having 'difficult' hips requiring complex reconstruction (e.g. post-fracture).

The review of effectiveness and the subsequent economic evaluation were limited by the amount and quality of research on mini-incision THR. Our searches identified few high-quality RCTs. In most of the studies identified, the sample sizes were small and the duration of follow-up was short. Although the results from the review appear to show some short-term benefits for minimal incision THR, many of the complications arising from THR occur over a longer time span and, for these outcomes, data are lacking. Further expert opinion might have been used but it is unclear if estimates of relative effectiveness would be any more robust than those used here. Nevertheless, this might represent a potential weakness of the report. According to current NICE guidance on the selection of prostheses for primary THR,[106] the most recent available evidence shows that the best prostheses have revision rates of 10% or less at 10 years after surgery. Based on this evidence, NICE recommended that, wherever possible, the NHS should use implants and techniques that can be expected to last for 10 years or more.

Due to the small number of RCTs identified, the review of effectiveness included a number of non-randomised prospective comparative studies. The data from these comparative studies and the trials were not formally combined in the meta-analyses but their data were broadly consistent with those from the trials. However, in terms of dislocation rates, the results from the comparative studies suggested a trend towards lower rates following minimal incision as opposed to a trend towards standard THR based on data from the trials. In neither case was the difference statistically significant.

Data identified as part of the review of effectiveness were not always reported in a form amenable to meta-analysis. For continuous variables, means and SDs for both minimally invasive and standard THR were not always reported. More importantly, there seemed to be a tendency for these to be provided where the estimate was in a particular direction (e.g. duration of operation). For this reason, we chose to estimate missing data by imputing the standard error of the mean difference for individual studies on the basis of available information on *p*-values. This approach made the assumption that SDs are the same in both arms of the trial. Where information on *p*-values was also unavailable, 'dummy' SDs were imputed as the weighted means of SDs reported in the other studies which did report data on the same outcome or where they could be imputed from *p*-values.

In addition to problems with obtaining data amenable to meta-analysis, there are also some concerns about the usefulness of some of the meta-analyses that could be conducted. There was evidence of statistical heterogeneity in the trial data on length of hospital stay. As reported above, when using a fixed effects approach length of stay

was shorter for the mini-incision approach compared with standard THR. When data were reanalysed using a random effects model instead of a fixed effects model the difference in length of hospital stay was no longer statistically significant. It also needs to be borne in mind that length of hospital stay may be influenced by hospital policy for discharge rather than the clinical needs of each patient. Statistical heterogeneity was also evident in the trial data on operation time. The results from a fixed effects approach favoured the mini-incision approach but when a random effects model was applied, the difference in operation time was no longer statistically significant. Caution is therefore required in interpreting these findings.

The studies included in the review of effectiveness also varied in terms of surgeon experience (learning curve effect) and operative approach used (e.g. posterior, anterior). Lack of standardisation in outcome measurements was also evident, particularly in terms of quality of life such as postoperative pain and functional recovery, and some outcomes were assessed in only one or two reports. This made comparison across studies difficult.

There are also possible uncontrolled factors influencing the outcomes of THR. For example, aggressive rehabilitation programmes may offer a shorter recovery period regardless of incision length.[110] Patients' awareness of incision length may be another factor influencing outcomes: although blinding the patients to the incision size is difficult, patients who are aware of a smaller incision may recover slightly more quickly than those who are not.[111]

As with any economic evaluation, a number of assumptions have been made, mostly in response to the very limited data available. For example, results from the meta-analysis conducted as part of the review of effectiveness in relation to long-term outcomes such as revision were so limited that they were not used in the economic evaluation. As a result, it has been assumed for the base-case analysis that differences in complications are equal following both forms of surgery (but with wide CIs). Although this is a strong assumption to make, it was deemed appropriate given that no statistically significant differences were found in the outcomes of interest and that any differences that did exist would likely be small. Nevertheless, further long-term data following mini-incision THR are essential. This being said, the baseline risks of complications from long-term Swedish Registry data are so small that only large differences in relative complications following mini-incision THR in comparison with standard THR would greatly alter the cost-effectiveness results. A threshold analysis around revisions showed that if society were willing to pay £30,000 for a QALY, mini-incision THR would have to be associated with a 7.5% increase in revisions for it to be no longer considered cost-effective. Given the likely absolute rate of revisions for standard THR, this is approximately equal to one more revision for every 200 procedures performed.

In the economic model, estimates of the absolute effectiveness of minimal incision THR for many parameters were based on combining relative effect sizes for the differences between minimal incision THR with estimates for the absolute effectiveness of standard THR. One of the main sources of data on the relative effectiveness of standard THR was the Swedish Registry. Although it is true that there are likely to be some differences between Scandinavian and UK populations, long-term UK specific data are lacking, The National Joint Registry for England and Wales is a recent innovation and their most recent report contains, for the main, a maximum follow-up of 3 years, and only a crude calculation of the risk of revision can be calculated. Furthermore, there is little information about postoperative complications. The Swedish Registry is internationally recognised as being the original and most respected database reporting the outcomes for THR. It is applicable to this study in that it covers a north European population with a predominantly public healthcare system. Traditionally, implant choice was more similar to that in the UK than in some countries with an emphasis on cemented implants (although this is starting to change a little in the UK). The advantage of such registry data in comparison with studies from individual hospitals or surgeons is that they may be more representative, and the large number of patients included, allow estimates for outcomes to be identified with greater precision. Unfortunately, at this time we are not aware of any formal publication comparing the two populations covered by the National Joint Registry for England and Wales and the Swedish Registry.

One area where data are lacking relates to the rate at which failed primary and revision THR patients might receive non-operative treatment as opposed to further revision surgery. It was assumed that there would be no difference in this rate following both modes of surgery. If, in the future,

differences are found to lie in this area, then the costs and consequences of this will have to be addressed.

The main cost drivers in the model are the reduced hospital length of stay and operation duration assumed to be associated with minimal incision THR. These estimates were taken from the review of effectiveness and, as stated previously, these estimates are uncertain. When the analysis was repeated but with the alternative assumption that there were no economically important differences in operation time or length of stay, mini-incision THR became more costly than standard THR by approximately £200 per patient. Further data relevant to the UK are needed to judge whether any differences in length of hospitalisation and operation exist and, if they do exist, whether they are economically important.

In addition to limitations in estimates of the relative effect sizes, there are also concerns about the limited cost and utilities data available. In the case of costs, no high-quality economic evaluations have been conducted, so a bottom-up costing of the two forms of surgery was attempted. However, it was not possible to include all relevant elements of the operation cost. For example, certain cost elements in relation to hospital resource use, such as consumables, instrumentation and equipment costs, were not available and therefore not included in the calculation of operation cost. Nonetheless, it is likely that such elements would be similar for both mini-incision and standard THR procedures and that their inclusion would not greatly alter the estimated difference in cost between the two procedures. Furthermore, in terms of operating room instrumentation, it has been assumed in this report that only a specialised minimally invasive instrumentation kit would be required in addition to the standard THR instrumentation kit. Nevertheless, it is plausible that further additional instrumentation and equipment might be used depending on the preference of the surgeon and the particular surgical centre. In such instances, these elements of cost would need to be accounted for. With respect to utilities few useable data were available relevant to the comparison of mini-incision to standard THR, although data from one RCT were used for a sensitivity analyses. The trial, however, was very small, so estimates are subject to considerable imprecision. Some exploration of the likely importance of any difference in health state utilities was provided by the threshold analysis which was conducted. For the base-case analysis, mini-incision THR remained a less costly but more effective alternative than standard THR provided that it was assumed that it was associated with a quicker recovery. In the analysis which assumed that mini-incision THR is associated with more intensive resource usage, then recovery would need to be on average 1.5 weeks sooner before the incremental cost per QALY was £30,000.

It was not possible to conduct any subgroup analysis around model estimates. Consequently, it is not possible to assess the suitability of minimal incision THR techniques to particular patient demographics and operative approaches and hence the applicability of results to all groups is limited.

Chapter 9
Conclusions

Implications for the NHS

- Compared with standard THR, minimal incision THR has small perioperative advantages in terms of blood loss and operation time. It may offer a shorter hospital stay and quicker recovery. It appears to have a similar procedure cost to standard THR, but evidence on its longer term performance is very limited.
- There is no evidence of differences between patients receiving minimal incision and standard incision THRs in postoperative complication rates and self-reported quality of life.
- The use of single mini-incision THR continues a trend within the NHS towards the use of minimally invasive procedures. Given the similarities between minimal incision and standard THR, the adoption of minimal incision THR would involve relatively small changes compared with the adoption of other minimally invasive procedures.
- The main uncertainty is the related long-term performance of minimal incision THR.
- A 7.5% difference in revision rates would be required for minimal incision THR for it no longer to be considered cost-effective at a £30,000 threshold.
- It is plausible that the longer term outcomes following minimal incision THR will be similar to those of standard THR. Therefore, there is no current evidence to suggest that its use should be restricted.
- Due to the difficulty in obtaining adequate visualisation of the hip, minimal incision THR may be technically more difficult. It is this lack of visualisation that has led to concerns that the risk of revision and dislocation may be higher than with standard THR. Appropriate training is needed for both patient selection and technical aspects of the procedure.
- Few data were identified relevant to the two minimal incision THR approach. Given its current low use within the NHS, these data provide no basis to suggest that this approach should be further adopted.
- Standard THR remains an effective treatment. As the apparent short-term benefits of minimal incision THR are modest, the quality of an individual operation should not be compromised purely to conform to an arbitrary limit in terms of wound size.
- The increase in minimal incision THRs performed may reduce the number of cases of standard THRs available for the training of junior surgeons. Generally, an orthopaedic surgeon would need to be proficient in the standard technique before modifying it to a mini-incision technique and, when it is taken into account that further training might be required in computer aided navigation and robotic guidance, this might reduce still further the necessary number of standard THRs required for training.

Implications for patients and carers

- The use of minimal incision THR could provide advantages to patients in terms of reduced time under anaesthetic and possibly less time in hospital. The shorter incision and reduced muscle dissection also result in a quicker recovery. It would be natural for patients to want to obtain these benefits but they should be aware that the longer term outcomes are uncertain.
- The use of minimal incision THR is not suitable for all patients. It is generally not recommended for those who are obese or heavily muscled and for those with significant deformity or severe osteoporosis.
- Compared with standard THR, minimal incision THR is a relatively new and evolving technique. As a consequence, the procedure may not be practised by all surgeons who perform THR.

Implications for research

- An important issue that needs to be addressed formally by the orthopaedic community relates to definitional issues around minimally invasive techniques. Currently, there is little consensus across studies, making the evaluation of such techniques especially difficult.
- The main difficulty about making a decision to use minimal incision THR is lack of reliable

information on longer term outcomes, especially revision and other long-term complications.

- Securing reliable information on longer term outcomes is not straightforward. The ideal design would be a sufficiently large RCT with follow-up for at least 5 years. However, differences in long-term performance are not likely to be large and so a big trial would be needed to provide sufficiently precise estimates, and this may not be feasible and/or worth the cost. If such a trial were to be conducted, however, it would be recommended that an economic evaluation be conducted as part of it.
- Data from national registers, such as the National Joint Registry and the Scottish Arthroplasty Project, would certainly be useful for assessing short-term complications and operator issues, such as related to training and learning. Registers can include large numbers of procedures and hence give relatively precise estimates; however, registers would be less satisfactory than large RCTs for assessing differences in long-term outcome because the selection bias inherent in a register is likely to obscure or exaggerate any true differences between minimal incision THR and standard THR.
- This lack of understanding of long-term outcomes translates into uncertainty about longer term costs. Such costs related to minimal incision and standard THRs, therefore, would likely be enhanced by reliable data from high-quality RCTs.
- The need for long-term observation is a major impediment for assessing developments in hip and other joint replacement; research to fund reliable surrogate outcomes that can be measured earlier should therefore be encouraged, for example collection of data in relation to implant position, cement quality and radiostereometry.
- Further research around the use of robotic guidance and computer navigation techniques to improve positioning of the implants may also be worthwhile.
- Further research is required in relation to the operative approach from different locations (i.e. posterior, anterior).
- Direct measurements of health state utilities to reflect potential differences in pain, mobility, return to normal activities and general quality of life are required to supplement the available evidence base from RCTs so that the economic evaluation of minimal incision THR can be made more robust.
- If two minimal incision THR is to be adopted widely, high-quality RCTs comparing two minimal incision with standard THR are necessary. Given that this technique has generally fallen out of favour within the UK orthopaedic community and, as a consequence, has a low use within the NHS, such trials are unlikely to be considered worthwhile.

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Mari Imamura (Research Fellow), Shihua Zhu (Research Fellow) and Cathryn Glazener (Reader) completed the review of effectiveness. Robyn de Verteuil (Research Assistant) conducted the review of economic evaluations and the economic modelling. Cynthia Fraser (Information Officer) developed and ran the search strategies and was responsible for obtaining papers and for reference management. Niall Munro (Consultant in Orthopaedics) and James Hutchison (Regius Professor of Surgery) drafted the background chapter and along with Douglas Coyle (Associate Professor), Kathryn Coyle (Consultant) and Adrian Grant (Professor of Health Services Research) provided advice and commented on drafts of the review. Luke Vale (Professor of Health Technology Assessment) led the review team.

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Appendix 1

Search strategies

Clinical effectiveness

Search strategies used to identify reports of clinical effectiveness of minimally invasive hip arthroplasty

MEDLINE (1966–February Week 3 2007), EMBASE (1980–2007 Week 8) (MEDLINE In-Process 1 March 2007)

Ovid multi-file search.

URL: http://gateway.ovid.com/athens

1 Arthroplasty, Replacement, Hip/
2 Total Hip Prosthesis/ use emez
3 Hip Prosthesis/
4 (hip adj3 (arthroplast$ or replace$ or prosthes$ or implant$)).tw.
5 or/1-4
6 Osteoarthritis,Hip/su
7 exp Arthritis/su
8 (osteoarthritis or arthritis).tw.
9 hip.tw,hw.
10 (7 or 8) and 9
11 or/6,10
12 Hip Joint/su use mesz
13 Hip/su use mesz
14 Hip Surgery/ use emez
15 (arthroplast$ or replace$ or prosthes$ or implant$).tw.
16 (12 or 13 or 14) and 15
17 5 or 11 or 16
18 Surgical procedures,minimally invasive/
19 Robotics/
20 Video-assisted Surgery/
21 (minimal$ adj3 (invasiv$ or access$ or surg$)).tw.
22 ((small or single or double or mini or one or two) adj3 incision$).tw.
23 computer aid$.tw.
24 robotic$.tw.
25 (key hole or keyhole).tw.
26 (less adj5 invasiv$).tw.
27 or/18-26
28 17 and 27
29 humans/
30 animals/ or nonhuman/
31 30 not (29 and 30)
32 28 not 31
33 remove duplicates from 32

Science Citation Index (1985–2 March 2007), Biosis (1985–1 March 2007)

Web of Knowledge. URL: http://wok.mimas.ac.uk/

#1 TS=(hip SAME arthroplast*)
#2 TS=(hip SAME replace*)
#3 TS=(hip SAME prosthes*)
#4 TS=(hip SAME implant*)
#5 TS=(hip SAME (surgery or surgical))
#6 #1 or #2 or #3 or #4 or #5
#7 TS=(minimal* SAME (invasiv* or access* or surg*))
#8 TS=((small or single or double or mini or one or two) SAME incision*)
#9 TS=(robotic* or computer-aid*)
#10 #7 or #8 or #9
#11 #6 and #10

Cochrane Library (Issue 1, 2007)

URL: http://www3.interscience.wiley.com/cgi-bin/mrwhome/106568753/HOME

#1 MeSH descriptor Arthroplasty, Replacement, Hip, this term only
#2 MeSH descriptor Hip Prosthesis, this term only
#3 MeSH descriptor Osteoarthritis, Hip, this term only with qualifier: SU
#4 MeSH descriptor Arthritis explode all trees with qualifier: SU
#5 MeSH descriptor Hip Joint, this term only with qualifier: SU
#6 MeSH descriptor Hip, this term only with qualifier: SU
#7 (arthroplast* or replace* or prosthes* or implant*)
#8 (((#5 OR #6) AND #7)
#9 (hip near/3 (arthroplast* or replace* or prosthes* or implant*))
#10 (osteoarthritis or arthritis) and (hip)
#11 (hip)
#12 (#4 AND #11)
#13 (#1 OR #2 OR #3 OR #8 OR #9 OR #10 OR #12)
#14 MeSH descriptor Surgical Procedures, Minimally Invasive, this term only
#15 MeSH descriptor Robotics, this term

#16 MeSH descriptor Video-Assisted Surgery, this term only
#17 (minimal* near/3 (invasiv* or access* or surg*)) or ((small or single or double or mini or one or two) near/3 incision*) or (computer aid*) or (robotic* or key hole or keyhole) or (less near/3 invasiv*)
#18 (#14 OR #15 OR #16 OR #17)
#19 (#13 AND #18)

National Research Register (Issue 4, 2006)
URL: http://www.update-software.com/National/
1 MeSH Arthroplasty, Replacement, Hip
2 MeSH Hip Prosthesis
3 MeSH Osteoarthritis, Hip QUALIFIERS SU
4 MeSH Arthritis QUALIFIERS SU EXPLODE 1
5 MeSH Hip Joint QUALIFIERS SU
6 MeSH Hip QUALIFIERS SU
7 (arthroplast* or replace* or prosthes* or implant*)
8 ((#5 or #6) and #7)
9 (hip near/3 (arthroplast* or replace* or prosthes* or implant*))
10 ((osteoarthritis OR arthritis) AND hip)
11 hip
12 (#4 and #11)
13 (#1 OR #2 OR #3 OR #8 OR #9 OR #10 OR #12)
14 MeSH Surgical Procedures, Minimally Invasive
15 MeSH Robotics
16 MeSH Video-Assisted Surgery
17 (minimal* near (invasiv* or access* or surg*)
18 (small or single or double or mini or one or two) near incision*)
19 (computer aid*)
20 (robotic* or key hole or keyhole)
21 (less near invasiv*)
22 #14 or #15 or #16 or #17 or #18 or #19 or #20 or #21
23 #13 and #22

Clinical Trials (December 2006)
URL: http://clinicaltrials.gov/ct/gui/c/r
Hip and minimally and (arthroplasty or replacement)

Current Controlled Trials (December 2006)
URL: http://www.controlled-trials.com/
Hip and Minimal% and (arthroplast% or replac% or implant% or prosthes% or surg%)

Cost-effectiveness and economic evaluations

Search strategies used to identify reports of cost-effectiveness and economic evaluations of minimally invasive hip arthroplasty

MEDLINE (1966–February Week 3 2007), EMBASE (1980–Week 8 2007) (MEDLINE In-Process 1 March 2007)
Ovid multi-file search. URL: http://gateway.ovid.com/
1 Arthroplasty, Replacement, Hip/
2 Total Hip Prosthesis/ use emez
3 Hip Prosthesis/
4 (hip adj3 (arthroplast$ or replace$ or prosthes$ or implant$)).tw.
5 or/1-4
6 Osteoarthritis,Hip/su
7 exp Arthritis/su
8 (osteoarthritis or arthritis).tw.
9 hip.tw,hw.
10 (7 or 8) and 9
11 or/6,10
12 Hip Joint/su use mesz
13 Hip/su use mesz
14 Hip Surgery/ use emez
15 (arthroplast$ or replace$ or prosthes$ or implant$).tw.
16 (12 or 13 or 14) and 15
17 5 or 11 or 16
18 Surgical procedures,minimally invasive/
19 Robotics/
20 Video-assisted Surgery/
21 (minimal$ adj3 (invasiv$ or access$ or surg$)).tw.
22 ((small or single or double or mini or one or two) adj3 incision$).tw.
23 computer aid$.tw.
24 robotic$.tw.
25 (key hole or keyhole).tw.
26 (less adj5 invasiv$).tw.
27 or/18-26
28 17 and 27
29 exp "costs and cost analysis"/
30 economics/
31 exp economics,hospital/
32 exp economics,medical/
33 economic,pharmaceutical/
34 exp budgets/
35 exp models, economic/
36 exp decision theory/
37 ec.fs. use mesz
38 monte carlo method/
39 markov chains/
40 exp quality of life/
41 "Value of Life"/

42 cost of illness/
43 exp health status indicators/
44 cost$.ti.
45 (cost$ adj2 (effective$ or utilit$ or benefit$ or minimis$)).ab
46 economics model$.tw.
47 (economics$ or pharmacoeconomic$ or pharmo-economic$).ti.
48 (price$ or pricing$).tw.
49 (financial or finance or finances or financed).tw.
50 (value adj2 (money or monetary)).tw.
51 quality adjusted life.tw.
52 disability adjusted life.tw.
53 (qaly? or qald? or qale? or qtime? or daly?).tw.
54 (euroqol or euro qol or eq5d or eq 5d).tw.
55 (hql or hqol or h qol or hrqol or hr qol).tw.
56 (hye or hyes).tw.
57 (health adj3 (indicator? or status or utilit?)).tw.
58 markov$.tw.
59 monte carlo.tw.
60 (decision$ adj2 (tree? or analy$ or model$)).tw.
61 or/29-60
62 28 and 61
63 Remove duplicates from 62

Science Citation Index (1985–2 March 2007)
Web of Knowledge URL: http://wok.mimas.ac.uk/
#1 TS=(hip SAME arthroplast*)
#2 TS=(hip SAME replace*)
#3 TS=(hip SAME prosthes*)
#4 TS=(hip SAME implant*)
#5 TS=(hip SAME (surgery or surgical))
#6 #1 or #2 or #3 or #4 or #5
#7 TS=(minimal* SAME (invasiv* or access* or surg*))
#8 TS=((small or single or double or mini or one or two) SAME incision*)
#9 TS=(robotic* or computer-aid*)
#10 #7 or #8 or #9
#11 #6 and #10
#12 TS=economic*
#13 TS=cost*
#14 TS=(price* OR pricing*)
#15 TS=(financial or finance*)
#16 TS=(decision* SAME (tree* OR analy* or model*))
#17 TS=markov*
#18 TS=monte carlo
#19 TS=(health SAME (indicator* or status or utilit*))
#20 TS=quality of life
#21 TS=quality adjusted life
#22 TS=disability adjusted life
#22 TS=(qaly* or qald* or qale* or qtime* or daly*)
#23 TS=(euroqol* or euro qol* or eq5d or eq 5d)
#24 TS=(hql or hqol or h qol or hrqol or hr qol)
#25 TS=(hye or hyes)
#26 #12 or #13 or #14 or #15 or #16 or #17 or #18 or #19 or #20 or #21 or #22 or #23 or #24 or #25
#17 #11 and #26

NHS EED (December 2006)
URL: http://www.york.ac.uk/inst/crd/nhsdhp.htm
#1 MeSH Arthroplasty, Replacement, Hip EXPLODE 1 2
#2 MeSH Hip Prosthesis EXPLODE 1
#3 hip
#4 arthroplasty OR replac* OR prosthes* OR implant*
#5 #3 And #4
#6 #1 OR #2 OR #5

Search strategy for additional search for utilities, cost data and revision rates for total hip arthroplasty

MEDLINE (1995–January Week 5 2007), EMBASE (1995–2007 Week 5) (MEDLINE In-Process 8 February 2007)
Ovid multi-file search URL: http://gateway.ovid.com/athens
1 Arthroplasty, Replacement, Hip/
2 Total Hip Prosthesis/ use emez
3 Hip Prosthesis/
4 (hip adj3 (arthroplast$ or replace$ or prosthes$ or implant$)).tw.
5 or/1-4
6 Hip Joint/su use mesz
7 Hip/su use mesz
8 Hip Surgery/ use emez
9 (arthroplast$ or replace$ or prosthes$ or implant$).tw.
10 (6 or 7 or 8) and 9
11 5 or 10
12 exp quality of life/
13 "Value of Life"/
14 cost of illness/
15 exp health status indicators/
16 quality adjusted life.tw.
17 disability adjusted life.tw.
18 (qaly? or qald? or qale? or qtime? or daly?).tw.
19 (euroqol or euro qol or eq5d or eq 5d).tw.
20 (hql or hqol or h qol or hrqol or hr qol).tw.
21 (hye or hyes).tw. (70)
22 (health adj3 (indicator? or status or utilit?)).tw.
23 markov$.tw.
24 monte carlo.tw.
25 (decision$ adj2 (tree? or analy$ or model$)).tw.
26 or/12-24
27 11 and 26

28 27 and eng.la. (1076)
29 limit 28 to yr="1995 - 2007"
30 remove duplicates from 29
31 (case reports or letter).pt.
32 30 not 31
33 exp "costs and cost analysis"/
34 economics/
35 exp economics,hospital/
36 exp economics,medical/
37 economics,pharmaceutical/
38 exp budgets/
39 exp models, economic/
40 exp decision theory/
41 ec.fs. use mesz
42 monte carlo method/
43 markov chains/
44 cost$.ti.
45 (cost$ adj2 (effective$ or utilit$ or benefit$ or minimis$)).ab.
46 economics model$.tw. (16)
47 (economics$ or pharmacoeconomic$ or pharmo-economic$).ti.
48 (price$ or pricing$).tw.
49 (financial or finance or finances or financed).tw.
50 (value adj2 (money or monetary)).tw.
51 or/33-50
52 11 and 51
53 united kingdom/ use emez
54 exp great britain/ use mesz
55 53 or 54
56 52 and 55
57 remove duplicates from 56
58 exp prosthesis failure/
59 prosthesis-related infection/ use mesz
60 prosthesis infection/ use emez
61 hip prosthesis/ae
62 follow-up studies/ use mesz
63 follow-up/ use emez
64 10 year$.ti.
65 ten year$.ti.
66 (11 year$ or eleven year$).ti
67 (12 year$ or twelve year$).ti.
68 (13 year$ or thirteen year$).ti.
69 (14 year$ or fourteen year$).ti.
70 (15 year$ or fifteen year$).ti.
71 (20 year$ or twenty year$).ti.
72 cohort studies/
73 or/58-63,72
74 11 and 73
75 ((failed or failure) adj3 (prosthes$ or arthroplast$ or operat$)).tw.
76 ((re operat$ or reoperat$ or revision) adj rate$).tw.
77 (follow up or long term or longterm).ti.
78 or/64-71,75-77
79 74 and 78
80 79 not 31
81 limit 80 to english language
82 limit 181to yr="1995 - 2007"
83 remove duplicates from 82
84 32 or 57 or 83

General searches

Search strategies used to identify reports of clinical or cost effectiveness of minimally invasive hip arthroplasty

HMIC (1979–January 2007)

URL: http://gateway.ovid.com/

1 joint replacement surgery/
2 arthroplasty/
3 hip.tw,hw.
4 (1 or 2) and 3
5 (hip adj3 (arthroplast$ or replac$ or prosthes$)).tw.
6 4 or 5
7 hip joint replacement/
8 6 or 7
9 minimally invasive therapy/
10 (minimal$ adj3 (invasiv$ or access$ or surg$)).tw.
11 ((small or single or double or mini or one or two) adj3 incision$).tw.
12 or/9-11
13 8 and 12

DARE and HTA Databases (December 2006)
NHS Centre for Reviews and Dissemination

URL: http://nhscrd.york.ac.uk/welcome.htm

#1 MeSH Arthroplasty, Replacement, Hip EXPLODE 1 2
#2 MeSH Hip Prosthesis EXPLODE 1
#3 hip
#4 arthroplasty OR replac* OR prosthes* OR implant*
#5 #3 And #4
#6 #1 OR #2 OR #5

National Registries consulted

AOA National Joint Replacement Registry (Australian). URL: http://www.dmac.adelaide.edu.au/aoanjrr/index.jsp
Canadian Joint Replacement Registry. URL: http://secure.cihi.ca/cihiweb/dispPage.jsp?cw_page=services_cjrr_about_e
Danish Hip Arthroplasty Registry. URL: http://www.dhr.dk/ENGLISH.htm
European Arthroplasty Register. URL: http://www.ear.efort.org/
Finnish Arthroplasty Registry. URL: http://www.nam.fi/english/publications/

Norwegian Arthroplasty Register. URL: http://www.haukeland.no/nrl/
Romanian Arthroplasty Register. URL: http://www.rne.ro/site/
Scottish Arthroplasty Project. URL: http://www.arthro.scot.nhs.uk/
Swedish National Hip Arthroplasty Regstry. URL: http://www.jru.orthop.gu.se/
New Zealand National Joint Registry. URL: http://www.cdhb.govt.nz/NJR/
UK National Joint Registry. URL: http://www.njrcentre.org.uk/

Conference Proceedings Abstracts:

Amercian Academy of Orthopaedic Surgeons (AAOS)
2003 Annual Meeting, San Fransisco, CA, March 2003.
2004 Annual Meeting, New Orleans, LA, March 2004.
2005 Annual Meeting, Washington, DC, February 2006.
2006 Annual Meeting, Chicago, IL, March 2006.

American Association of Hip and Knee Surgeons (AAHKS)
15th Annual Meeting, Dallas,TX, November 2005.
16th Annual Meeting, Dallas,TX, November 2006.

American Orthopaedic Assocation (AOA)
117th Annual Meeting, Boston, MA, June 2004.
118th Annual Meeting, Huntington Beach, CA, June 2005.
119th Annual Meeting, San Antonio, TX, June 2006.

Association of Bone and Joint Surgery (ABJS):
57th Annual Meeting, Carmel, CA, June 2005
58th Annual Meeting, Buenos Aires, April 2006

British Hip Society
Annual Meeting, Belfast, February 2003.
Annual Meeting, Sheffield, March 2004.
Annual Meeting, Wrightington Hospital, March 2005.
Annual Meeting, Edinburgh, March 2006.

British Orthopaedic Association (BOA)
Annual Congress, Manchester, September 2004.
Annual Congress, Birmingham, September 2005.
Annual Congress, Glasgow, September 2006.

Hip Society and AAHKS
9th Annual Combined Open Meeting, New Orleans, LA, February 2003.
10th Annual Combined Open Meeting 2004 San Fransisco, CA, March 2004.
11th Annual Combined Open Meeting 2005 Washington, DC, February 2005.
12th Annual Combined Open Meeting 2006 Chicago, IL, March 2006.

International Society for Technology in Arthoplasty (ISTA)
18th Annual Symposium, Kyoto, October 2005.
19th Annual Symposium,Washington,DC, October 2006.

Mid-American Orthopaedic Association
22nd Annual Meeting, La Quinta April 2004.
23rd Annual Meeting, Amelia Island, FL, April 2005.
24th Annual Meeting, San Antonio, TX, April 2006.

Journals (full-text search)

***Journal of Arthroplasty* (2000–February 2007)**
Science Direct. URL: www.sciencedirect.com/

***Journal of Bone and Joint Surgery, American Volume* (2000–March 2007)**
URL: http://www.ejbjs.org/

***Journal of Bone and Joint Surgery, British Volume* (2000–February 2007)**
URL: www.jbjs.org.uk/

***Clinical Orthopaedics and Related Research* (2000–February 2007)**
Ovid Journals. URL: http://gateway.ovid.com/athens

Hip* and (minimal* or MIS or incision*)

Websites searched for other evidence-based reports and background information

American Academy of Orthopaedic Surgeons. URL: http://www.aaos.org/
American Association of Hip and Knee Surgeons. URL: http://www.aahks.org/
British Hip Society. URL: http://www.britishhipsociety.com/
British Orthopaedic Association. URL: http://www.boa.ac.uk/
Depuy International (Johnson & Johnson). URL: http://jnjgateway.com/
Smith and Nephew. URL: http://www.smithnephew.com/
Styker. URL: http://www.stryker.com/
Zimmer. URL: http://www.zimmer.co.uk/

Appendix 2

Study eligibility form

Minimally invasive hip arthroplasty versus conventional hip arthroplasty for the treatment of arthritic disease of the hip

Assessor initials: _____ Date assessed: _____

Study identifier
(surname of first author + year of publication)

Type of study

Q1. Is the study (*circle one number*)
1. a randomised controlled trial, or
2. a comparative study (at least 2 groups) or
3. a case series/cohort study?
4. other

Yes ⇩ Go to next question
Unclear ⇩ Go to next question
No ⇩ **Exclude**

Design: FU:

Participants in the study

Q2. Are some or all of the participants in the study adults with arthritis (excluding osteoporosis, fracture or tumour)?

Yes ⇩ Go to next question
Unclear ⇩ Go to next question
No ⇩ **Exclude**

Interventions in the study

Q3. Did some or all of the participants receive minimally invasive primary total hip replacement (and not revision surgery or hip resurfacing or computer modelling surgery)?

Yes ⇩ Go to next question
Unclear ⇩ Go to next question
No ⇩ **Exclude**

Outcomes in the study

Q4. Does the study report short-term and/or long-term outcome data on the patients that underwent the intervention(s)?
For case series/cohort studies only rare complications and long-term outcomes are to be collected.

Yes ⇩ **Include**
Unclear ⇩ **Include**
No ⇩ **Exclude**

Final decision (subject to clarification of 'unclear' points) **Include** **Unclear** **Exclude**

Appendix 3

Data extraction form

Minimally invasive hip arthroplasty versus conventional hip arthroplasty for the treatment of arthritic disease of the hip

Reviewer ID: ☐ Date: _____

Study	
Study ID: **Country:** Funding: government/private/manufacturer/other (specify) **Additional information on study design** (e.g. prospective/ retrospective, method of randomisation):	RCT ☐ Quasi-RCT ☐ Cohort study (Comparative) ☐ Cohort study (one-group) ☐ Unclear ☐

Participants
Recruitment dates: _____ Number of eligible patients: _____Number of patients randomised: _____
Criteria for Inclusion:
Criteria for Exclusion:

Intervention		
	Surgical technique	**No of Patients**
Intervention 1		
Intervention 2		
Intervention 3		
Comments: **(i.e. operator information, specialised equipment used, length of incision)**		

Patient Characteristics				
Specify	**Intervention 1**	**Intervention 2**	**Intervention 3**	**Overall**
Age (years)				
Sex (M/F)				
Body weight (kg)				
Height				
BMI				
Muscular patient* (%)				
Significant bone deformity* (%)				
Severe osteoporosis* (%)				
Emergency case (%)				
Follow-up period: _____ Number of patients lost to follow-up: _____				
Comments:				

* Note details on how assessed

Indications for total hip replacement				
Specify	**Intervention 1**	**Intervention 2**	**Intervention 3**	**Overall**
Total (No.) **Arthritis** • **Degenerative arthritis (osteoarthritis)** • **Rheumatoid arthritis**				
Deformity				

Operative approach				
Specify	**Intervention 1**	**Intervention 2**	**Intervention 3**	**Overall**
Total (No.) **Operative method performed?** • Anterolateral • Lateral • Posterolateral • Transtrochanteric **Type and name of prosthesis used?** **Cemented or uncemented procedure?**				

Short-term Outcomes			
Intra-operative	**Intervention 1**	**Intervention 2**	**Intervention 3**
Duration of operation (min)			
Operating theatre throughput			
Blood loss			
Opposite method initiated (pre-operative)			
Intra-operative fracture			
Conversion (intra-operative)			
Post-operative			
Dislocation			
Infection (specify, e.g. wound)			
Nerve injury			
Vascular injury			
Deep vein thrombosis			
Peri-prosthetic fracture			
30 day mortality			
Length of hospital stay			

Post-operative pain (specify)			
Time to return to usual activities (days)			
Implant position (radiographic analysis)			
Other			
Long-term Outcomes	**Intervention 1**	**Intervention 2**	**Intervention 3**
Functional result (Harris hip, Mayo and Charnley scores)			
Pain relief			
Revision rates			
Time to revision (months)			
Health related quality of life			
Long term pain			
Limb length inequality			
Mortality			
Surrogates for long-term outcomes • Implant migration (radiostereometry anal) • Heterotopic ossification • Component orientation • Cement quality			
Other (e.g. patient perception/satisfaction)			
Additional information/Other comments			
Contact with Author			

Date: ……/……/…… Signature: ……

Appendix 4

Quality assessment form – RCTs

Minimally invasive hip arthroplasty versus conventional hip arthroplasty (Verhagen *et al.*, 1998)[26]

Reviewer ID: **Date:**

Question	*Yes*	*No*	Unclear
1. Was a method of randomisation performed? **Adequate approaches to sequence generation** • Computer-generated random tables • Random number tables **Inadequate approaches to sequence generation** • Use of alternation, case record numbers, birth dates or week days			
2. Was the treatment allocation concealed? **Adequate approaches to concealment of randomisation** • Centralised or pharmacy-controlled randomisation • Serially numbered identical containers • On-site computer based system with a randomisation sequence that is not readable until allocation • Other approaches with robust methods to prevent foreknowledge of the allocation sequence to clinicians and patients **Inadequate approaches to concealment of randomisation** • Use of alternation, case record numbers, birth dates or week days • Open random number lists • Serially numbered envelopes			
3. Were the groups similar at baseline regarding the most important prognostic indicators?			
4. Were the eligibility criteria specified?			
5. Was the outcome assessor blinded?			
6. Was the care provider blinded?			
7. Was the patient blinded?			
8. Were point estimates and measures of variability presented for the primary outcome measures?			
9. Did the analysis include an intention-to-treat analysis?			

Appendix 5

List of included studies

Included studies (full-text papers)

Archibeck, 2004
Archibeck MJ, White RE Jr. Learning curve for the two-incision total hip replacement. *Clin Orthop* 2004; **429**:232–8.

Asayama, 2006
Asayama I, Kinsey TL, Mahoney OM. Two-year experience using a limited-incision direct lateral approach in total hip arthroplasty. *J Arthroplasty* 2006; **21**:1083–91.

Berger, 2004
Berger RA. Mini-incision total hip replacement using an anterolateral approach: technique and results. *Orthop Clin North Am* 2004;**35**:143–51.

Chen, 2006
Chen J, Chen W, Zhou J, Huang H. Clinical research and following results on the minimal incision and traditional total hip arthroplasty. *Fudan Xuebao (Yixueban)* 2006;**33**:257–82.

Chimento, 2005
Primary reference
Chimento GF, Pavone V, Sharrock N, Kahn B, Cahill J, Sculco TP. Minimally invasive total hip arthroplasty: a prospective randomized study. *J Arthroplasty* 2005; **20**:139–44.

Secondary reference
Sculco TP, Jordan LC, Walter WL. Minimally invasive total hip arthroplasty: the Hospital for Special Surgery experience. *Orthop Clin North Am* 2004;**35**:137–42.

Chung, 2004
Chung WK, Liu D, Foo LS. Mini-incision total hip replacement – surgical technique and early results. *J Orthop Surg* 2004;**12**:19–24.

Ciminiello, 2006
Primary reference
Ciminiello M, Parvizi J, Sharkey PF, Eslampour A, Rothman RH. Total hip arthroplasty: is small incision better? *J Arthroplasty* 2006;**21**:484–8.

Secondary reference
Rothman RH, Ciminiello M, Parvizi J. Total hip arthroplasty: does incision length matter. Annual Meeting of the American Academy of Orthopaedic Surgeons, Washington, DC, March 2005. Paper No. 137.

De Beer, 2004
de Beer J, Petruccelli D, Zalzal P, Winemaker MJ. Single-incision, minimally invasive total hip arthroplasty: length doesn't matter. *J Arthroplasty* 2004; **19**:945–50.

DiGioia, 2003
Primary reference
DiGioia AM III, Plakseychuk AY, Levison TJ, Jaramaz B. Mini-incision technique for total hip arthroplasty with navigation. *J Arthroplasty* 2003; **18**:123–8.

Secondary references
DiGioia AM III. Mini incision supported by navigation. Annual Meeting of the American Academy of Orthopaedic Surgeons, San Francisco, March 2003. Symposia (ORS1).

Hafez MA, Seel MJ, Jaramaz B, DiGioia AM III. Navigation in minimally invasive total knee arthroplasty and total hip arthroscopy. *Oper Tech Orthop* 2006; **16**:207–10.

Dorr, 2007
Primary reference
Dorr L, Thomas D, Long W, Polatin P, Sirianni L. Psychologic reasons for patients preferring minimally invasive total hip arthroplasty. *Clin Orthop* 2007; **458**:94–100.

Secondary reference
Inaba Y, Dorr LD, Wan Z, Sirianni L, Boutary M. Operative and patient care techniques for posterior mini-incision total hip arthroplasty. *Clin Orthop* 2005; **441**:104–14.

Duwelius, 2007
Primary reference
Duwelius PJ, Burkhart RL, Hayhurst JO, Moller H, Butler JB. Comparison of the 2-incision and mini-incision posterior total hip arthroplasty technique. *J Arthroplasty* 2007;**22**:48–56.

Secondary reference
Duwelius PJ. Two-incision minimally invasive total hip arthroplasty: techniques and results to date. *Instr Course Lect* 2006;**55**:215–22.

Duwelius, 2003
Primary reference
Duwelius PJ, Berger RA, Hartzband MA, Mears DC. Two-incision minimally invasive total hip arthroplasty: operative technique and early results from four centers. *J Bone Joint Surg Am* 2003;**85A**:2240–2.

Secondary references
Berger RA, Duwelius PJ. The two-incision minimally invasive total hip arthroplasty: technique and results. *Orthop Clin North Am* 2004;**3**:163–72.

Berger RA. Total hip arthroplasty using the minimally invasive two-incision approach. *Clin Orthop* 2003; **417**:232–41.

Duwelius PJ, Berger RA. The two-incision minimally invasive total hip arthroplasty: technique and results. *Semin Arthroplasty* 2004;**15**:99–107.

Duwelius PJ. Two-incision minimally invasive total hip arthroplasty: techniques and results to date. *Instr Course Lect* 2006;**55**:215–22.

Flören, 2006
Flören M, Lester DK. Durability of implant fixation after less-invasive total hip arthroplasty. *J Arthroplasty* 2006;**21**:783–90.

Hart, 2005
Primary reference
Hart R, Stipcak V, Janecek M, Visna P. Component position following total hip arthroplasty through a miniinvasive posterolateral approach. *Acta Orthop Belg* 2005;**71**:60–4.

Secondary reference
Hart R, Stipcak V, Janecek M, Visna P. Radiological study of THA after mini-incision technique. *Hip Int* 2005;**15**:98–101.

Hartzband, 2006
Hartzband MA. Posterolateral mini-incision total hip arthroplasty. *Oper Tech Orthop* 2006;**16**:93–101.

Howell, 2004
Howell JR, Masri BA, Duncan CP. Minimally invasive versus standard incision anterolateral hip replacement: a comparative study. *Orthop Clin North Am* 2004; **35**:153–62.

Kim, 2006
Kim Y-H. Comparison of primary total hip arthroplasties performed with a minimally invasive technique or a standard technique. *J Arthroplasty* 2006;**21**:1092–8.

Li, 2005
Li Z, Shi Z, Guo W, Zhang N, Sun W. Preliminary experiences in minimally invasive and mini-incision surgery total hip arthroplasty for late osteonecrosis of the femoral head. *Chung Kuo Hsiu Fu Chung Chien Wai Ko Tsa Chih* 2005;**19**:710–13 (in Chinese).

O'Brien, 2005
O'Brien DA, Rorabeck CH. The mini-incision direct lateral approach in primary total hip arthroplasty. *Clin Orthop* 2005;**441**:99–103.

Ogonda, 2005
Primary reference
Ogonda L, Wilson R, Archbold P, Lawlor M, Humphreys P, O'Brien S, *et al*. A minimal-incision technique in total hip arthroplasty does not improve early postoperative outcomes. A prospective, randomized, controlled trial. *J Bone Joint Surg Am* 2005;**87**:701–10.

Secondary references
Lawlor M, Humphreys P, Morrow E, Ogonda L, Bennett D, Elliott D, *et al*. Comparison of early postoperative functional levels following total hip replacement using minimally invasive versus standard incisions. A prospective randomized blinded trial. *Clin Rehabil* 2005;**19**:465–74.

Bennett D, Ogonda L, Elliott D, Humphreys L, Beverland DE. Comparison of gait kinematics in patients receiving minimally invasive and traditional hip replacement surgery: a prospective blinded study. *Gait Posture* 2006;**23**:374–82.

Pagnano, 2006
Pagnano MW, Trousdale RT, Meneghini RM, Hanssen AD. Patients preferred a mini-posterior THA to a contralateral two-incision THA. *Clin Orthop* 2006; **453**:156–9.

Pilot, 2006
Pilot P, Kerens B, Draijer WF, Kort NP, ten Kate J, Buurman WA, *et al*. Is minimally invasive surgery less invasive in total hip replacement? A pilot study. *Injury* 2006;**37**:S17–23.

Pipino, 2004
Pipino F. CFP prosthetic stem in mini-invasive total hip arthroplasty. *J Orthop Traumatol* 2004;**5**:165–71.

Siguier, 2004
Siguier T, Siguier M, Brumpt B. Mini-incision anterior approach does not increase dislocation rate: a study of 1037 total hip replacements. *Clin Orthop* 2004; **426**:164–73.

Swanson, 2005
Swanson TV. Early results of 1000 consecutive, posterior, single-incision minimally invasive surgery total hip arthroplasties. *J Arthroplasty* 2005:**20**:26–32.

Szendrói, 2006
Szendrói M, Sztrinkai G, Vass R, Kiss J. The impact of minimally invasive total hip arthroplasty on the standard procedure. *Int Orthop* 2006;**30**:167–71.

Tanavalee, 2006
Tanavalee A, Jaruwannapong S, Yuktanandana P, Itiravivong P. Early outcomes following minimally invasive total hip arthroplasty using a two-incision approach versus a mini-posterior approach. *Hip Int* 2006;**16**:S17–22.

Teet, 2006
Teet JS, Skinner HB, Khoury L. The effect of the "mini" incision in total hip arthroplasty on component position. *J Arthroplasty* 2006;**21**:503–7.

Woolson, 2004
Primary reference
Woolson ST, Mow CS, Syquia JF, Lannin JV, Schurman DJ. Comparison of primary total hip replacements performed with a standard incision or a mini-incision. *J Bone Joint Surg Am* 2004;**86A**: 1353–8.

Secondary reference
Mow CS, Woolson ST, Ngarmukos SG, Park EH, Lorenz HP. Comparison of scars from total hip replacements done with a standard or a mini-incision. *Clin Orthop* 2005;**441**:80–5.

Wright, 2004
Wright JM, Crockett HC, Delgado S, Lyman S, Madsen M, Sculco TP. Mini-incision for total hip

arthroplasty: a prospective, controlled investigation with 5-year follow-up evaluation. *J Arthroplasty* 2004; **19**:538–45.

Yan, 2005
Yan Z-Q, Chen Y-S, Yang Y, Li W-J, Chen Z-R, Zhang G-J. Two-incision minimal invasive approach for total hip replacement. *Acta Acad Med Shanghai* 2005; **32**:557–60 (in Chinese).

Zhang, 2006
Zhang XL, Wang Q, Jiang Y, Zeng BF. Minimally invasive total hip arthroplasty with anterior incision. *Chung Hua Wai Ko Tsa Chih* 2006;**44**:512–15 (in Chinese).

Included studies (abstracts only)

Charles, 2006
Charles MN, Fejbel RJ, Kim P. Minimally invasive surgery of the hip – a randomized pilot study. Annual Meeting of the Canadian Orthopaedic Association, Toronto, June 2006. Poster 88.

Greidanus, 2006
Greidanus NV, Garbuz DS, Masri BA, Duncan CP, Callaghan JJ, Hozack WJ. Comparative cohort study of 2-incision versus 1-incision MIS THA. Annual Meeting of the American Academy of Orthopaedic Surgeons, Chicago, March 2006. Paper No. 200.

Pagnano, 2007a
Pagnano MW, Meneghini RM, Kaufman K, Colemam-Wood K, Berg E, Hanssen AD. No benefit of the 2-incision technique over miniposterior total hip arthroplasty: a comprehensive gait analysis and strength testing study. *J Arthroplasty* 2007;**22**:301.

Pagnano, 2007b
Pagnano MW, Leone J, Hanssen AD, Trousdale RTM, Berg E. A prospective randomized clinical trial shows that 2-incision total hips do not recover quicker than miniposterior total hips. *J Arthroplasty* 2007;**22**:303.

Panisello, 2006
Panisello JJ, Canales V, Herrera A, Mateo J, Peguero A. Effectiveness of mini-incision technique in primary hip replacement. *J Bone Joint Surg Br* 2006;**88B**:63.

Rachbauer, 2006
Rachbauer F, Rosiek R, Nogler M, Kessler O. The benefits of the direct anterior approach in minimally invasive THA. Annual Meeting of the American Academy of Orthopaedic Surgeons, Chicago, March 2006. Paper No. 202.

Sharma, 2006
Sharma S, Bharma MS. A prospective randomised pilot study to compare early post-operative recovery after conventional versus minimal incision posterior approach for total hip joint replacement. *J Bone Joint Surg Br* 2006;**88B**:243.

Takahira, 2006
Takahira N, Uchiyama K, Takasi S, Katano M, Itoman M. Prospective comparison study of clinical data between the minimal incision and conventional incision in total hip arthroplasty. 19th Annual Symposium of the International Society for Technology in Arthroplasty, New York, October 2006. Abstract A9-3.

Yoon, 2005
Yoon TR, Moon E, Rowe SM, Jung ST, Seo HY, Lee JY. Minimally invasive total hip arthroplasty: comparison between one-incision and two-incision technique. Annual Meeting of the American Academy of Orthopaedic Surgeons, Washington, DC, March 2005. Paper No. 147.

Appendix 6

List of ongoing trials

Title of trial	Contact	Project details
Minimally invasive surgery of the hip: a randomised study	Dr Paul Kim Division of Orthopedics 501 Smyth Road Ottawa Ontario K1H 8L6, Canada Email: pkim@Ottawahospital.on.ca	A pilot trial compares minimally invasive THR via a modified lateral approach with a standard lateral (Hardinge) approach with 12-week follow-up. Variables measured included in-hospital length of stay, incidence of surgical complications and validated pain and function scores Intended number of participants: 40 Poster presented at the Canadian Orthopaedic Association meeting, June 2006, Ontario: Charles MN, Feibel RJ and Kim P, Minimally invasive surgery of the hip – a randomised pilot study
Clinical evaluation comparing minimally invasive and standard skin incisions in cementless total hip arthroplasty using the Bimetric Hip System with the 38 mm M2A cup. Clinical evaluation of incision size in total hip replacement	Mr James Calder North Hampshire Hospital NHS Trust Aldermaston Road Basingstoke Hants RG24 9NA, UK Email: james.calder@imperial.ac.uk	The trial has now ended recruiting and is evaluating general health scores, hip scores, patient satisfaction, blood loss, length of stay, time to discharge and postoperative X-rays. Follow-up is still ongoing
Minimally invasive surgery in total hip arthroplasty: the 2-incision technique versus conventional total hip arthroplasty. A prospective, randomised, controlled trial	Dr Dr Jakob van Oldenrijk Academic Medical Center (AMC) Department of Orthopedics P.O. Box 22660 Meibergdreef 9 1100 DD Amsterdam The Netherlands Email: J.vanoldenrijk@amc.uva.nl	The trial is in progress, without any substantial evidence to publish yet. Switched from a two-incision technique to the anterolateral (Rottinger) MIS in March 2006 and conducting a prospective non-blinded RCT comparing this technique with the lateral transgluteal technique The patient recruitment period was planned from March 2006 to March 2008, with 1-year follow-up. Planned outcome measures include operation time, blood loss, fractures, dislocation, perioperative complications, length of hospital stay, short- and long-term pain, radiographic evaluation, function scores (e.g. Harris hip score, WOMAC), revision rates, health-related quality of life (e.g. SF-36) and patient satisfaction Intended number of participants: 100

continued

Title of trial	Contact	Project details
Effectiveness of computer-navigated minimally invasive total hip surgery compared with conventional total hip arthroplasty: design of a randomised controlled trial	Inge Reininga University Medical Centre Groningen Department of Orthopaedic Surgery P.O. Box 30001 9700 RB Groningen The Netherlands Email: i.reininga@orth.umcg.nl	The trial compares computer-navigated minimally invasive THR (the Smith–Petersen anterior approach) with a conventional technique (the posterolateral approach). Patient recruitment was planned from March 2007 to May 2008. The main focus is cost-effectiveness analysis besides the clinical follow-up for 6 months. Planned outcome measures include perioperative complications, gait analysis, implant position (radiographic analysis) and self-reported functional status and health-related quality of life Intended number of participants: 110 The trial protocol was recently published: Reininga IHF, Wagenmakers R, van den Akker-Scheek J, Stant AD, Groothoff JW, Bulstra SK, *et al*., Effectiveness of computer-navigated minimally invasive total hip surgery compared to conventional total hip arthroplasty: design of a randomised controlled trial' (protocol), *BMC Musculoskeletal Disorders* 2007;**8**:4(11 January 2007)
A randomized controlled trial utilising RSA for a comparison of minimally invasive surgery (MIS) vs standard exposure in primary total hip arthroplasty with the ProfemurZ modular femoral stem	Dr Michael Gross QEII Health Sciences Centre Halifax Nova Scotia B3H 3A7 Canada Tel. 902-473-6811 Email: mgross@eastlink.ca	The trial compares minimally invasive and standard THR using the direct lateral approach. It is recruiting patients and will have preliminary clinical results in 1 year from January 2007. Hip function will be assessed using Harris hip score, Oxford-12 and WOMAC. The primary outcome will be implant micromotion (RSA analysis). The RSA part of the study has a 2-year follow-up Intended number of participants: 100 Protocol: Dr Michael Gross (Principal Investigator), A randomised controlled trial utilising RSA for a comparison of Minimally Invasive Surgery (MIS) vs standard exposure in primary total hip arthroplasty with the ProfemurZ modular femoral stem
Randomised, prospective, post-market surveillance study comparing the outcomes of minimally invasive and conventional surgical procedures in subjects requiring primary total hip arthroplasty (THA) for osteoarthritis	Dr S Young South Warwickshire General Hospitals NHS Trust Lakin Road Warwich CV34 5BW, UK Email: skyoung@uk-consultants.co.uk	The project is in its very early stages and there are no results available; being coordinated at DePuy
Comparison of two minimally invasive hip arthroplasties in a randomised trial	Associate Professor Per Rotbøll Nielsen H:S Tværfaglige Smertecenter Neurocentret H:S Rigshospitalet Blegdamsvej 9 DK-2100 København Ø Denmark Email: rotboell@rh.dk	The trial has just started and will be collecting data for next 15 months. The research team has a contract that forbids them from providing further information

continued

Title of trial	Contact	Project details
Single versus dual incision minimally invasive hip arthroplasty	Professor Bo Nibvrant Perth Orthpaedic Institute Gate 3, Verdun Street Nedlands Perth 6009, Australia Email: bo.nivbrant@uwa.edu.au	The trial data are still in process; no further information available
Minimally invasive total hip replacement (prospective randomised, multi-centre study of synergy total hip system comparing the effectiveness and safety of minimally invasive THR arthroplasty vs standard surgery)	Mr Simon Scott Aintree Trust University Hospital Aintree Lower Lane Liverpool L9 7AL, UK Email: wicksyontour@hotmail.com	The trial has had the funding withdrawn by the company
Is minimally invasive total hip replacement clinically advantageous, safe and cost effective compared to conventional total hip arthroplasty?	Dr David Beard Nuffield Department of Orthopaedic Surgery (NDOS) University of Oxford Windmill Road Oxford OX3 7LD, UK Email: david.beard@orthopaedic-surgery.oxford.ac.uk	The trial was suspended before it became live (in the pilot stage) because the two incision method proposed for one arm of the trial was found to have an obvious and unacceptable complication rate (four out of 10 patients); it is no longer performed in the hospital; funding was returned
Does a small incision at the time of total hip replacement surgery confer any advantage to patients by comparison to a standard incision?	Mr John Timperley Exeter Hip Unit Princess Elizabeth Orthopaedic Hospital RA & E Barrack Road Exeter EX2 5DW, UK Email: john.timperley@virgin.net	The trial was abandoned at an early stage, as the research team felt there were sufficient data available in the world literature that proves that the size of incision is not the important factor in determining outcome or cost-effectiveness
A prospective randomised control trial comparing two different surgical approaches for minimally invasive total hip replacement	Mr H Apthorp Conquest Hospital The Ridge St Leonard's on Sea East Sussex TN37 7RD, UK	The trial has been put on hold, as the research team are worried that they are getting significantly better results with their posterior approaches compared with anterior approaches
Image guidance for minimally invasive hip replacement	Professor Dave Hawkes Radiological Sciences 5th Floor, Thomas Guy House Guy's Hospital St Thomas' Hospital London SE1 9RT, UK Email: david.hawkes@kcl.ac.uk	No available data at the time of writing
Comparison of the clinical effectiveness and cost-effectiveness of the MIS anterolateral approach (MIS Watson Jones, G3) versus anterolateral mini or posterolateral mini approaches in primary total hip arthroplasty	James Latteier Vancouver General Hospital Vancouver British Colombia V5Z 1L8 Canada Email: jlatteier@arthritisresearch.ca	No available data at the time of writing

Appendix 7

Detailed quality assessment score for the included trials and comparative studies (see *Table 6*)

Study	Q1a	Q1b	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
One incision										
RCT and quasi-RCT										
Charles, 2006[69a]	Y	U	U	Y	N	Y	Y	Y	N	N
Chimento, 2005[31]	Y	Y	N	Y	Y	Y	U	U	Y	Y
Chung, 2004[32]	Y	N	N	U	Y	Y	N	N	Y	Y
Hart, 2005[40]	Y	N	N	U	Y	Y	N	U	N	Y
Kim, 2006[43]	Y	N	N	Y	N	Y	Y	Y	N	U
Ogonda, 2005[46]	Y	Y	N	Y	Y	Y	Y	Y	Y	U
Rachbauer, 2006[75a]	Y	U	U	Y	Y	U	U	U	N	U
Sharma, 2006[77a]	Y	U	U	N	N	Y	Y	Y	U	U
Zhang, 2006[58]	Y	Y	Y	Y	Y	Y	Y	U	Y	Y
Comparative studies										
Asayama, 2006[28]	N	N	N	N	Y	Y	Y	Y	N	Y
Berger, 2004[29]	N	N	N	U	N	U	U	U	N	U
Chen, 2006[30]	N	N	N	U	Y	N	U	U	Y	U
Ciminiello, 2006[33]	N	N	N	Y	Y	N	N	N	N	U
de Beer, 2004[34]	N	N	N	Y	Y	N	N	N	Y	Y
DiGioia, 2003[35]	N	N	N	Y	Y	Y	N	N	N	Y
Dorr, 2007[36]	N	N	N	Y	N	U	N	N	Y	Y
Howell, 2004[42]	N	N	N	N	Y	N	N	N	Y	U
Li, 2005[44]	N	N	N	Y	Y	Y	U	N	Y	Y
O'Brien, 2005[45]	N	N	N	N	Y	U	U	N	Y	Y
Panisello, 2006[74a]	N	N	N	Y	N	U	U	U	N	U
Pilot, 2006[48]	N	N	N	N	N	N	N	N	N	Y
Szendrói, 2006[52]	N	N	N	N	Y	Y	N	Y	Y	Y
Takahira, 2006[78a]	N	N	N	U	N	U	U	U	N	U
Teet, 2006[54]	N	N	N	U	Y	Y	U	U	Y	U
Woolson, 2004[55]	N	N	N	N	Y	Y	U	N	Y	Y
Wright, 2004[56]	N	N	N	N	Y	U	U	N	Y	U
Two incisions										
RCT and quasi-RCT										
Pagnano, 2007a[72a]	Y	Y	U	Y	N	U	U	U	N	U
Pagnano, 2007b[73a]	Y	Y	U	Y	N	U	U	U	N	U
Yan, 2005[57]	Y	U	U	Y	Y	U	U	U	Y	U
Comparative studies										
Duwelius, 2007[38]	N	N	N	Y	Y	N	N	N	N	U
Greidanus, 2006[71a]	N	N	N	Y	N	U	U	U	N	U
Pagnano, 2006[47]	N	N	N	Y	Y	U	N	N	N	Y
Tanavalee, 2006[53]	N	N	N	N	Y	Y	U	N	Y	U
Yoon, 2005[79a]	N	N	N	U	N	U	U	U	N	U

N, no; U, unclear; Y, yes.
[a] Abstract only.

Appendix 8

Characteristics of included studies

In the following tables:

- continuous data: total *N*, mean (SD), [range]
- dichotomous data: n/N
- abbreviations: FU, follow-up; MD, midi-incision; MI, mini-incision; 2MI, 2 mini-incision; NR, not reported; NS, not statistically significant; SI, standard incision.

One mini-incision

RCTs and quasi-RCTs

Study details	Participant characteristics	Intervention/comparator	Outcomes	
			Short term	**Long term (including surrogates)**
Charles, 2006[69] Study design: pilot blinded RCT Location: Canada Recruitment dates: NR Funding: NR Duration of FU: 12 weeks	Inclusion criteria: NR Exclusion criteria: NR *N* eligible: NR *N* randomised: 40 Lost to FU: NR Indications: NR Age (years, SD): MI 66.6, SI 70.8, $p = 0.094$ Body weight (kg): MI 72.7, SI 72. 65, $p = 0.926$ Height (cm): MI 166.6, SI 169.7, $p = 0.310$ BMI (kg/m^2): MI 25.8, SI 25.2, $p = 0.513$ American Society of Anesthesiologists (ASA) status: MI 1.89, SI 2.16, $p = 0.102$	MI: $N = 20$ SI: $N = 20$ **Operative approach** MI: single-incision lateral approach SI: single-incision lateral approach Additional information: surgeries performed by 2 surgeons	**Intraoperative** Duration of operation (minutes) MI *20*, 95.2, SI *20*, *87.7*, $p = 0.315$ Intraoperative blood loss (ml) MI 460.0, SI 462.5, $p = 0.966$ **Postoperative** Nerve injury (transient femoral nerve palsy): MI 1/20, SI 0/20 Length of hospital stay (days) MI *20*, 5.35, SI *20*, 5.70, $p = 0.501$ **Postoperative pain** PCA narcotic consumption (mg): MI *18*, 22.8, SI *19*, 19.5, $p = 0.105$ Pain score: MI *18*, 3.94, SI *19*, 3.68, $p = 0.129$ **Time to return to usual activities** Days to independent ambulation: MI 1.25, SI 1.15, $p = 0.632$	**Functional results** WOMAC: MI *16*, 91.99, SI *19*, 89.60, $p = 0.690$ **Health-related quality of life** SF-36: MI *16*, 40.8, SI *19*, 40.4, $p = 0.583$ **Satisfaction** Satisfaction score: MI *18*, 15.222, SI *19*, 14.579, $p = 0.341$

continued

Study details	Participant characteristics	Intervention/comparator	Outcomes	
			Short term	**Long term (including surrogates)**
Chimento, 2005[31,68] Study design: RCT Location: New York, USA Recruitment dates: November 1999–July 2000 Funding: none Duration of FU: 2 years	Inclusion criteria: BMI <30 Exclusion criteria: prior hip surgery; hip pathology requiring extensile exposure (*N* = 0) *N* eligible: 265 (251 solicited for study) *N* randomised: 60 Lost to FU: MI 1, SI 3 (including 2 deaths) Indications: osteoarthritis: MI 28/28, SI 32/32 Age (years): MI 67.2 (8.6), SI 65.6 (10.5), NS Sex (M/F): MI 16/12, SI 13/19 Body weight (kg): MI 71.7 (12.8), SI 73.0 (13.0), NS Height (cm): MI 168 (9.3), SI 171 (10.9) BMI (kg/m^2): MI 25.2 (3.1), SI 24.8 (2.5) Harris hip score: MI 54.2 (9.4), SI 53.4 (7.9)	MI: *N* = 28 SI: *N* = 32 **Operative approach** MI: 8-cm single-incision, modified posterolateral approach 27 hybrid (cementless cup + cemented stem), 1 uncemented SI: 15-cm single-incision, posterolateral approach 28 hybrid (cementless cup + cemented stem), 4 uncemented Additional information: all surgeries performed by or supervised by the senior author (Sculco) Small specialised retractors for MI	**Intraoperative** Duration of operation (minutes) MI *28*, 70.3 (10.7), SI *32*, 70.0 (8.5), *p* = 0.4 Intraoperative blood loss (ml) MI *28*, 127 (48), SI *32*, 170 (65), *p* = 0.003 Conversion: MI: 0/28 (no incisions needed extension) **Postoperative** Dislocation: MI 2/28, SI 0/32, NS Infection: MI 0/28, SI 0/32 Nerve injury: MI 0/28, SI 0/32 DVT: MI 0/28, SI 0/32 Length of hospital stay (days) MI *28*, 5.8 [4–13], SI 32, 5.5 [3–15], NS **Postoperative pain** Patient-controlled epidural anaesthesia (ml): MI *28*, 285 (185), SI *32*, 319 (177), NS Oral narcotics (*n*): MI *28*, 3.27 (1.9), SI *32*, 3.13 (2.6), NS **Time to return to usual activities** Days to reach rehabilitation goals (Figure 2), NS Time to transfer independently Time to ambulate with a walker Time to ambulate with a cane Time to negotiate stairs **Implant position (postoperative radiographic analysis)** Stem in varus: MI 1/28, SI 1/32, NS Acetabular component abduction angle: MI *28*, 36.6° (*R* 30–45), SI *32*, 36.5° (*R* 30–47), NS Gap >2 mm in dome of acetabulum (= uncemented): MI 2, SI 2, NS	**Functional results** Harris hip score (at 2 years): MI 27, 94.5, SI 29, 94.5 Required a cane at 6 weeks: MI 9/28, SI 15/32, NS Persistent limp at 6 weeks: MI 6/28, SI 15/31, *p* = 0.04 Persistent limp at 1 year: MI 0/27, SI 0/29 Revision rates: MI 1/27, SI 0/29 Mortality (at 2 years) MI 0/28, SI 2/32 (unrelated to surgery) **Surrogates for long-term outcomes** Cement quality: MI A = 4/27, B = 20/27, C = 3/27; SI A = 8/28, B = 19/28, C = 1/28; NS for overall grading or for *N* of grade C **Other** • total blood loss (ml): MI 28, 378 (151), SI 32, 504 (205), *p* = 0.009 • discharge to home/facility • serum IL-6 levels/cytokine • atrial flutter • visual hallucination while on the PCEA pump • developed a rash • experienced analgesic-related confusion • sciatic pain in the contralateral leg (perioperative complication)?: MI 1/28, SI 0/32

continued

Study details	Participant characteristics	Intervention/comparator	Outcomes	
			Short term	Long term (including surrogates)
Chung, 2004[32] Study design: quasi-RCT (alternate allocation) Location: Australia Recruitment dates: NR Funding: NR Duration of FU: 1.2 [0.8–2.2] years	Inclusion criteria: osteoarthritis Exclusion criteria: weight >100 kg; semi-ankylosed joints; severe protrusio; dysplasia *N* eligible: 120 *N* randomised: 120 Lost to FU: none Indications: osteoarthritis: MI 60/60, SI 60/60 Age (years): MI 61 [41–83], SI 64 [48–81] Sex (M/F): MI 24/36, SI 28/32 Body weight (kg): MI 84, SI 86.5	MI: *N* = 60 SI: *N* = 60 **Operative approach** MI: 9.2 [6–11]-cm single-incision, posterolateral approach Porous-coated cup + uncemented stem SI: 20.0 [15–28]-cm single-incision, posterior approach Porous-coated cup + uncemented stem Additional information: all surgeries performed by one surgeon with no specialised equipment; early results of MI from first 60 cases	**Intraoperative** Duration of operation (minutes) MI *60*, 49 (9.4) [35–65], SI *60*, 55.1 (17.9) [30–90], NS Intraoperative blood loss (ml) MI *60*, 136 (41.1) [75–250], SI *60*, 200.5 (65.2) [95–300], $p < 0.01$ **Postoperative** Dislocation: MI 0/60, SI 0/60 Infection (wound): MI 0/60, SI 0/60 Nerve injury: MI 0/60, SI 0/60 DVT: MI 3/60, SI 5/60 Length of hospital stay (days) MI *60*, 4.41 (1.1) [3–7]. SI *60*, 5.34 (1.4) [4–9], $p < 0.01$ **Postoperative pain** Narcotic use (days): MI *60*, 2.2, SI *60*, 2.64, NS **Time to return to usual activities** Use of walking aids (days): MI *60*, 21.4 (4.8) [14–30], SI *60*, 24.8 (5.4) [14–30] Implant position (radiographic analysis – timing unclear) Implant insertion errors or component malalignment: MI 0/60, SI 0/60 All femoral stems within 3° of neutral alignment with respect to the femoral shaft axis All acetabular components within the 40 to 50° abduction angle range	**Functional results** Harris hip score at last follow-up: MI 95.5, SI 93.5, NS

continued

Study details	Participant characteristics	Intervention/comparator	Outcomes	
			Short term	**Long term (including surrogates)**
Hart, 2005[40,64] Study design: quasi-RCT (alternate allocation – author contacted) Location: Czech Republic Recruitment dates: September 2000–February 2002 Funding: NR Duration of FU: 3.25 [2.7–3.8] years	Inclusion criteria: age >65 years; BMI <35 Exclusion criteria: coagulation disorders; anaemic (haemoglobin level <12 g/dl) *N* eligible: 120 *N* randomised: 120 Lost to FU: none Indications: primary osteoarthritis grade 3 or 4 MI 60/60, SI 60/60 Age (years): 72.4 [66–78] Sex (M/F): 40/80 Body weight (kg): 72.1 [61–87] BMI (kg/m^2): 27.6 [22.6–34.9] Merle d'Aubigné-Charnley score: MI 10.6, SI 10.6	MI: *N* = 60 SI: *N* = 60 **Operative approach** MI: 9–10-cm single-incision, posterolateral approach 60 Cemented cup and stem SI: 20-cm standard posterolateral approach 60 Cemented cup and stem Additional information: THRs performed by 2 senior surgeons with standard instruments (but a slightly modified broad Müller retractor) and without fluoroscopy	**Intraoperative** Duration of operation (minutes) MI *60*, 71 [55–84], SI *60*, 70 [51–86] Intraoperative blood loss (ml) MI *60*, 318.8 [200–460], SI *60*, 544.4 [390–880] Intraoperative fracture MI 0/60, SI 0/60 **Postoperative** Dislocation: MI 1/60, SI 1/60 Infection (deep): MI 0/60, SI 0/60 Nerve injury (legion of the sciatic nerve): MI 0/60, SI 0/60 Peri-prosthetic fracture: MI 0/60, SI 0/60 DVT: MI 0/60, SI 0/60 Implant position (radiographic analysis 3 days after surgery and at the last follow-up control in July 2004) Femoral component varus alignment of <3° [range 4–6°]: MI 6/60, SI 7/60 Femoral component coronal alignment within 3° of neutral position: MI 54/60, SI 53/60 Cup inclination angle: MI 60, 42.3° [36–52°], SI 60, 42.4° [35–50°] Cup anteversion angle: MI 60, 13.6° [6–29°], SI 60, 13.6° [8–24°]	**Functional results** Merle d'Aubigné–Charnley score at 6 weeks (overall, max. 18 points): MI 16.6, SI 14.1, $p < 0.02$ Merle d'Aubigné–Charnley score at 12 months (overall): *MI* 60, 17.4, *SI* 60, 17.3, NS Revision rates: MI 0/60, SI 0/60 **Surrogates for long-term outcomes** Implant migration MI 0/60, SI 0/60 Cement quality (no defects): MI 60/60, SI 60/60 **Other** • postoperative blood loss into drainage: MI *60*, 613.3 [350–1180], SI *60*, 853.7 [510–1390] • pulmonary emboli: MI 0/60, SI 0/60 • aseptic loosening: MI 0/60, SI 0/60 • haematoma: MI 0/60, SI 0/60 • seroma: MI 0/60, SI 0/60

continued

Study details	Participant characteristics	Intervention/comparator	Outcomes	
			Short term	**Long term (including surrogates)**
Kim, 2006[43] Study design: quasi-RCT; bilateral simultaneous THRs (MI on one hip and SI on the other hip) Location: Korea Recruitment dates: February 2002–February 2003 Funding: none Duration of FU: 26.4 (24–36) months	Inclusion criteria: NR Exclusion criteria: NR *N* eligible: 75 *N* randomised: 70 (140 hips) Lost to FU: none Indications: osteoarthritis: 10/70 (14%); osteonecrosis: 56/70 (80%); ankylosing spondylitis: 4/70 (6%) Age (years): 55.6 [43–68] Sex (M/F): 53/17 Body weight (kg): 65.8 [54–98] Height (cm): 167.3 [148–188] BMI (kg/m^2): 25.6 [18.7–35.6] Harris hip Score: MI 46, SI 45, $p = 0.2899$	MI: $N = 70$ hips SI: $N = 70$ hips **Operative approach** MI: 8-cm single-incision modified posterolateral approach Cementless cup and stem SI: 15–20-cm single-incision standard posterolateral approach Cementless cup and stem Additional information: surgeries performed by one surgeon with specialised retractors, reamers, cup inserters and ceramic bearing holder in MI MI randomised to left or right hip; the order of using MI and SI assigned alternately, i.e. MI first on 1st patient and SI first on 2nd patient etc.	**Intraoperative** Duration of operation (minutes) MI *70*, 52 [48–70], SI *70*, 61 [51–80], $p < 0.001$ Intraoperative blood loss (ml) MI *70*, 445.8, SI *70*, 567.5, $p = 0.1687$ **Postoperative** Dislocation: MI 1/70, SI 1/70 Infection (deep wound): MI 1/70, SI 0/70 Nerve injury (peroneal nerve palsy): MI 1/70, SI 1/70 Length of hospital stay (days): MI and SI 12.8 [9–14] **Postoperative pain** 10-point analogous scale (0 = no pain): no difference between groups ($p > 0.05$) at 2 weeks, 3 months, 6 months, 1 year and 2 years Implant position (postoperative radiographic analysis) Cup abduction (*N* of outliers, goal = 35–45°): MI 6/70, SI 5/70, $p = 0.371$ Cup anteversion (*N* of outliers, goal = 20–30°): MI 7/70, SI 6/70, $p = 0.354$ Stem varus/valgus: MI 4/70, SI 4/70, $p = 0.182$ Stem anteversion (*N* of outliers): MI 8/70, SI 7/70, $p = 0.368$ Anteroposterior view stem (degree): MI 1.8 (1.6) [–2, 7], SI 1.3 (1.3) [–2, 5] Anteroposterior view cup (degree): MI 44.3 (5.8) [30, 57], SI 41.9 (7) [25, 55] Lateral view stem (anteversion, degree) MI 15.1(4.9) [2, 26], SI 12.5 (16) [0, 23] Lateral view cup (degree): MI 31.1 (7.1) [9, 46], SI 26.9 (4) [17, 38]	**Functional results** Harris hip score: MI 93 [86–100], SI 91 [85–100], $p = 0.7435$ Pain relief: see postoperative pain Limb length inequality (cm): MI 0.6 (0.59) [0–0.8] longer than preoperative length, SI 0.7 (0.79) [0–0.9] longer than preoperative length, NS **Other** • "at the final follow-up, all acetabular and femoral components were radiographically stable" (no loosening)

continued

Study details	Participant characteristics	Intervention/comparator	Outcomes	
			Short term	**Long term (including surrogates)**
Ogonda, 2005[46,59,66] Study design: RCT Location: Belfast, UK Recruitment dates: December 2003–June 2004 Funding: none Duration of FU: 6 weeks	Inclusion criteria: unilateral hip arthroplasty Exclusion criteria: previous hip surgery; severe inflammatory polyarthritis *N* eligible: NR *N* randomised: 219 Lost to FU: SI 2 (deaths); another 2 could not be seen at 6 weeks (group not specified) Indications: osteoarthritis MI 107/109, SI 107/110; rheumatoid arthritis MI 2/109, SI 1/110; osteonecrosis MI 0/109, SI 2/110 Age (years): MI 67.4 (9.8), SI 65.9 (10.3), $p = 0.25$ Sex (M/F): MI 49/60, SI 58/52 BMI (kg/m^2): MI 28.2 (4.33), SI 28.94 (4.33), $p = 0.21$ **Muscular patient** Mid-thigh circumference (cm): MI 49.3 (5.3), SI 50 (5.7), $p = 0.33$ Thigh circumference at trochanteric ridge (cm): MI 60.73 (5.7), SI 61.53 (4.6), $p = 0.25$ Depth of subcutaneous fat layer (cm): MI 2.72 (1.59), SI 2.83 (1.27), $p = 0.59$ Male with a mid-thigh circumference >55 cm: MI 16/49, SI 26/58	MI: *N* = 109 SI: *N* = 110 Bennett, 2006[59] MI *N* = 9, SI *N* = 8 **Operative approach** MI 9.5 (0.95)-cm single-incision, posterior approach Hybrid (cementless cup + cemented stem) SI 15.81 (0.93)-cm single-incision, posterior approach Hybrid (cementless cup + cemented stem) Additional information: all surgeries performed by an experienced surgeon except exposure performed by arthroplasty fellow in 15% of SI group; no specialised equipment used. Patients recruited consecutively	**Intraoperative** Duration of operation (minutes) MI *109*, 60.3 (9.2), SI *110*, 65.9 (13.2) Of the three phases, i.e. incision to insertion of the acetabular liner, insertion of the liner to reduction of the hip and reduction to closure of the skin, significant difference in first and last phases of surgery ($p = 0.001$ and $p < 0.001$, respectively) Intraoperative blood loss (ml) MI *109*, 314.2 [90–1310], SI *110*, 365.8 [100–1100], $p = 0.03$ Intraoperative fracture MI 0/109, SI 2/110 Conversion MI 0/109 (2 in SI group would have been difficult with MI) **Postoperative** Dislocation: MI 1/109, SI 1/110 Infection Deep infection: MI 1/109, SI 0/110 Superficial infection: MI 1/109, SI 0/110 DVT: MI 0/109, SI 1/110 30-day mortality (before discharge) MI 0/109, SI 2/110 Length of hospital stay (days) MI *109*, 3.65 (2.04), [2–13] SI *110*, 3.68 (2.45), [2–22], NS **Postoperative pain** No significant difference in pain score (recorded with visual analogue scale) in first 36 hours (Ogonada Table IV)	**Functional results** (at 6 weeks) Harris hip score at 6 weeks: MI *107*, 84.15 (10.56), SI *108*, 83.36 (8.33), $p = 0.54$ WOMAC at 6 weeks: MI *107*, 74.4 (13.88), SI *108*, 73.95 (12.90), $p = 0.81$ Oxford hip score at 6 weeks: MI *107*, 24.97 (7.33), SI 108, 25.88 (6.29), $p = 0.33$ Timed 10-m walk at 6 weeks (seconds): MI *107*, 13.52 (7.1), SI 108, 12.36 (4.69), $p = 0.16$ No significant difference in use of walking aids at 6 weeks (Lawlor Table 5) Revision rates: no revisions Health-related quality of life SF-12 physical component at 6 weeks: MI *107*, 38.48 (10.2), SI *108*, 37.73 (9.48), $p = 0.58$ SF-12 mental component at 6 weeks: MI *107*, 50.61 (11.05), SI *108*, 51.11 (10.54), $p = 0.73$ **Satisfaction** Scar measurement at 6 weeks (cm): MI *107*, 8.44 (1.02), *SI* 108, 13.95 (1.26) Mean contraction at 6 weeks as % of total would lengthen at the end of surgery: MI *107*, 11% (1.06/9.5 cm), SI *108*, 12% (1.86/15.81 cm), $p = 0.70$

continued

Study details	Participant characteristics	Intervention/comparator	Outcomes	
			Short term	**Long term (including surrogates)**
			Pain score in first 7 days following discharge: MI *109*, 33 (18), SI *110*, 33.6 (19.6) $p = 0.82$ Volume of morphine used (mg): MI *109*, 42.9 (97.4), SI *110*, 45.0 (96.8), $p = 0.89$ **Time to return to usual activities** No significant difference in Iowa level-of-assistance scale (from supine to sit, sit to stand and mobilisation with aid) on day 2 ($N = 104$ for MI, 105 for SI) No significant difference in 10-m walking time or stair climbing time ($N = 104$ for MI, 105 for SI; Ogonda Table V) No significant difference in stride analysis (100 patients randomly selected from the sample; *N* in each group not reported) Implant position (radiographic analysis immediately post-operative) Cup outliers (<30° or >50°): MI 16/105, SI 19/109, NS Femoral stem alignment on lateral radiograph: MI posterior = 25/105, anterior 4/105, neutral = 76/105, SI posterior = 34/109, anterior = 1/109, neutral = 74/109 Femoral stem alignment on anterolateral radiograph: MI: varus = 3/105, valgus = 0/105, neutral = 102/105, SI: varus = 8/109, valgus = 0/109, neutral = 101/109 Cup abduction angle: MI *105*, 45.85° (5.0), SI *109*, 46.65° (5.6), NS Stem angle: MI *105*, 0.81° (1.25) of varus, SI *109*, 1.02° (1.49) of varus, NS	**Surrogates for long-term outcomes** Cement quality (at immediate post-operative period): MI A = 32/105, B = 45/105, C1 = 23/105, C2 = 5/105, D = 0/105, SI A = 29/109, B = 54/109, C1 = 22/109, C2 = 4/109, D = 0/109, $p = 0.93$ Bennett, 2006[59] Functional results (preoperatively, 2 days postoperatively and 6 weeks postoperatively) *Temporal–spatial variables*: No significant difference between groups except for cadence on day 2 with MI group showing a greater reduction than SI *Kinematic variables*: No significant difference at Day 2; between week 6 and day 2, SI had a greater improvement in hip flexion/extension and a greater reduction in external rotation, than MI; between week 6 and preoperatively, SI had a greater reduction in pelvic tilt and in external hip rotation than MI **Other** • serum levels of C-reactive protein • postoperative swelling (increase in mid-thigh circumference at 48 hours) • discharge to home • subgroup analysis by muscular or obese patients

continued

Study details	Participant characteristics	Intervention/comparator	Outcomes	
			Short term	**Long term (including surrogates)**
Rachbauer, 2006[75] (abstract only) Study design: RCT Location: Austria Recruitment dates: NR Funding: NR Duration of FU: NR	Inclusion criteria: NR Exclusion criteria: BMI >35, previous hip surgery, preoperative neurological deficits, age >80 years *N* eligible: NR *N* randomised: 120 Lost to FU: NR Indications: NR Patient characteristics: "Demographically equally distributed"	MI: *N* = 60 SI: *N* = 60 **Operative approach** MI: single-incision anterior approach SI: single-incision lateral transgluttal approach Additional information: surgeries performed by 2 surgeons	**Intraoperative** Duration of operation (minutes): no difference Intraoperative blood loss (ml) MI less, SI more, $p < 0.01$ **Postoperative** Postoperative pain Use of analgesic: no difference Postoperative pain in the first week: MI lower, SI higher, significant difference **Time to return to usual activities** MI shorter, SI longer, significant difference	
Sharma, 2006[77] (abstract only) Study design: quasi-RCT Location: UK Recruitment dates: NR Funding: NR Duration of FU: early postoperative period only	Inclusion criteria: NR Exclusion criteria: NR *N* eligible: NR *N* randomised: 40 Lost to FU: NR Indications: NR Age (years): MI 66.95, SI 68.55, $p = 0.51$ BMI (kg/m^2): MI 26.5, SI 24.4, $p = 0.029$ Oxford hip score: MI 41.75, SI 42.15, $p = 0.87$	MI: *N* = 20 SI: *N* = 20 **Operative approach** MI: single-incision posterior approach SI: 12-cm single-incision posterolateral approach Additional information: none	**Intraoperative** Duration of operation (minutes) MI NR, SI NR, $p = 0.207$ **Postoperative** Dislocation: MI 0/20, SI 0/20 Infection (superficial or wound): MI 0/20, SI 0/20 Peri-prosthetic fracture: MI 0/20, SI 0/20 Length of hospital stay (days) MI 1.65 days earlier than SI, $p = 0.042$ **Postoperative pain** 10-point visual analogue scale at day 1: MI 4.05, SI 6.25, $p = 0.009$ Similar results on day 2 and day of discharge	

continued

Study details	Participant characteristics	Intervention/comparator	Outcomes	
			Short term	**Long term (including surrogates)**
Zhang, 2006[58] Study design: RCT Location: China Recruitment dates: August 2002–February 2004 Funding: NR Duration of FU: 1.7 [1–2.5] years	Inclusion criteria: good health (BMI ⩽27) Exclusion criteria: BMI >27, osteoporosis, fracture, tumour *N* eligible: 120 *N* randomised: 120 Lost to FU: none Indications: osteoarthritis: MI 36, SI 35; rheumatoid arthritis: MI 3, SI 2; osteonecrosis: MI 21, SI 23 Age (years): MI 61 [48–72], SI 62.5 [52–77] Sex (M/F): MI 25/35, SI 28/32 Harris hip score: MI 51.3, SI 51.6, NS	MI: *N* =60 SI: *N* = 60 **Operative approach** MI: 7.9-cm single-incision anterior approach SI: 16.3-cm single-incision posterolateral approach Additional information: none	**Intraoperative** Duration of operation (minutes) MI 75, SI 69, $p > 0.05$ **Postoperative** Infection Deep infection: MI 0/60, SI 0/60 Superficial infection: MI 0/60, SI 0/60 Nerve injury: MI 0/60, SI 0/60 Vascular injury: MI 0/60, SI 0/60 DVT: MI 0/60, SI 2/60 Length of hospital stay (days) MI 7 [5–8], SI 13.5 [12–16]	**Functional results** Harris hip score at 3 months: MI 91.4, SI 78.5, $p < 0.05$ Harris hip score at final visit: MI 95.1, SI 95.6, $p > 0.05$

Comparative studies

Study details	Participant characteristics	Intervention/comparator	Outcomes	
			Short term	**Long term (including surrogates)**
Asayama, 2006[28] Study design: prospective comparative cohorts Location: USA and Japan Recruitment dates: September 2001–March 2003 Funding: manufacturer (Stryker Orthopaedics, Mahwah, NJ, USA) Duration of FU: minimum 2 years (data reported up to 42 months)	Inclusion criteria: non-complex, cementless, unilateral cases with no prior surgeries to the affected hip Exclusion criteria: complex cases (N = 48), including multiple joint procedures under the same anesthetic, previous fractures or surgeries, severe pelvic deformities, other surgical approach, cemented fixation, postoperative fracture (N = 1), hemiarthroplasty; obesity (BMI >39.1); co-morbid complications (n = 3), including cardiovascular, gastrointestinal bleeding N eligible: 138 (148 THRs) N selected: 96 patients (102 cases) Lost to FU: NR Indications: osteoarthritis: MI 41, SI 36; rheumatoid arthritis: MI 1, SI 2; avascular necrosis: MI 7, SI 9; ankylosing spondylitis: MI 0, SI 2; developmental dysplasia: MI 0, SI 1; posttraumatic arthritis: MI 1, SI 2 Age (years): MI 64.3 [19–83], SI: 65.1 [37–89], NS Sex (M/F): MI 24/28, SI 25/25, NS	MI: N = 52 cases SI: N = 50 cases **Operative approach** MI: 8–10 cm single-incision direct lateral approach Uncemented SI: 15–20-cm single-incision traditional direct lateral approach Uncemented Additional information: surgeries performed by a single surgeon without special instrumentation MIS = limited incision + limiting the involvement of the gluteus maximus muscle belly	**Intraoperative** Duration of operation (minutes) Operation time: MI *50*, 58.6 [32–89], SI *50*, 57.9 [36–90], p = 0.715 Anaesthetic time: MI *50*, 100 [62–133], SI *52*, 98 [71–140], NS Intraoperative blood loss (ml) Recorded by surgeon: MI *52*, 217.5 [50–600], SI *50*, 247 [100–550] Recorded by anaesthesiology: MI 227.9 [75–700], SI 276 [50–600] Intraoperative fracture (femoral): MI 2/52, SI 0/50 **Postoperative** Dislocation: MI 0/52, SI 1/50 **Infection** Infection: MI 0/52, SI 1/50 Aseptic wound problems: MI 0/52, SI 0/50 Nerve injury (nerve palsy): MI 0/52, SI 0/50 DVT: MI 0/52, SI 1/50 Peri-prosthetic fracture: see exclusion criteria Length of hospital stay (days) MI *52*, 2.96 [1–6], SI *50*, 2.94 [2–4], p = 0.858 **Postoperative pain** Total intravenous narcotic received during hospitalisation (equianalgesic equivalency to morphine) (mg): MI *52*, 92.7 [37–180], SI *50*, 94.9 [38–188], NS	**Functional results** Harris hip score at 2 years: 96.2 for both, NS Revision rates: MI 0/52, SI 2/50 Time to revision (months): 1/2 revision at less than 1 month **Long-term pain** *At 2 weeks* No pain: MI 7/52, SI 5/50 Mild pain: MI 37/52, SI 40/50 Moderate pain: MI 8/52, SI 5/50, NS *At 6 weeks* No pain: MI 38/52, SI 38/49, NS Walk without limp: MI 15/52, SI 13/49, NS Walk without aid: MI 39/52, SI 37/49, NS *At 3 months* Mild pain: MI 2/52, SI 3/49 Use of walking aid: MI 4/52, SI 4/49 Very slight limp: MI 19/52, SI 16/49, NS Limb length inequality: MI 0/52, SI 0/50 **Other** • urinary complications at minimum 2.3 year follow-up: MI 3/52, SI 0/50 • shortness of breath at minimum 2.3 year follow-up: MI 1/52, SI 0/50

continued

Study details	Participant characteristics	Intervention/comparator	Outcomes	
			Short term	**Long term (including surrogates)**
	Body weight (kg): MI 75.8 [46–120], SI 86.5 [52–132], $p = 0.005$ Height (cm): MI 169.4 [152–193], SI 172.8 [152–198], NS BMI (kg/m^2): MI 26.12 [18.6–39.1], SI 28.67 [17.9–38.3], $p = 0.007$		Time to return to usual activities (before discharge) First ambulation (days): MI *51*, 1.06 [1–2], SI *49*, 1.10 [1–2], NS Total distance at day 2 (ft): MI *51*, 352 [10–870], SI *49*, 379 [48–2000], NS Max. distance in a session (ft): MI *51*, 193 [56–300], SI *49*, 191 [30–800] Implant position (postoperative radiographic analysis) Components well-placed; no difference in quality of component placement Average abduction of the acetabular cup: 41.1° [22–52] Cut anteversion: 4.8° [0–10.8] Femoral offset (mm): 41.3 [27–60] Body weight lever arm distance (mm): 106.1 [82–124]	• discharge disposition (home/inpatient rehabilitation) – Table 4 • "no unstable fixation at 24–42 months" (no aseptic loosening)

continued

Study details	Participant characteristics	Intervention/comparator	Outcomes	
			Short term	**Long term (including surrogates)**
Berger, 2004[29] Study design: prospective comparative consecutive series Location: USA Recruitment dates: NR Funding: NR Duration of FU: initial postoperative period only	Inclusion criteria: primary THR Exclusion criteria: NR *N* eligible: 200 Lost to FU: NR Indications: NR Age (years): MI 57, SI 59	MI: *N* = 100 SI: *N* = 100 **Operative approach** MI: 3.25 [2.75–3.75]-inch single-incision, anterolateral approach Cemented/cementless: NR SI: 6–8-inch single incision, standard anterolateral approach Cemented/cementless: NR Additional information: specialised retractors and reamers in MI; specially designed provisional neck and head (mini-incision instrument set); special retractors with built-in fibre-optic lights may also be used in MI MI = small incision + removing 20–25% of the abductor off the trochanter SI = 6–8-inch incision + removing 50% of the abductor off the trochanter	**Intraoperative** Duration of operation (minutes) MI *99*, 72, SI *100*, 66 Intraoperative blood loss (ml) MI *99*, 154, SI *100*, 278, $p > 0.05$ Opposite method initiated MI 1/100, SI 0/100 Intraoperative fracture MI 1/99, SI 1/100 **Postoperative** Dislocation: MI 0/99, SI 0/100 Infection or skin breakdown: MI 0/99, SI 0/100 Length of hospital stay (days): MI *100*, 1.9. SI *100*, 3.5, $p > 0.05$	**Other** • PE: MI 0/99, SI 0/100 • myocardial infarction: MI 0/99, SI 0/100 • "other serious problems": MI 0/99, SI 0/100 • transfer rate to a rehabilitation facility: MI 12/99, SI 28/100, $p > 0.05$ • readmission: MI 0/99, SI 0/100

continued

Study details	Participant characteristics	Intervention/comparator	Outcomes	
			Short term	**Long term (including surrogates)**
Chen, 2006[30] Study design: prospective comparative cohorts Location: China Recruitment dates: June 2002–January 2005 Funding: NR Duration of FU: 0.5–2.2 years	Inclusion criteria: NR Exclusion criteria: NR *N* eligible: 146 Lost to FU: NR Indications: osteoarthritis MI 12, SI 19; osteonecrosis MI 8, SI 15; deformity MI 0, SI 8; femoral neck fracture MI 31, SI 53 Age (years): MI 68.06 (5.92), SI 69.78 (8.57) Sex (M/F): MI 28/23, SI 54/41 Body weight (kg): MI 68.08 (4.6), SI 70.59 (5.17) Harris hip score: MI 26.16 (16.48), SI 22.51 (16.75) Preoperative pain: MI 83.78 (8.03), SI 83.39 (8.33) Possibly based on Harris hip score **Co-morbidity** Cardiopathy: MI 2/51, SI 5/95 Hypertension: MI 5/51, SI 9/95 Diabetes: MI 11/51, SI 21/95 Other: MI 2/51, SI 3/95	MI: $N = 51$ (36 single-incision, 15 two-incision) SI: $N = 95$ **Operative approach** MI: (1) ⩽10-cm single-incision posterior (Gibson) approach; (2) two-incision MIS 29 cemented, 22 cementless SI: 15–20-cm single-incision posterior (Gibson) approach 56 cemented, 39 cementless Additional information: none	**Intraoperative** Duration of operation (minutes) MI *51*, 88.41 (17.60), SI *95*, 90.84 (17.81) Intraoperative blood loss (ml) MI *51*, 175.49 (51.90), SI *95*, 293.68 (84.50) **Postoperative** Dislocation: MI 0/51, SI 0/95 Nerve injury Lateral thigh nerve paralysis: MI 0/51, SI 2/95 Peri-prosthetic fracture: MI 3/51, SI 4/95 Length of hospital stay (days): MI 51, 11.16 (0.83), SI 95, 12.83 (1.96) Time to return to usual activities (weeks): MI 8.06 (1.8), SI 16.43 (1.53)	**Functional results** Harris hip score at 6 months: MI 89.71 (3.62), SI 83.78 (8.03) Long-term pain: MI 30 (15.26), SI 49.58 (16.38), $p < 0.05$ Possibly based on Harris hip score **Satisfaction** Patient satisfaction higher in MI group than in SI group **Other** • total blood loss (operation + 1–3 days postoperative) (ml): MI 369.51 (65.05), SI 509.63 (117.39)

continued

Study details	Participant characteristics	Intervention/comparator	Outcomes	
			Short term	**Long term (including surrogates)**
Ciminiello, 2006[33,76] Study design: prospective matched-pair study; the two groups matched for age, sex, BMI, American Society of Anesthesiologists (ASA) score, diagnosis, prosthesis, type of fixation, anaesthesia, surgical approach and intraoperative patient positioning Location: USA Recruitment dates: NR (8-month period) Funding: none Duration of FU: 6 weeks	Inclusion criteria: end-stage osteoarthritis Exclusion criteria: NR *N* eligible: 120 Lost to FU: NR Indications: osteoarthritis MI 60, SI 60 Age (years): MI 69.8 [39–89], SI 70.2 [42–79] Sex (M/F): MI 15/45, SI 15/45 BMI (kg/m^2): MI 23.81 [20.1–34.8], SI 24.11 [21.2–35.1] Harris hip score: MI 49.26 [20–75], SI 56.13 [30–80] Other: ASA score	MI: *N* = 60 SI: *N* = 60 **Operative approach** MI: single-incision (<5 inch), anterolateral approach 60 uncemented THR (stem + component) SI: single-incision (⩾5 inch), anterolateral approach 60 uncemented THR (stem + component) Additional information: all surgeries performed by or supervised by a single surgeon at a high-volume joint arthroplasty centre	**Intraoperative** Duration of operation (minutes) MI *60*, 55.45 [40–170], SI *60*, 56.95 [35–90], NS Intraoperative blood loss (ml) MI *60*, 201.67 [40–170], SI *60*, 191.73 [100–400], NS **Postoperative** Dislocation: MI 0/60, SI 0/60 Infection (deep or superficial): MI 0/60, SI 0/60 Peri-prosthetic fracture: MI 0/60, SI 0/60 30-day mortality: MI 0/60, SI 0/60 Length of hospital stay (days) MI *60*, 3.7 [2–7]; SI *60*, 3.63 [2–5], NS **Postoperative pain** Equianalgesic requirement up to 6 weeks (mg): MI *60*, 118 [10.5–450.6], SI *60*, 121 [8.6–390.5], NS Implant position (radiographic analysis at 6 weeks) Acetabular component optimally positioned (i.e. anteversion between 10–20° and an abduction angle between 30–50°): MI 60/60, SI 60/60 Femoral component optimally positioned (i.e. the varus or valgus angle was less than 5°): MI 60/60, SI 60/60	**Functional results** Harris hip score at 6 weeks: MI 91.02 [60–100], SI 94.93 [70–100] Improvement from preoperative Harris hip score: MI 41.76 (11.06) SI 38.80 (11.25), NS Revision rates: MI 1/60, SI 0/60 Time to revision (months): MI 8 months Long-term pain (thigh pain): MI 0/60, SI 0/60 Mortality (at 6 weeks): MI 0/60, SI 0/60 **Surrogates for long-term outcomes** Implant migration: MI 1/60, SI 0/60 **Other** • discharge to rehabilitation facility: MI 49/60 (81%), SI 46/60 (76%)

continued

Study details	Participant characteristics	Intervention/comparator	Outcomes	
			Short term	**Long term (including surrogates)**
de Beer, 2004[34] Study design: matched pair study; matched for age, gender, BMI, diagnosis and American Society of Anesthesiologists (ASA) score, stratified by surgeon; pilot study Data gathered from a prospectively gathered arthroplasty database of 400 primary THRs Location: Ontario, Canada Recruitment dates: 16-month period Funding: NR Duration of FU: 6 weeks	Inclusion criteria: osteoarthritis; primary THR Exclusion criteria: NR *N* eligible: 400 Lost to FU: none Indications: osteoarthritis MI 30, SI 30 Age (years): MI 71 (8.9) [45–86], SI 69 (12.3) [39–85], NS Sex (M/F): MI 10/20, SI 10/20 BMI (kg/m^2): MI 32.4 (5.0) [21.6–41.7], SI 31.7 (5.9) [19.6–43.4], $p = 0.579$ Harris hip score: MI 36.8 (12) [21–59], SI 36.4 (6.8) [23–48], NS Oxford hip score: MI 43.6 (6.2) [31–54], SI 40.9 (6.6) [31–53], NS Flexion: see *Table 1* All patients had an average ASA range of 2, indicating mild systematic disease	MI: $N = 30$ SI: $N = 30$ **Operative approach** MI: 7.7 [6–10]-cm single-incision, direct lateral approach 26/30 cementless stem 4/30 cemented stem 30/30 cementless acetabular cluster SI: 13.9 [11–22]-cm single-incision, standard direct lateral approach 26/30 cementless stem 4/30 cemented stem 30/30 cementless acetabular cluster Additional information: all surgeries operated by or supervised by 2 surgeons at a high-volume arthroplasty centre with standard instrumentation and retractors "The dissection deep to the fascia lata was identical for both MI and SI groups" (p. 946)	**Intraoperative** Duration of operation (minutes) MI *30*, 46.6 [24–90], SI *30*, 44.5 [17–75], $p = 0.572$ Intraoperative blood loss (ml) MI *30*, 180 (69) [100–300], SI *30*, 246.7 (99) [100–600], $p = 0.04$ **Postoperative** DVT: MI 0/30, SI 1/30 Peri-prosthetic fracture: MI 1/30 (fall at home), SI 0/30 Length of hospital stay (days) MI *30*, 5.13 [3–8], SI *30*, 5.10 [4–8], $p = 0.894$ Postoperative pain Equianalgesic opioid consumption (mg): MI *30*, 147.7 [18–337.9], SI *30*, 169.3 [23.3–413.3], $p = 0.336$ Implant position (radiographic analysis at 6 weeks) Femoral stem neutral alignment: MI 30/30, SI 30/30 Cup acetabular lateral opening (cup abduction angle): MI 39.03° (6.5) [22–52], SI 37.7° (5.6) [24–50], $p = 0.414$ Cup anteversion angle: MI 18.5° (6.8) [4–30], SI 16.5° (7.3) [0–30], $p = 0.28$ Combined acetabular angle: MI 57.6° (9.6) [38–80], SI 54.2° (7.6) [40–86], $p = 0.146$	**Functional results** Harris hip score at 6 weeks: MI 71.1 (9.8) [41–87], SI 66.6 (12.2) [32–84], $p = 0.193$ Oxford hip score at 6 weeks: MI 26.5 (8.4) [13–40], SI 28.4 (7.5) [19–39], $p = 0.494$ **Long-term pain** Subcutaneous hematoma, mild sciatica and thigh pain: MI 0/30, SI 1/30 **Other** • inferior ischaemic change requiring admission to cardiac unit: MI 0/30, SI 1/30

continued

Study details	Participant characteristics	Intervention/comparator	Outcomes	
			Short term	**Long term (including surrogates)**
DiGioia, 2003[35,63,70] Study design: prospective matched-pair study; matched by diagnosis, gender, age and Harris hip score Location: Pennsylvania, USA Recruitment dates: October 1998– (end date NR) Funding: none Duration of FU: 1 year	Inclusion criteria: osteoarthritis Exclusion criteria: NR *N* eligible: selected from cohorts of 121 (MI) + 120 (SI) patients *N* matched: 66 Lost to FU: NR Indications: osteoarthritis MI 33/33, SI 33/33 Age (years): MI 65 [49–80], SI 65 [49–76], $p = 0.86$ Sex (M/F): MI 19/14, SI 19/14 Body weight (kg): MI 79.8, SI 79.5 Height (cm): MI 170.6, SI 167.8 BMI (kg/m^2): MI 27, SI 28, $p > 0.5$ Harris hip score: MI 52.29 [24–74], SI 53.44 [22–76], $p = 0.88$	MI: *N* = 33 (35 hips) SI: *N* = 33 (35 hips) **Operative approach** MI 11.7 [7.3–13]-cm single-incision modified posterior approach with image-guided navigation 33 press-fit acetabular component; 27 cemented and 6 non-cemented femoral implant SI 20.2 [14.8–26]-cm single-incision standard posterior approach with image-guided navigation 33 press-fit acetabular component; 27 cemented and 6 non-cemented femoral implant Additional information: all surgeries performed by one surgeon with standard retractors MIS = mini-incision + minimising soft tissue dissection	**Intraoperative** Duration of operation (minutes) MI *33*, 120, SI *33*, 100 **Postoperative** Dislocation at 1 year: MI 0/33, SI 0/33 Nerve injury at 1 year: MI 0/33, SI 0/33 Length of hospital stay (days) MI *33*, 3.8, SI *33*, 3.9, $p = 0.6$ **Time to return to usual activities** See Harris hip scores Implant position (postoperative radiographic analysis) Acetabular cup alignment for both groups was within 5° of the preoperatively planned position, i.e. 45° of abduction and 20° of flexion Average abduction after final cup placement: 46° [42–48°] Average flexion (cup anteversion): 22° [18–25°]	**Functional results** Harris hip score ay 3 months: MI 33, increase by 34 points [63–96], SI 33, increase by 27 points [63–95], $p = 0.045$, i.e. MI 86.29, SI 80.44 Harris hip score by 6 months: MI *33*, increase by 41 points [84–100], SI *33*, increase by 34 points [71–100], $p = 0.017$ Harris hip score at 1 year: MI *33*, 96 [86–100], SI *33*, 94 [79–100], $p = 0.08$ (NS) **Long-term pain** See detailed Harris hip score results above **Surrogates for long-term outcomes** Heterotopic ossification: MI 0/33, SI 3/33 (type I)

continued

Study details	Participant characteristics	Intervention/comparator	Outcomes	
			Short term	**Long term (including surrogates)**
Dorr, 2007[36,65] Study design: controlled before-and-after surveys Location: USA Recruitment dates: NR Funding: research foundation and manufacturer (Zimmer) Duration of FU: 0.5–1 year	Inclusion criteria: NR Exclusion criteria: enrolled in a randomised study (*N* = 23); lived outside state and did not return for 6-week FU (*N* = 11, 12 hips); problem with language (*N* = 4); younger than 18 years (*N* = 1) *N* eligible: 204 *N* followed-up: 165 Lost to FU: 0/165 (but see exclusion criteria) Indications: NR Age (years): MI 63.5 (12.3), SI 65.6 (13.3) Sex (M/F): MI 52/57, SI 26/30 BMI (kg/m^2): MI 26.67 (4.3), SI 26.4 (4.7) Employed/retired: MI 70/39, SI 36/20 Preoperative expectations for all 14 questions favoured the small-incision approach	MI: *N* = 109 (131 hips) SI: *N* = 56 (56 hips) **Operative approach** MI: 9.6 (1.5)-cm single-incision posterior approach Type of prosthesis: NR SI: 17.9 (3.5-cm) single-incision posterior approach Type of prosthesis: NR Additional information: surgeries performed by 2 surgeons; research tools include (1) specially designed 14-item questionnaire, (2) SF-36 v2, (3) 8-item telephone survey questionnaire	**Postoperative** DVT: 1/165 Peri-prosthetic fracture: 1/165	Health-related quality of life SF-36 physical component: MI *109*, 54.5 (4.29), SI *56*, 56.24 (3.87), significant difference SF-36 mental component: MI *109*, 60.38 (3.84), SI *56*, 60.74 (3.42), significant difference Satisfaction (8-item telephone survey at 6 months to 1 year postoperative) Q4. Is cosmesis still important? (yes/no/no difference) (%): MI 76/20/3.7, SI 0/70/30, $p = 0.000$ Q5. Happy with cosmesis? (yes/no/no difference) (%): MI 100/0/0, SI 39/38/23, $p = 0.000$ **Other** • Patients' expectations as measured by 14-item questionnaire focusing on three domains of pain, function and perception: "Do you feel that a patient who has had a small hip incision (2–4 inches long) is more likely to have the following than a patient who has had a traditional incision (10–12 inches long)?"

continued

Study details	Participant characteristics	Intervention/comparator	Outcomes	
			Short term	**Long term (including surrogates)**
Howell, 2004[42] Study design: prospective concurrent comparison Location: Canada Recruitment dates: June 2002–June 2003 Funding: lead author (Howell) was supported by a grant from the John Charnly Trust Duration of FU: none	Inclusion criteria: NR Exclusion criteria (for control group, *N* = 16): the complexity of the primary THR was affected by previous surgery or by a congenital condition; during the operation required an additional procedure; the anterolateral approach was not used *N* eligible: 118 Lost to FU: NA Indications: primary osteoarthritis (OA) MI 39, SI 35; OA secondary to dysplasia MI 5, SI 9; post-traumatic OA MI 1, SI 4; ankylosing spondylitis MI 0, SI 3; osteonecrosis MI 2, SI 1; developmental protrusion MI 1, SI 2; rheumatoid arthritis: MI 0, SI 2; multiple epiphyseal dysplasia MI 2, SI 0; SCFE with secondary degeneration MI 0, SI 1 Age (years): MI 59.8 (11.7), SI 62.3 (13.5) Sex (M/F): MI 34/16, SI 27/30 BMI (kg/m^2): MI 26.2 (3.7), SI 28.8 (5.8), $p = 0.007$ Co-morbidity score: MI 0.5 (1.01), SI 0.5 (0.68)	MI: *N* = 46 (50 hips) SI: *N* = 56 (57 hips) **Operative approach** MI: single-mini-incision anterolateral approach 36 cementless, 14 hybrid SI: standard single-incision anterolateral approach 35 cementless, 22 hybrid Additional information: all surgeries by a single surgeon (senior author); study represents early experience of the surgeon with MIS (initial learning curve)	**Intraoperative** Duration of operation (minutes) MI *50*, 97 (19), SI *57*, 84 (15), $p = 0.0001$ Intraoperative blood loss (ml) MI *50*, 387 (155), SI *57*, 469 (147), $p = 0.007$ Intraoperative fracture: MI 2/50, SI 0/57 **Postoperative** Infection *Clostridium difficile* enterocolitis: MI 0/50, SI 1/57 Length of hospital stay (days) MI *50*, 4.4 (2.9), SI *57*, 5.7 (3.1), $p = 0.03$	
Li 2005[44] Study design: Prospective comparison of consecutive series Location: China Recruitment dates: March 2003– (end date NR) Funding: NR Duration of FU: 0.9 [0.5–1.7] years	Inclusion criteria: later osteonecrosis of femoral head Exclusion criteria: NR *N* eligible: 36 Lost to FU: none Indications: osteoarthritis MI 0, SI 6; osteonecrosis MI 18, SI 7; femoral neck fracture: MI 0, SI 5 Age (years): MI [24–57], SI [31–71] Sex (M/F): MI 13/5, SI 14/4 BMI (kg/m^2): MI 24.6 [17.1–30.1], SI 26.1 [18.4–32.5] Muscular patient (%): MI 61%, SI NR Harris hip score: MI 46, SI 46	MI: *N* =18 (22 THRs) SI: *N* = 18 (22 THRs) **Operative approach** MI: 9.3 (0.4) [8.7–10.5]-cm single-incision posterolateral approach Cemented SI: 16.8 (2.3) [14–20]-cm single-incision posterolateral approach Cemented Additional information: none	**Intraoperative** Duration of operation (minutes) MI *18*, 91.0 (16.4) [65–120], SI *18*, 97.0 (15.6) [75–150], $p > 0.05$	**Functional results** Harris hip score at 6 months: MI 92, SI 90, $p > 0.05$ Revision rates: MI 0/18, SI 1/18 **Other** • total blood loss (ml): MI 318 (223.1) [150–1100], SI 523 (210.7) [200–1000], $p < 0.05$

continued

Study details	Participant characteristics	Intervention/comparator	Outcomes	
			Short term	**Long term (including surrogates)**
O'Brien, 2005[45] Study design: retrospective comparison of consecutive series of patients Location: Canada Recruitment dates: May 2003–September 2004 Funding: none Duration of FU: 6 weeks	Inclusion criteria: direct lateral approach; primary THRs, patients were given MIS based on the overall girth of the patients upper thigh/hip girdle Exclusion criteria: posterior approach ($N = 2$) *N* eligible: 85 (89 hips) Lost to FU: none Indications: primary osteoarthritis MI 28, SI 39; rheumatoid arthritis MI 0, SI 3; posttrauma osteoarthritis MI 0, SI 3; osteoarthritis secondary to dysplasia MI 2, SI 5; avascular necrosis MI 4, SI 1; ankylosing spondylitis MI 0, SI 1; psoriatic MI 0, SI 1 Age (years): MI 67, SI 67, NS Sex (M/F): MI 19/13, SI 25/26, NS Body weight (kg): MI 79.2, SI 90.9, NS Height (cm): MI 170, SI 168, NS BMI (kg/m^2): MI 27 (4), SI 30 (9) American Society of Anesthesiologists (ASA) score (%): MI 2, SI 2, NS	MI: $N = 32$ (34 hips) SI: $N = 51$ (53 hips) **Operative approach** MI: 10-cm single-incision direct lateral approach Component fixation: 97% cementless, 3% hybrid; 26% acetablular screw fixation SI: >10-cm single-incision direct lateral approach Component fixation: 87% cementless, 13% hybrid; 15% acetablular screw fixation Additional information: all surgeries performed by one surgeon. Feasibility study for RCT	**Intraoperative** Duration of operation (minutes) MI 32, 74 (15), SI 53, 80 (10), $p = 0.048$ Intraoperative fracture MI 2/34, SI 1/53, NS Conversion: MI 0/34, SI 0/53 **Postoperative** Early dislocation: MI 0/34, SI 0/53 Infection Infection: MI 0/34, SI 0/53 Wound complication: MI 0/34, SI 0/53 Nerve injury Neurological injury: MI 0/34, SI 0/53 DVT: MI 0/34, SI 3/53 Length of hospital stay (days): MI 5.4 (2.1), SI 6.2 (2.8), $p = 0.014$ Implant position (radiographic analysis) Femoral component position varus >5°: MI 3% (1/34), SI 4% (2/53) Femoral component position valgus >5°: MI 0% (0/34), SI 2% (1/53) Femoral component position neutral or within 5° varus/valgus: MI 97%, SI 94% NB: outliers = >55° and <35° Abduction angle: MI 45° [34–58], SI 45° [25–65], $p = 0.933$	**Other** • PE: MI 1, SI 0 • myocardial infarction: MI 0, SI 3 • gastrointestinal bleeding: MI 0, SI 1 • discharged home: MI 94%, SI 77%, $p = 0.038$

continued

Study details	Participant characteristics	Intervention/comparator	Outcomes	
			Short term	**Long term (including surrogates)**
Panisello, 2006[74] (abstract only) Study design: prospective comparative cohorts Location: Spain Recruitment dates: NR Funding: NR Duration of FU: short-term	Inclusion criteria: NR Exclusion criteria: NR *N* eligible: NR *N* randomised: 80 Lost to FU: NR Indications: NR	MI: *N* = 40 SI: *N* = 40 **Operative approach** MI: single mini-incision Cementless SI: classic approach Cementless	**Postoperative** Length of hospital stay (days) MI 5.6, SI 6.7	
Pilot, 2006[48] Study design: comparative study; pilot study Location: The Netherlands Recruitment dates: November 2004–January 2005 Funding: NR Duration of FU: none	Inclusion criteria: unilateral THR Exclusion criteria: NR *N* eligible: 20 Lost to FU: NA Indications: NR Age (years): MI 67.9, SI 67.5, NS Sex (M/F): MI 4/6, SI 2/8 Height (cm): MI 169, SI 167, NS BMI (kg/m^2): MI 29.1, SI 26.4, $p = 0.048$ American Society of Anesthesiologists (ASA) grading (1/2/3/4): MI 4/5/1/0, SI 3/7/0/0	MI: *N* = 10 SI: *N* = 10 **Operative approach** MI: 8.6-cm single-incision anterior approach Unclear whether cemented or cementless SI: 17.4-cm single-incision posterolateral approach Unclear whether cemented or cementless Additional information: 5 surgeons experienced in conventional THR; all attended a cadaver course on mini-incision THR (learning curve)	**Intraoperative** Duration of operation (minutes) MI *10*, 99.5, SI *10*, 81.0, $p = 0.056$ Intraoperative blood loss (ml) MI *10*, 699, SI *10*, 540, $p = 0.28$	**Other** • muscle damage and inflammation • heart-type fatty acid binding protein (H-FARB) • interleukin-6 (IL-6)

continued

Study details	Participant characteristics	Intervention/comparator	Outcomes	
			Short term	**Long term (including surrogates)**
Szendrói, 2006[52] Study design: prospective comparison of consecutive cohorts Location: Hungary Recruitment dates: January 2003–December 2004 Funding: none Duration of FU: 3 months	Inclusion criteria: primary THR Exclusion criteria: severe forms of congenital dislocations of the hip revision THR *N* eligible: 102 Lost to FU: none Indications (all groups): primary osteoarthritis 76/102; secondary osteoarthritis: 17/102; aseptic necrosis of the femoral head: 6/102; post-traumatic arthritis 3/102 Age (years): MI 64 (12) [44–88], MD 62 (13) [38–85], SI 57 (13) [30–80] Body weight (kg): MI 70 (13.5) [48–102], MD 78 (13) [61–104] SI 78 (19.5) [50–116], $p = 0.009$ (MI–MD), p = NS (MD–SI), p = NS (MI–SI) BMI (kg/m^2): MI 26 (3.3) [20–35.4], MD 28 (4.2) [17.8–37.1], SI 29.5 (7) [20.3–44.2], $p = 0.026$ (MI–MD), p = NS (MD–SI), $p = 0.048$ (MI–SI)	MI: *N* = 38 MD: *N* = 43 SI: *N* = 21 **Operative approach** MI 8.8 (0.98)-cm single-incision, direct lateral approach 24 cemented, 14 uncemented MD: 12.6 (1.21)-cm single-incision, direct lateral approach 25 cemented, 18 uncemented SI: 16.1 (1.88)-cm single-incision, direct lateral approach 11 cemented, 10 uncemented Additional information: all surgeries performed by the senior author; femoral shaft, bent Hohman retractors and spike retractor are used. No fluoroscope THR always starts as a short incision (<10 cm) and then extended as necessary during surgery	**Intraoperative** Duration of operation (minutes) MI *38*, 84 (16) [50–120], MD *43*, 93 (18) [60–130], SI *21*, 102 (12) [80–120], $p = 0.020$ (MI–MD), $p = 0.028$ (MD–SI), $p < 0.001$ (MI–SI) Intraoperative blood loss (ml) MI *38*, 244 (100) [100–550], MD *43*, 265 (114) [70–600], SI *21*, 304 (136) [150–600], $p = 0.399$ (MI–MD), $p = 0.278$ (MD–SI), $p = 0.098$ (MI–SI) Intraoperative fracture (femoral shaft): MI 0/38, MD 0/43, SI 0/21 Conversion MI 0/38, MD 43/43, SI 21/21 **Postoperative** Dislocation: MI 0/38, MD 0/43, SI 0/21 Infection: MI 0/38, MD 0/43, SI 0/21 **Nerve injury** Complete sciatic nerve palsy: MI 0/38, MD 0/43, SI 0/21 Transient femoral nerve palsy: MI 2/38, MD 3/43, SI 0/21 DVT: MI 2/38, MD 3/43, SI 2/21 Postoperative pain (by the individual visual analogue scale at day 3): MI *38*, 1.5 (1.15) [0–5], MD *43*, 2.15 (1.2) [0–4], SI *21*, 2.1 (1.3) [0–4], $p = 0.028$ (MI–MD), $p = 0.876$ (MD–SI), $p = 0.112$ (MI–SI) Implant position (postoperative radiographic analysis) Cup: % hips within normal range (35°–50°): MI 89% (34/38), MD 95% (41/43), SI 85% (18/21), $p = 0.348$ (MI–SI), $p = 0.209$ (MD–SI), $p = 0.686$ (MI–SI)	Functional results: "depended more on the general condition, age, coexistent diseases of the patient rather than the length of incision" Revision rates: MI 0/38, MD 0/43, SI 0/21 Patient satisfaction: MI highest, MD high, SI high (over 90% in all groups) **Surrogates for long-term outcomes** Cement quality "poor": MI 0/24, MD 0/25, SI 0/11 (cemented prosthesis only) **Other** • total blood loss: MI 744 (260), MD 708 (221), SI 771 (235); less blood loss for cemented ($n = 60$, 642 ml) vs cementless ($n = 42$, 868 ml) prostheses ($p = 0.011$) • preoperative pain: MI 7.8 (1.3) [5–10], MD 7.9 (1.3) [5–10], SI 8.5 (1.4) [5–10]; drop in pain from the preoperative to postoperative level higher in MI group ($p = 0.028$) • loose and unstable component: MI 0/38, MD 0/43, SI 0/21 • swelling around the wound: MI some, MD 0/43, SI 0/21 • wound necrosis: MI 0/38, MD 0/43, SI 0/21

continued

Study details	Participant characteristics	Intervention/comparator	Outcomes	
			Short term	**Long term (including surrogates)**
			Cup: % of components that were outliers: MI 8.25% (<35°), 2.75% (>50°), MD 5% (>50°), SI 5% (<35°), >50° (10%) Cup inclination: MI 44.2° (5.3), MD 44.8° (3.5), SI 44.8° Stem alignment (normal range ±5° to the ventral axis of the femur): MI 8% (2/38) varus, 92% normal, MD 5% (2/43) vargus, 95% normal, SI 5% (1/21) varus, 95% normal, $p = 0.568$ (MI–SI), $p = 0.969$ (MD–SI), $p = 0.682$ (MI–SI)	
Takahira, 2006[78] (abstract only) Study design: prospective comparative cohorts Location: Japan Recruitment dates: May 2003–January 2004 Funding: NR Duration of FU: NR	Inclusion criteria: osteoarthritis without complications Exclusion criteria: NR *N* eligible: NR Lost to FU: NR Indications: osteoarthritis Sex (M/F): MI 3/7, SI 1/9 Body weight (kg): MI 66.4 [55–76], SI 63.1 [56–75]	MI: *N* = 10 SI: *N* = 10 **Operative approach** MI: 7.5 [6–9]-cm single-mini-incision approach Cementless SI: 13.8 [11–17]-cm single-incision, conventional approach Cementless	**Intraoperative** Duration of operation (minutes) MI 126.5, SI 119.9 **Intraoperative fracture** MI 1/10, SI 0/10 **Postoperative** Nerve injury (femoral nerve palsy): MI 1/10, SI 0/10 Length of hospital stay (days) MI 22, SI 23.4	**Functional results** JOA (Japanese Orthopaedic Association) score at discharge: MI 79.5, SI 79.4, NS **Surrogates for long-term outcomes** Heterotopic ossification: MI 0/10, SI 1/10 **Other** • total blood loss (ml): MI 796, SI 772

continued

Study details	Participant characteristics	Intervention/comparator	Outcomes	
			Short term	**Long term (including surrogates)**
Teet, 2006[54] Study design: retrospective comparative study of consecutive patient Location: USA Recruitment dates: 1999–2003 Funding: none Duration of FU: 1.5 years [6 weeks to 4.5 years]	Inclusion criteria: primary THR Exclusion criteria: patients with less than 6-week FU *N* eligible: 127 Lost to FU: NR Indications: NR	MI: *N* = 73 SI: *N* = 54 **Operative approach** MI: ⩽12 cm (approx. 10 cm) 73/73 uncemented acetabular component, 39/73 cemented, 34/73 cementless SI: >12 cm (approx. 17–22 cm) 54/54 uncemented acetabular component, 31/54 cemented, 23/54 cementless Additional information: all surgeries by one surgeon	**Postoperative** Dislocation: MI 1/73, SI 4/54 Implant position (radiographic analysis at the most recent FU; minimum 6 weeks) Femoral component >2° varus: MI 30.5% (4/73), SI 7.4% (4/54), $p = 0.0009$ Femoral component in neutral position: MI 21.9%, SI 25.9%, NS Acetablular angle of abduction: MI 40.8° (7.3), SI 41.66° (7.25), $p = 0.51$ Anteversion angle of the cup: MI 12.29° (7.03), SI 16.21° (7.01), $p = 0.001$	**Surrogates for long-term outcomes** Heterotopic ossification: "no heterotopic bone in 2/3 of both groups" Cement quality (Barrack cement grading of the cemented femoral stems, max. points 7): MI 1.72 (0.65), SI 1.63 (0.72), NS **Other** • failure of ingrowth (radiolucency) – for uncemented components • femoral component ingrowth (uncemented)/cement technique (cemented components only; good in both groups) • subgroup analysis: cemented vs uncemented
Woolson, 2004[55,67] Study design: retrospective comparison of consecutive patients Location: USA Recruitment dates: September 2001–March 2003 Funding: none Duration of FU: Woolson, 2004 (*N* = 135): minimum 6 months; Mow, 2005 (*N* = 32):	Inclusion criteria: primary unilateral THR; MI group selected primarily based on body habitus, e.g. lower BMI Exclusion criteria: NR *N* eligible: 135 Lost to FU: NR Indications: osteoarthritis MI 43, SI 66; osteonecrosis MI 2, SI 8; congenital dysplasia MI 2, SI 6; other MI 3, SI 5 Age (years): MI 60 [20–81], SI 63 [35–91], NS Sex (M/F): MI 29/21, SI 31/54, $p = 0.01$	MI: *N* = 50 SI: *N* = 85 Mow, 2005:[67] MI *N* = 19 (20 hips), SI *N* = 13 (14 hips) **Operative approach** MI: ⩽10-cm single-incision posterior approach 48 uncemented, 2 hybrid (cemented femoral component + cementless acetabular component) SI: 15–25-cm single-incision posterior approach 64 uncemented, 21 hybrid (cemented femoral	**Intraoperative** Duration of operation (minutes) MI *50*, 97, SI *85*, 105, $p = 0.13$ Intraoperative blood loss (ml) MI *50*, 603, SI *85*, 507, $p = 0.12$ Intraoperative fracture MI 2/50, SI 0/85 **Postoperative** Dislocation: MI 0/50, SI 1/85 **Infection** Superficial wound infection: MI 1/50, SI 0/85 **Nerve injury** Partial peroneal nerve palsy: MI 0/50, SI 1/85 Complete sciatic nerve palsy: MI: 1/50, SI: 0/85	**Functional results** Harris hip score: see Mow, 2005, below Limb length inequality (mm): MI *50*, 0.6 (5), SI *85*, –0.2 (6), $p = 0.42$ **Surrogates for long-term outcomes** Cement quality (C2 or D): MI 0/12, SI 0/21 Patient satisfaction: see Mow, 2005, below **Other** • *N* of patients discharged home/*N* discharged to a skilled nursing or rehabilitation facility: MI 24/26, SI 30/55, $p = 0.15$

continued

Study details	Participant characteristics	Intervention/comparator	Outcomes	
			Short term	**Long term (including surrogates)**
minimum 17 months; average 23 months (MI), 25 months (SI)	Body weight (kg): MI 78 [53–113], SI 82 [44–140], NS Height (cm): MI 174, SI 170, $p = 0.019$ BMI (kg/m^2): MI 25.1, SI 28.2, $p = 0.008$ *N* of patients who were obese (BMI $\geqslant$30): MI 3/50, SI 30/85, $p = 0.0001$ Other: American Society of Anesthesiologists (ASA) score: MI 1.76, SI 2.14, $p = 0.006$ *N* of hips in ASA classes 3 and 4: MI 4/50, SI 21/85, $p = 0.016$ *N* of procedures done with regional anaesthesia/*N* with general anaesthesia: MI 45/5, SI 65/20	component + cementless acetabular component) Additional information: surgeries performed by 3 fellowship trained surgeons; MI surgeries represent the initial experience of these surgeons with this technique; MI surgeries done with specialised retractors; length of incision measured before the operation began	DVT: MI 1/50, SI 2/85 Length of hospital stay (days) MI *50*, 4.3, SI *85*, 4.0, $p = 0.44$ Implant position (postoperative radiographic analysis) *N* of acetabular component that were outliers ($\leqslant$30° or $\geqslant$50° of abduction): MI 15/50, SI 13/85, $p = 0.04$ Abduction angle of acetabular component: MI *50*, 40.5° (8) [21–56], SI *85*, 40° (7) [26–60], $p = 0.64$ *N* of stems in varus alignment: MI 6/50, SI 3/85, $p = 0.056$ *N* of hips with poor fixation grade or in varus alignment (definition = the fit and fill of hips with cementless femoral components was poor, the cementing was grade C2/D for hips with cement fixation, or the stem was in varus alignment): MI 7/50, SI 3/85, $p = 0.02$ *N* of hips according to grade (good/fair/poor) of fit and fill of components inserted without cement: MI 26/16/6, SI 42/22/0, $p = 0.0036$	• Prolonged wound drainage: MI 0/50, SI 2/85 Mow, 2005[67] Examination by plastic surgeon Harris hip score at min. 17 months: MI *20*, 99 [89–100], SI *14*, 97 [65–100], $p = 0.43$ Wound problem: MI 2/20, SI 0/14, $p = 0.22$ Appearance (good/fair/poor): MI 4/10/6, SI 7/6/1 Colour – Table 2 Contour – Table 2 Distortion – Table 2 Fizpatrick classification – Table 2 Recommend scar revision – Table 2 Subcutaneous tissue necrosis – Table 2 Patients perception Opinion of scar (excellent/average/unacceptable): MI 12/8/0, SI 3/11/0, $p = 0.026$ Scar appearance (as expected/better than expected/worse than expected): MI 8/12/0, SI 8/6/0, $p = 0.32$ Outcome importance: scar found to be low on the patients' priority; from most important to least important (both groups): no hip pain, how long THR will last, how long with crutches, length of incision, a perfect scar

continued

Study details	Participant characteristics	Intervention/comparator	Outcomes	
			Short term	**Long term (including surrogates)**
Wright, 2004[56] Study design: prospective comparison of two cohorts Location: USA Recruitment dates: November 1996–December 1997 (MI); November 1996–February 1997 (SI) Funding: NR Duration of FU: MI 5.08 (0.33) years, SI 5.17 (0.37) years	Inclusion criteria: no specific criteria; decision to use MI depended on the presence or absence of a particular group of assistant surgeons (MI, non-consecutive THRs; SI, consecutive THRs) Exclusion criteria: developmental hip dysplasia ($N = 6$); a definite tendency to avoid MI in obese patients *N* eligible: 336 THRs Lost to FU: MI 5 (2 died and 3 lost to FU), SI 3 (2 died and 1 lost to FU) Indications: osteoarthritis MI 37/42, SI 39/42; rheumatoid arthritis MI 1/42, SI 0/42; osteonecrosis MI 4/42, SI 3/42 Age (years): MI 64.2 (15.1), SI 65.0 (8.2), $p = 0.76$ Body weight (kg): MI 71.4 (20.6), SI 80.9 (18.7), $p = 0.03$ Height (cm): MI 168.9 (11.5), SI 167.8 (8.2), $p = 0.62$ BMI (kg/m^2): MI 24.4 (5.7), SI 28.3 (6.1), $p < 0.01$ Harris hip score: MI 39.1 (12.9), SI 40.6 (10.8), $p = 0.60$	MI: $N = 42$ hips SI: $N = 42$ hips **Operative approach** MI: 8.8 (1.5)-cm single-incision modified posteroloateral approach Hybrid (press-fit acetabular component with no supplement screw fixation + cemented femoral components) SI: 23.0 (2.1)-cm modified posterolateral approach Hybrid (press-fit acetabular component with no supplement screw fixation + cemented femoral components) Additional information: all surgeries performed by one senior surgeon (Sculco)	**Intraoperative** Duration of operation (minutes) MI *42*, 71.4 (11.2), SI *42*, 77.7 (13.2), $p = 0.02$ Intraoperative blood loss (ml) MI *42*, 151.8 (53.9), SI *42*, 173.2 (57.5), $p = 0.08$ Conversion: MI 2/42, SI 0/42 **Postoperative** Dislocation: MI 0/42, SI 1/42 Infection (septic and aseptic): MI 0/42, SI 0/42 Nerve injury (nerve palsy): MI 0/42, SI 0/42 30-day mortality: MI 0/42, SI 0/42 Length of hospital stay (days) MI 42, 6.12, SI 42, 6.07, $p = 0.92$ Implant position (initial postoperative radiographic analysis) Acceptable alignment for 100% of both femoral and acetabular components (i.e. no outliers) Acetabular component inclination between 35° and 50° was considered "well-aligned" Femoral component angulation between 3° varus and 3° valgus relative to the femoral shaft axis considered "well-aligned"	**Functional results** Harris hip score at 5 years: MI *37*, 86.9 (4.1), SI *39*, 84.2 (6.4), $p = 0.042$ Revision rates: MI 0/37, SI 0/39 Mortality at 5 years (secondary to events unrelated to the hip arthroplasty): MI 2/42, SI 2/42 **Satisfaction** Satisfaction with appearance of incision (Table 4): Enthusiastic: MI 16/37, SI 3/37 Satisfied: MI 15/37, SI 17/37 Indifferent: MI 6/37, SI 14/37 Disappointed: MI 0/37, SI 5/37 Would be more pleased if incision is shorter: MI 41% (15/37), SI 67% (25/37) Would be less pleased if incision is longer: MI 73% (27/37), SI 49% (18/37) **Surrogates for long-term outcomes** Cement quality: MI A = 38/42, B = 4/42, SI A = 37/42, B = 5/42 **Other** • progressive radiolucencies: MI 0/37, SI 0/39 • cavity osteolysis: MI 0/37, SI 0/39

Case series

Study details	Participant characteristics	Intervention/comparator	Outcomes	
			Short term	**Long term (including surrogates)**
Flören, 2006[39] Study design: consecutive cohort study Location: Germany Recruitment dates: 1988–1991 Funding: none Duration of FU: 10.9 (1.1) years [range 10–13 years]	Inclusion criteria: initial cohort (*N* = 122) represents consecutive series not selected for age, sex, bone type, body weight or diagnosis Exclusion criteria: patients with less than 10-year FU *N* eligible: 122 (137 hips) Lost to FU: 43 (of whom 32 died; all 32 who had died had annual FU and none needed revision) 10-Year follow-up group Indications: osteoarthritis 74; rheumatoid arthritis 5 Age (years): 73 (12.9) [32–97] Sex (M/F): 31/48 Body weight (kg): 80.9 (18.3) Height (cm): 162 (9.5) **Initial group** Indications: osteoarthritis 115; rheumatoid arthritis 7 Age (years): 64 (13.4) [19–91] Sex (M/F): 50/72	MI: *N* = 79 (90 hips) **Operative approach** MI: single-mini-incision posterior approach Cementless cup and stem Additional information: all surgeries performed by a single surgeon	**Postoperative** Dislocation: 0/90 Infection: 0/90 Length of hospital stay (days): *79*, 4.7 (2.0) [1–13] Implant position (radiographic analysis, mean radiographic FU 10.9 ± 1.0 [range 10–13] years) Stems in varus: 12/70 Stems in neutral position: 58/70	Functional results (at >10 years) Mean Harris hip score: *79*, 92.3 (7.9) [66–99] Harris hip score (Excellent, 90–99/Good, 80–89/Fair, 70–79/Poor, <70): 65/18/6/1 Harris hip score subscale: gait • limp (none/slight/moderate/ severe): 67/20/3/0 • support (none/cane for long walks/cane most of the time/1 crutch/2 crutches/not able to walk): 72/5/9/4/0/0 • distance walked (unlimited/6 blocks/2 or 3 blocks/indoors only/bed and chair): 66/4/20/0/0 Harris hip score subscale: activities • stairs (normally without using a railing/normally using a railing/in any manner/unable to do stairs): 29/57/2/2 • shoes and socks (with ease/with difficulty/unable): 69/20/1 • sitting (comfortably in ordinary chair for 1 h/on a high chair for 0.5 h/unable to sit comfortably in any chair): 86/2/2 Revision rates: 8/90 Time to revision (years): *90*, 6.8 (1.8) [4–10] Long-term pain Means score for Harris hip pain subscale: *90*, 43.2 (2.7) [30–44] Harris hip score pain subscale (none or ignore it/slight, occasional, no compromise in activities/mild pain, no effect on average activities/moderate pain, tolerable, some limitation of motion activity or work/marked pain, serious limitation of activities/totally disabled, crippled, pain in bed, bedridden): 80/7/3/0/0/0 Mortality: 32/122 (see Lost to FU)

continued

Study details	Participant characteristics	Intervention/comparator	Outcomes	
			Short term	Long term (including surrogates)
				Surrogates for long-term outcomes Implant migration: 0/70 (no subsidence of stem) Cement quality: 2 cups had polyethylene-induced osteolysis in zone 2, and 3 arthroplasties had radiolucent lines (⩾2 mm) in zones 1 and 2; 5 cups demonstrated radiolucent lines (⩽1 mm) in all zones **Other** • discharged home: 69% • discharged to facility: 31% • aseptic loosening: 0/70 • atrophic bone changes: 40/70 • radioluscent lines (⩽2 mm): 10/70 • osteolysis: 8/70 • clinical loosening: • polyethylene wear: • sclerotic changes around the stem: 3/70

continued

Study details	Participant characteristics	Intervention/comparator	Outcomes	
			Short term	**Long term (including surrogates)**
Hartzband, 2006[41] Study design: consecutive case series Location: USA Recruitment dates: January–May 2000 Funding: NR Duration of FU: 5.75 [5.6–6] years	Inclusion criteria: NR Exclusion criteria: NR *N* eligible: 98 Lost to FU: NR Indications: osteoarthritis 76/100; developmental dysplasia of the hip 8/100; avascular necrosis 9/100 Age (years): M 61 [30–93], F 65 [40–87] Sex (M/F): 41/57 Body weight (kg): M 92.6 [67.2–131.5], F 72.6 [38.6–108.0]	MI: *N* = 98 (100 cases) **Operative approach** MI: 7.26 [6–8]-cm single-incision posterolateral approach Additional information: the author performed all procedures	**Intraoperative** Duration of operation (minutes): 37.5 [27–90] **Postoperative** Dislocation: 0/100 Infection (postoperative infections): 0/100 Nerve injury (nerve palsy): 0/100 DVT: 4/100 Length of hospital stay (days): 100, 2.89 [3–5] Implant position (radiographic analysis) Average cup abduction: 100, 45.2° [30°–56°]	Long-term pain: no significant pain Limb length inequality (*N* of patients): 7/100, with a maximum postoperative length discrepancy of 0.5 cm **Surrogates for long-term outcomes** Implant migration: no component subsidence or loosening occurred
Pipino, 2004[49] Study design: single cohort Location: Italy (Genoa and Monza) Recruitment dates: April 1997–July 2004 (until December 2002 in Genoa, Monza thereafter) Funding: NR Duration of FU: 1–7 years	Inclusion criteria: generally good quality of the remaining healthy femoral bone, especially a structurally intact femoral neck with near-normal inclination Exclusion criteria: NR *N* eligible: 368 (303 in Genoa, 65 in Monza) Lost to FU: 37 (37 hips) Indications: coxarthritis 302; necrosis of femoral neck 29; coxarthritis and dysplasia 22; other 15 Age (years): 60 Sex (M/F): 220/148	MI: *N* = 368 (390 hips) at baseline *N* = 331 (353 hips) at 1–7 years **Operative approach** MI: transglutteal direct lateral access; 12–15-cm incision in Genoa; 8–10-cm incision in Monza 390 CFP stems, designed for "collum femoris-preserving" technique, a mini-invasive surgery that preserves and respects as much as possible the joint structure (bone stock and soft tissues) 388/390 cups positioned by press-fitting; 2/390 cups with screws (due to fracture)	**Intraoperative** Intraoperative blood loss (ml): *368*, 150 **Postoperative** Infection (deep *S. aureus* infection): 1/331 Nerve injury: 0/331 Vascular injury: 0/331 Peri-prosthetic fracture: 3/331 Implant position (radiographic analysis immediately postoperative) Cup slope (cup abduction outside normal range): <50° 18/353, >60° 11/353; 50–60° (normal) 324/353 Stem aligned in varus 18/353, in valgus 3/353, correctly 332/353 Cup sat correctly in the cotyloid cavity 342/353, too deep 4/353, too shallow 7/353, small gap beneath the prosthetic rim 2/353	**Functional results** Harris hip score at 1–7 years: Excellent, 90–100: 321/353 Good, 80–89: 20/353 Fair, 70–79: 8/353 Poor, <70: 4/353 Return to a full normal lifestyle at 1–7 years: 96% (318/331) Able to take up sports at a good amateur level at 1–7 years: 12% (40/331) Revision rates: 2/331 Time to revision (months): after 2 months **Long-term pain** Thigh pain at 2 months: 7/331 Persistent thigh pain at 1–7 years: 1/331 **Limb length inequality** Change less than 1 cm: 28/331 Change more than 1 cm: 0/331

continued

Study details	Participant characteristics	Intervention/comparator	Outcomes	
			Short term	**Long term (including surrogates)**
		Additional information: all surgeries performed by single surgeon (in two locations) MIS = short incision + preservation of the femoral neck	Stem size correct 328/353, oversized 14/353, undersized: 11/353	**Surrogates for long-term outcomes** Implant migration (at 1–7 years): 0/331 (the implanted cups did not detach, migrate or mobilise, and none presented osteolysis or radiolucent lines; 2 stems had aseptic loosening, while the integration of the implanted stem into the bone was generally good in the remaining 351 cases) Heterotopic ossification: 155/353 (Brooker's classification grade I/II/III/IV: 106/28/21/0, where IV = worst) **Other** • massive detachment of the stem, several months after surgery: 1/353 (patient diagnosed with gastric carcinoma 2 months after surgery) • altered bone remodelling around the stem (ingrowth) • spot-welds

continued

Study details	Participant characteristics	Intervention/comparator	Outcomes	
			Short term	**Long term (including surrogates)**
Siguier, 2004[50] Study design: retrospective study of continuous series Location: Paris, France Recruitment dates: June 1993–June 2000 Funding: none Duration of FU: unclear. Some data reported up to 3 years	Inclusion criteria: no previous hip surgery Exclusion criteria: obese patients requiring longer incision (*N* = 15); muscular men (*N* = 8); congenital posterior dislocated hips; dysplastic hips; fractured neck of the femur or acetabulum *N* eligible: NR Lost to FU: 45 patients after 1st visit Indications: osteoarthritis 950; congenital dysplastic hip 46; avascular necrosis 20; inflammatory arthritis 11; post-traumatic osteoarthritis 5; Legg–Calvé–Perthes disease 3; disability after epiphysiolysis 2 Age (years): 67.8 [23–93] Sex (M/F): 336/590	MI: *N* = 926 (1037 THRs) **Operative approach** MI: <10-cm single-incision anterior approach, without muscle or tendon sectioning 1037 cemented procedures Additional information: surgeries performed by 2 surgeons without navigation or image intensifier	**Postoperative** Dislocation: 10/1037 (0.96%) Infection (septic complication): 5/926 = 5/1037 hips Peri-prosthetic fracture: MI 1/926	**Functional results** Limp (postoperative period, possibly <3 months): 0/926 Revision rates (for haematoma): 0/926 **Surrogates for long-term outcomes** Heterotopic ossification: MI 0/926 **Other** • re-operation after fracture: 2/926 • refused re-operation after fracture at 3 months, 8 months and 3 years: 1/926 • femoral paresis: 2/926 • asceptic loosening: 3/926 • loosening of septic origin: 3/926

continued

Study details	Participant characteristics	Intervention/comparator	Outcomes	
			Short term	**Long term (including surrogates)**
Swanson, 2005[51] Study design: consecutive case series Location: USA Recruitment dates: May 1997– Funding: manufacturer; partial or in total support of the research material (Plus Orthopedics, San Diego, CA, consulting fee) Duration of FU: 3.1 [2–5.2] years	Inclusion criteria: minimum 2-year FU Exclusion criteria: death or loss to FU in first 2 years (*N* = 83); patients requiring extensive hardware removal, having significant deformity, requiring structural bone grafts or undergoing femoral osteotomy; no patients were excluded because of weight or BMI *N* eligible: 842 (1115 THRs) Lost to FU: 83 (not included in the study; see above) Indications: osteoarthritis 812/1000; rheumatoid arthritis 19/1000; osteonecrosis 68/1000; developmental dysplasia of the hip 22/1000; other 79/1000 Age (years): 62.3 (13.5) [23–93] Sex (M/F): 415/585 (based on *N* of hips) Body weight (kg): 76.7 (19.2) [43–163] Height (cm): 169 (10) [126–198] BMI (kg/m^2): 26.5 (5.7) [14.3–56.5] Harris hip score: 34 (12) [25–45] **Other** Dorr bone types Charnley functional classes	MI: *N* = 759 (1000 THRs) **Operative approach** MI: 8.8 (2.0) [6–16]-cm single-incision, posterior approach Tapered titanium femoral component + hemispherical press-fit ingrowth acetabular component; supplemental acetabular screws were used in most patients Additional information: all procedures performed by one surgeon (author) with a Charnley retractor (modified to minimise skin tension) and standard hemispherical power reamers, length of incision largely dependent on patients' BMI "Minimally invasive" surgery defined as mini-incision + minimise soft tissue dissection	**Intraoperative** Duration of operation (minutes): *1000*, 61.2 (24.2) [23–274] Intraoperative blood loss (ml) *1000*, 317.3 (230.6) [100–2000] Intraoperative fracture (femoral shaft): 7/1000 Trochanteric fracture: 3/1000 **Postoperative** Dislocation: 30/1000 **Infection** Deep infection: 3/1000 Superficial infection: 5/1000 Nerve injury (transient nerve palsy): 6/1000 DVT and/or PE: 12/1000 Peri-prosthetic fracture (femoral shaft): 3/1000 (after falls in the early postoperative period) Length of hospital stay (days): *1000*, 3.7 (1.8) [2–18] **Time to return to usual activities** Time to begin unrestricted normal daily activities (self-report): 4.2 [1–11] weeks Implant position (radiographic analysis at each FU visit at 6 weeks, 3 and 6 months, 1 year and yearly thereafter) Femoral components in <5° of varus: 7/1000 Cup inclination <30° or >50°: 30/1000 Cup anteversion <0° or >30°: 10/1000 Cup abduction angle: 41.2° Cup anteversion: 14.6°	**Functional results** Harris hip score: *1000*, 92 (9) [67–100] Revision rates: 21/1000 Limb length inequality (within 7 mm of each other): 912/1000, i.e. 88/1000 not equal Mortality: see exclusion criteria **Other** • delayed wound healing: 10/1000 • "acute medical complications": 41/1000

continued

Two incisions

RCTs and quasi-RCTs

Study details	Participant characteristics	Intervention/comparator	Outcomes	
			Short term	**Long term (including surrogates)**
Pagnano, 2007a[72] (abstract only) Study design: RCT, matched by computerised randomisation Location: USA Recruitment dates: NR Funding: NR Duration of FU: 1 year	Inclusion criteria: NR Exclusion criteria: NR *N* eligible: NR *N* randomised: 20 Lost to FU: NR Indications: NR Age (years): 66, matched by computerised randomisation Sex (M/F): matched by computerised randomisation Body weight (kg): matched by computerised randomisation	2MI: *N* = 10 MI: *N* = 10 **Operative approach** 2MI: two-incision approach (Mears/Berger technique), fluoroscopy assisted MI: single-incision mini-posterior approach		**Functional results** Gait analysis at 1 year: no difference
Pagnano, 2007b[73] (abstract only) Study design: RCT, matched by computerised randomisation Location: USA Recruitment dates: NR Funding: NR Duration of FU: 1 year	Inclusion criteria: NR Exclusion criteria: NR *N* eligible: NR *N* randomised: 72 Lost to FU: NR Indications: NR Age (years): matched Sex (M/F): MI 20/16, SI 20/16 (matched) Body weight (kg): matched	2MI: *N* = 36 MI: *N* = 36 **Operative approach** 2MI: two-incision approach (Mears/Berger technique), fluoroscopy assisted MI: single-incision, mini-posterior approach	**Postoperative** Postoperative pain Time to discontinue narcotics: shorter for 2MI than MI **Time to return to usual activities** Time to return to normal activities: shorter for MI than 2MI Time to discontinue ambulatory aids: shorter for MI Time to climb stairs: shorter for MI	

continued

Study details	Participant characteristics	Intervention/comparator	Outcomes	
			Short term	**Long term (including surrogates)**
Yan, 2005[57] Study design: quasi-RCT; randomisation method not described Location: China Recruitment dates: December 2003–June 2004 Funding: NR Duration of FU: 6 months	Inclusion criteria: good health (body weight <100 kg), no osteoporosis and no deformity, low limb length shorting ⩽2 cm Exclusion criteria: NR *N* eligible: 30 *N* randomised: 30 Lost to FU: NR Indications: osteoarthritis MI 6, SI 7; osteonecrosis of femoral head MI 8, SI 6; femoral fracture MI 1, SI 3 Age (years): MI 63 [51–69], SI 61 [50–70] Sex (M/F): MI 6/9, SI 7/8 Harris hip score: MI 57, SI 62	2MI: *N* = 15 SI: *N* = 15 **Operative approach** MI: two-incision THR with 3.6 [3.0–4.5] and 5.7 [5.4–6.5]-cm incisions SI: 12.0 [9–14]-cm single-incision posterolateral approach	**Intraoperative** Duration of operation (minutes) MI *15*, 100 [90–220], SI *15*, 80 [60–150], $p < 0.05$ Intraoperative blood loss (ml) MI *15*, 760 [600–1200], SI *15*, 650 [500–800], $p < 0.05$ **Postoperative** Dislocation: MI 0/15, SI 0/15 Infection: MI 0/15, SI 0/15 Nerve injury (thigh): MI 1/15, SI 0/15 Peri-prosthetic fracture: MI 1/15, SI 1/15 Length of hospital stay (days): MI 6, SI 13, $p < 0.001$ Implant position (radiographic analysis) Femoral stem: all neutral position Abduction of the cup: MI [41–47°], SI [40–53°], $p < 0.05$	**Functional results** Harris hip score: At 1 week: MI 81, SI 72, $p < 0.05$ At 6 weeks: MI 89, SI 86, $p < 0.05$ At 3 months: MI 92, SI 91, $p > 0.05$ At 6 months: MI 93, SI 93, $p > 0.05$ Limb length inequality (cm): MI *0*, 0.3 [0.2–0.5], SI *15*, 0.5 [0.3–0.9], $p < 0.05$

Comparative studies

Study details	Participant characteristics	Intervention/comparator	Outcomes	
			Short term	**Long term (including surrogates)**
Duwelius, 2007[38,62] Study design: matched pairs; matched for age, gender, BMI, diagnosis, follow-up length and WOMAC score Location: USA Recruitment dates: December 2002–June 2004 Funding: manufacturer (Zimmer) Duration of FU: two-incision: 1.2 [0.5–2.0] years; one mini-incision: 1.1 [0.5–2.0] years; 13/43 in each group had 1-year FU data	Inclusion criteria: both two- and one-incision MIS: patients aged 18 years or older at the time of THR and who completed the weekly patient diary For two-incision: age <70 years; BMI < 40; patients who do not have a Crowe dysplasia classification of class III or IV and do not have an excessive anterior–posterior bow of the femur; the diameter of the intramedually canal of the femur do not exceed 18 mm and the size of the acetabular cup do not exceed 64 mm No selection criteria for one mini-incision; any patients who did not fit the criteria for the two-incision procedure were included Exclusion criteria: NR *N* eligible: 284 *N* matched: 86 Lost to FU (at 12 months): 2MI 6, MI 13 Indications: osteoarthritis 2MI 43/43, MI 43/43 Age (years): 2MI 57.4 (6.3) [40–68], MI 59.1 (8.2) [43–74] Sex (M/F): 2MI 24/19, MI 24/19	2MI: *N* = 43 MI: *N* = 43 **Operative approach** 2MI: two-incision minimally invasive surgery 43/43 trilogy acetabular component (+ 1 or 2 screws), 43/43 fully coated femoral stem MI: single posterior mini-incision minimally invasive surgery 43/43 trilogy acetabular component 11/43 VerSys FullCoat stem, 32/43 VerSys Fiber Metal MidCoat stem Additional information: all surgeries by experienced surgeon(s) – not part of the initial 'learning curve' – with intraoperative fluoroscopy; surgical technique described elsewhere (see p. 50 in ref. 38 for reference)	**Intraoperative** Duration of operation (minutes) 2MI *43*, 93.7 (90) [72–135], MI *43*, 61.7 (60) [39–111], $p = 0.002$ Intraoperative blood loss (as collected in a cell saver) (ml) 2MI *43*, 366 (215) [150–1400], MI *43*, 247 (90) [100–450], $p = 0.001$ Intraoperative fracture (femoral neck): 2MI 3/43, MI 1/43 **Postoperative** Nerve injury Sciatic, peroneal or common femoral nerve injury: 2MI 0/43, MI 0/43 Some numbness in the anterolateral thigh: 2MI 6/43 , MI 0/43 Nerve pain: 2MI 0/43, MI 0/43 Length of hospital stay (hours): 2MI *43*, 30.7 [12.9–55.7], MI *43*, 44.6 [13–102], $p < 0.001$, i.e. MI 1.25 [0.5–2.3] days, SI 1.9 [0.5–4.3] days **Postoperative pain** Prescription anti-inflammatory use: 2MI 47% (20/43), MI 23% (10/43), $p = 0.04$ **Time to return to usual activities** Time to resume driving (days): 2MI *43*, 13 [2–31], MI *43*, 24 [6–32], $p = 0.04$ Time to resume shopping (days): 2MI *43*, 14 [3–24], MI *43*, 26 [6–37], $p = 0.01$ Implant position (radiographic analysis at 6 weeks or 3 months)	**Functional results** Harris hip score (from graph): 6 weeks: 2MI 84, MI 84 3 months: 2MI 89, MI 88 6 months: 2MI 94, MI 88 1 year: 2MI 94, MI 88 2MI better than MI: no assistive device needed at 2 weeks ($p = 0.001$) and negotiating stairs without a railing at 5 weeks ($p = 0.004$) Also in Figure 1: WOMAC physical function, WOMAC stiffness. These do not appear to be significantly different between groups Revision rates: 2MI 0/43, MI 0/43 **Health-related quality of life** SF-36 physical function (Figure 1): 2MI 80, MI 70 **Long-term pain** WOMAC pain score (from graph) 6 weeks: 2MI 2, MI 2.5 6 months: 2MI 1.8, MI 1.6 1 year: 2MI 1.6, MI 1.6 Total WOMAC pain subscale at 6 weeks: 2MI 3.31 [0–11], MI 1.22 [0–10], $p = 0.003$ MI better than 2MI: no pain at night at 6 weeks ($p = 0.0028$) and pain at night in bed at 6 weeks ($p = 0.004$) SF-36 bodily pain (from graph): 6 weeks: 2MI 68, MI 76 6 months: 2MI 75, MI 75 1 year: 2MI 76, MI 75

continued

Study details	Participant characteristics	Intervention/comparator	Outcomes	
			Short term	**Long term (including surrogates)**
	BMI (kg/m^2) Normal (<25): 2MI 21/43, MI 21/43 Overweight (25–30): 2MI 15/43, MI 15/43 Obese (>30): 2MI 7/43, MI 7/43 WOMAC pain: 2MI 9.1 (2.8) [4–15], MI 9.0 (2.9) [2–14] WOMAC physical function: 2MI 28.4 (9.6) [5–45], MI 29.8 (9.8) [8–45] WOMAC fitness: 2MI 3.9 (1.6) [1–8], MI 4.4 (1.4) [2–8]		Stem in ⩾3° varus: 2MI 1/43, MI 1/43; all other stems in neutral alignment Cup abduction (*N* of outliers; target 45°): 2MI 4/43 (>50°), MI 2/43 Cup abduction angle: 2MI *43*, 49.4° (4.2) [41–60], MI *43*, 45.6° (5.3) [35–57], $p = 0.0003$ Cup anteversion: 2MI *43*, 20.2° (5.3) [5–25], MI *43*, 18.4 (7.9) [0–35], $p = 0.2624$ NB: radiographs were performed immediately postoperative, at 6 weeks, 3 months, 6 months and annual visits	Medical Outcomes Study (MOS) sleep scale: MI better than SI: no trouble falling asleep ($p = 0.0004$) and no trouble falling back to sleep ($p = 0.003$) Limb length inequality (at 6 weeks): 2MI 6/39, MI 6/38 **Surrogates for long-term outcomes** Implant migration (from the radiograph with the longest follow-up): 2MI 0/43, MI 0/43 (no components subsided) **Other** Patient compliance (diary and attendance at scheduled examination): 1 week: 2MI 91% [86–95], MI 88% [77–95], NS 6 weeks: 2MI 41/43, MI 41/43 6 months: 2MI 33/43, MI 28/43, NS 12 months: 2MI 26/37, MI 26/30, $p = 0.09$
Greidanus, 2006[71] (abstract only) Study design: prospective comparative cohorts Location: Canada Recruitment dates: 2002–4 Funding: NR Duration of FU: NR	Inclusion criteria: NR Exclusion criteria: NR *N* eligible: NR Lost to FU: NR Indications: NR Age (years): no difference Sex (M/F): no difference BMI (kg/m^2): no difference Co-morbid status: no difference WOMAC: no difference Oxford hip score: no difference SF-12: no difference	2MI: $N = 66$ MI: $N = 99$ **Operative approach** 2MI: two-incision approach MI: single-incision approach	**Postoperative** Length of hospital stay (days) Shorter for 2MI, $p < 0.05$ **Postoperative pain** Analgesic use: less for 2MI, $p < 0.05$	

continued

Study details	Participant characteristics	Intervention/comparator	Outcomes	
			Short term	**Long term (including surrogates)**
Pagnano, 2006[47] Study design: prospective comparative study; staged bilateral THRs (2MI on one hip and MI on the other) Location: USA Recruitment dates: 2003–4 Funding: manufacturer (Zimmer) Duration of FU: 6 months after 2nd surgery	Inclusion criteria: staged bilateral THRs; patients with a successful clinical outcome Exclusion criteria: patients with complications (2 in 2MI, 1 in MI) *N* eligible: 29 *N* selected: 27 Lost to FU: none Indications: osteoarthritis 26/26 *Age* (years): 69 [42–80] Sex (M/F): 10/16	2MI: *N* = 26 MI: *N* = 26 **Operative approach** 2MI: two-incision approach Uncemented hemispherical acetabular component and uncemented femoral stem MI: 6–9-cm single-mini-incision posterior approach Uncemented hemispherical acetabular component and uncemented femoral stem Additional information: all surgeries performed by one surgeon; two-incision THRs done with intraoperative fluoroscopy; focus on early functional results 12/26 patients had 2MI THR first then MI THR in the other hip; 14/26 had MI THR first, then 2MI THR in the other hip; second hip operated on within a 2-year period; unclear whether surgical approach was randomised	**Postoperative** Time to return to usual activities (from patients' milestone diary) Use of ambulatory aids (days): 2MI *26*, 28 [7–56], MI *26*, 27 [5–49], $p = 0.75$ Return to driving (days): 2MI *26*, 32 [8–49], MI *26*, 34 [20–56], $p = 0.38$ Return to work (days): 2MI *26*, 42 [9–56], MI *26*, 38 [14–90], $p = 0.60$ Unassisted stair climbing (days): 2MI *26*, 36 [24–43], MI *26*, 31 [10–56], $p = 0.25$ Walk 0.5 mile (days): 2MI *26*, 33 [3–49], MI *26*, 33 [10–90], $p = 0.95$	**Satisfaction** Patient preference (survey at 6 months after 2nd surgery) Operation preferred: 2MI 8/26, MI 16/26, no preference 2/26, $p = 0.015$ Preferred 2MI because of better early results 8/8, better cosmetic results 0/8, both 0/8 Preferred MI because of better early results 8/16, better cosmetic results 4/16, both 4/16

continued

Study details	Participant characteristics	Intervention/comparator	Outcomes	
			Short term	**Long term (including surrogates)**
Tanavalee, 2006[53] Study design: prospective comparison of two case series Location: Thailand Recruitment dates: October 2002–December 2004 Funding: NR Duration of FU: 1.7 [1–3] years	Inclusion criteria: stable medical condition; Dorr A or B femoral canal morphometry; leg length difference within 2 cm; no previous hip surgery Exclusion criteria: NR *N* eligible: 70 Lost to FU: NR Indications: primary osteoarthritis 2MI 5, MI 4; secondary osteoarthritis 2MI 2, MI 8; rheumatoid arthritis 2MI 0, MI 1; avascular necrosis: 2MI 27, MI 15; developmental dysplasia of the hip 2MI 5, MI 4; others: 2MI 1, MI 4 Age (years): 2MI 53 [34–75], MI 54.9 [38–76], NS Sex (M/F): 2MI 8/27, MI 20/15, $p = 0.007$ BMI (kg/m^2): 2MI 25 [17.1–33.3], MI 24.2 [19.3–33.3], NS	2MI: *N* = 35 (40 hips) MI: *N* = 35 (36 hips) **Operative approach** 2MI: two-incision approach with 5.2 [4.5–6]-cm anterior and 3.6 [3–4] posterior incisions Cementless MI: 9 [7–12]-cm single-incision posterior approach Cementless Additional information: all cases performed by single surgeon whose routine approach is standard single-incision posterior; two-incision approach included the surgeon's learning curve and was done with intraoperative fluoroscopy	**Intraoperative** Duration of operation (minutes) 2MI *35*, 168 [130–210], MI *35*, 113 [90–140], $p < 0.01$ **Intraoperative fracture** 2MI 2/35, MI 0/35 **Postoperative** **Nerve injury** Transient numbness along the anterior thigh for 6–8 weeks postoperative due to over-traction of the anterior wound: 2MI 4/35, MI 0/35 Peri-prosthetic fracture: 2MI 2/35 (including 1 fall at 1 month), MI 0/35 **Time to return to usual activities (days)** Return to walking (with aid): 2MI *35*, 1.2 (0.5), MI *35*, 1.6 (0.7), $p < 0.01$ Return to climbing stairs: 2MI *35*, 9 (10.5), MI *35*, 9 (4.2), NS Return to independent walking (without aid): 2MI *35*, 11 (11), MI *35*, 19 (8.6), $p < 0.01$ Return to working: 2MI *35*, 3 (1.3), MI *35*, 7 (2.1), $p < 0.01$ Return to driving (only patients who were able to drive preoperatively): 2MI *16*, 3, MI *15*, 5, $p < 0.01$ Implant position (radiographic analysis at the most recent follow-up ⩾1 year) Femoral component in neutral position: 2MI 80% (28/35), MI 83% (29/35), $p = 0.72$ Acetabular component within the preoperative target angle of 35–55°: 2MI 89% (31/35), MI 84% (29/35), $p = 0.41$ Acetabular abduction angle: 2MI 46.7°, MI 44.8°	**Functional results** Harris hip score at >1 year FU: 2MI 94.5 (4.7), MI 94.6 (4.5), $p = 0.95$ **Surrogates for long-term outcomes** Implant migration: 2MI 0/35, MI 0/35 (no radiographic evidence of subsidence)

continued

Study details	Participant characteristics	Intervention/comparator	Outcomes	
			Short term	**Long term (including surrogates)**
Yoon, 2005[79] (abstract only) Study design: comparison of consecutive patients Location: Korea Recruitment dates: NR Funding: NR Duration of FU: early results only	Inclusion criteria: NR Exclusion criteria: NR *N* eligible: NR Lost to FU: NR Indications: osteoarthritis 27; osteonecrosis 163; rheumatoid arthritis 8; ankylosing spondylitis 6; infection sequelae 9	2MI: *N* = 118 MI: *N* = 100 **Operative approach** 2MI: two-incision approach MI: 7.5-cm single-incision approach	**Intraoperative** Duration of operation (minutes) 2MI 72 [50–115], MI 52 [35–75] **Postoperative** Length of hospital stay (days) Shorter for 2MI **Postoperative pain** Period using crutches: shorter for 2MI	

Case series

Study details	Participant characteristics	Intervention/comparator	Outcomes	
			Short term	**Long term (including surrogates)**
Archibeck, 2004[27] Study design: prospective survey of trainee surgeons (N = 159) doing 851 cases, Location: USA Recruitment dates: October 2002–April 2004 Funding: manufacturer (Zimmer) Duration of FU: NR	Inclusion criteria: 159 surgeons learning two-incision MI reported 851 procedures Exclusion criteria: NR N eligible: 831 (851 cases) Lost to FU: NR Indications: osteoarthritis 660/851; post-traumatic arthritis 10/851; osteonecrosis 138/851; other 11/851 Age (years): 61 [21–100] Sex (M/F): 435/396 Body weight (kg): 77.6 [34.5–160] BMI (kg/m^2): 26 [10–56] "Patient demographics for 851 cases showed the population was typical for THR patients, with a slight propensity for younger and thinner patients" (p. 233 of ref. 27)	2MI: N = 831 (851 cases) **Operative approach** Two-incision MIS with 5.8 [1.5–19]-cm anterior incision and 3.7 [1–21]-cm posterior incision Cementless acetabular and femoral components Additional information: all surgeons attended Zimmer training on two-incision procedures and were asked to report to the company on their first 10 cases; 49/159 surgeons completed their first 10 cases (490 index cases, of which 11 cases not reported); fluoroscopy was used; data were self-reported by the surgeons involved (possible under-reporting of complications)	**Intraoperative** Duration of operation (minutes): *851*, 148 [50–455] Decreased as N of cases increased ($p < 0.05$) Intraoperative blood loss (ml): *851*, 496 [30–2800] Intraoperative fracture: 62/851 **Postoperative** Dislocation: 8/851 **Infection** Deep infection: 4/851 Superficial infection: 3/851 Nerve injury: 27/851 Peri-prosthetic fracture: 2/851	Revision rates: 5/851 Early revision or reoperation: 8/851 • 2 reoperations: removal for the THR done for infection • 1 open reduction and internal fixation for a femoral shaft fracture • 1 revision for fracture and stem subsidence • 3 revisions for dislocation • 1 revision for early acetabular loosening **Other** Subgroup analysis of 479 index cases by 49 surgeons • prevalence of key complications as a function of case number (NS), surgeon volume of THRs before training ($p = 0.0003$) and patient BMI ($p = 0.05$) • to explain difference between surgeons who did not report a key complication and those who did – regression analysis

continued

Study details	Participant characteristics	Intervention/comparator	Outcomes	
			Short term	**Long term (including surrogates)**
Duwelius, 2003[17,37] Study design: case series in 4 centres Location: USA Centre 1 (C1): Portland, OR (Duwelius); Centre 2 (C2): Hackensack, NJ (Hartzband); Centre 3 (C3): Chicago, IL (Berger); Centre 4 (C4): Pittsburgh, PA (Mears) (name refers to lead surgeon in each centre) Recruitment dates: NR Funding: NR Duration of FU: C1: 1 year C2: 1 [0.25–1.5] year C3: unclear C4: unclear	**Inclusion criteria:** C1: weight <100 kg, less muscularly developed than patients who had one-incision THR, age <75 years; C2: NR; C3: performed as the first operative procedure of the day; initially patients with straightforward anatomy only; later extended to obese patients and patients with dysplasia C4: consecutive patients; primary THRs **Exclusion criteria:** C1: no major co-morbidities, osteoporosis or cognitive impairment; no prior operation on ipsilateral hip C2: NR C3: NR C4: no patients excluded during the study period *N* eligible: NR Lost to FU: NR **Indications:** Osteoarthritis: C1 94/100, C2 80/100, C3 87/100, C4 63/75 Rheumatoid arthritis: C1 2/100, C2 0, C3 0/100, C4 3/75 Osteonecrosis: C1 4/100, C2 8/100, C3 5/100, C4 0/75 Developmental hip dysplasia: C1 0/100, C2 9/100, C3 8/100, C4 4/75	**Two-incision** C1: N = 100 C2: N = 100 C3: N = 100 C4: N = 75 (80 hips) **Operative approach** Two-incision with 4–6 cm anterior incision and 3–4 cm posterior incision C1: uncemented stem and socket C2: uncemented stem and socket C3: uncemented stem and socket C4: proximally coated femoral stem + multi-holed cup **Additional information:** All centres – Early results from two-incision THRs performed by one surgeon at each centre with fluoroscopy, specialised dog-leg inserter and specially designed reamers; patients managed with an "accelerated critical pathway" (rapid rehabilitation) for THR, with patients seen by a physiotherapist immediately upon return from the recovery room and weight bearing as tolerated (but first 12 patients at Centre 3 did not receive this)	**Intraoperative** Duration of operation (min) C1: *100*, 90 [80–120], C2: *100*, 62 [38–140], C3: *first 12*, 150 [94–255], *last 88*, 101 [80–120], C4: *75*, 85 [55–125] **Opposite method initiated** C3: 0/100 **Intra-operative fracture** C3: 1/100 C4: 2/80 hips **Conversion:** C3: 0/100 **Postoperative** **Dislocation** C1: 2/100 **Infection** C1: 1/100 ('probably due to hematogenenous infection from a lung abscess') **Nerve injury** Partial femoral nerve palsy: C4 2/75 Hypoesthesia of the anterior part of the thigh, consistent with a partial injury to the lateral femoral cutaneous nerve of the thigh: C4 16/75 DVT: C2: 1/100 Peri-prosthetic fracture: C1 1/100, C2 2/100	**Functional results** Harris hip score at 1 year: C1 *100*, 90 **Revision rates:** C1: 1/100, C2: 0/100 **Surrogates for long-term outcomes** **Implant migration:** C1: 1/100 femoral component subsided and required revision C4: 1/75 stem subsided but asymptomatic Heterotopic ossification: C4: 2/80 hips Grade I heterotopic bone **Other** • readmission for medical complications: C1 0/100, C2 0/100, C3 0/100, C4 0/75 • bowel obstruction: C2: 1/100 • 'other' complications: C3: 0/100

continued

Study details	Participant characteristics	Intervention/comparator	Outcomes	
			Short term	**Long term (including surrogates)**
	Trauma: C1 0/100, C2 3/100, C3 0/100, C4 0/75 Post-traumatic osteoarthritis: C1 0/100, C2 0/100, C3 0/100, C4 5/75 Age (years): C1 M 57, F 60; C2 56; C3 55 [30–76]; C4 M 58 [32–84], F 62 [43–82] Sex (M/F): C1 57/43, C2 56/44, C3 75/25, C4 NR Body weight (kg): C1 M 83.5, F 64; C2 M 88.1, F 67.2; C3 176 [102–265]; C4 M 104 [70–143], F 83.5 [51–123] Harris hip score: C1 52		Length of hospital stay (days) C3: *first 12*, 1.5 [1–3] NB: patients not subjected to rapid rehabilitation Discharged home within 24 hours of surgery: C1 90/100, C2 77/100, C3 75/88, C4 7/75 Discharged the next day: C1 10/100, C3 13/88, C4 58/75 Stayed >23 hours after surgery: C3 0/88 Implant position (radiographic analysis) C1 – cup abduction angle 47° (Duwelius, 2006[62]) C3 – Radiographic analysis at 1 year for 30/100 patients (Berger, 2003[60]) • femoral stem in neutral alignment (between neutral and 3° valgus): 91% • abduction angle of acetabular component: 45° [36–54]	

Appendix 9

Summary of outcomes reported in the included studies

Clinical performance, safety and resource utility

Study	Clinical performance								Safety							Resource utility			
	Revision rate (number having revision surgery)	Postoperative dislocation rates	Implant position (cup, number poorly placed)	Implant position (stem, number poorly placed)	Implant migration	Heterotopic ossification (number with ossification)	Cement quality (number with poor quality)	Limb length inequality (number with unequal lengths)	Blood loss (intraoperative, ml)	Blood loss (total, ml)	Fractures: intraoperative	Fractures: postoperative	Infection	Nerve injury	Vascular injury	DVT	PE	Duration of operation (minutes)	Length of hospital stay (days)
One incision																			
RCT and quasi-RCT																			
Charles, 2006[69]									✓					✓				✓	✓
Chimento, 2005[31]	✓	✓		✓			✓		✓	✓			✓	✓		✓		✓	✓
Chung, 2004[32]		✓	✓	✓					✓				✓	✓		✓		✓	✓
Hart, 2005[40]	✓	✓		✓	✓		✓		✓	✓	✓	✓	✓	✓		✓	✓	✓	
Kim, 2006[43]		✓	✓	✓					✓				✓	✓				✓	
Ogonda, 2005[46]	✓	✓	✓	✓			✓		✓		✓		✓			✓		✓	✓
Rachbauer, 2006[75]									✓									✓	
Sharma, 2006[77]		✓										✓	✓					✓	✓
Zhang, 2006[58]													✓	✓	✓	✓		✓	✓
Comparative studies																			
Asayama, 2006[28]	✓	✓	✓	✓				✓	✓		✓		✓	✓		✓		✓	✓
Berger, 2004[29]		✓							✓		✓		✓				✓	✓	✓
Chen, 2006[30]		✓							✓	✓		✓		✓				✓	✓
Ciminiello, 2006[33]	✓	✓	✓	✓	✓				✓			✓	✓					✓	✓
de Beer, 2004[34]				✓					✓			✓				✓		✓	✓
DiGioia, 2003[35]		✓				✓								✓				✓	✓
Dorr, 2007[36]																			

continued

Study	Clinical performance									Safety								Resource utility			
	Revision rate (number having revision surgery)	Postoperative dislocation rates	Implant position (cup, number poorly placed)	Implant position (stem, number poorly placed)	Implant migration	Heterotopic ossification (number with ossification)	Cement quality (number with poor quality)	Limb length inequality (number with unequal lengths)	Blood loss (intraoperative, ml)	Blood loss (total, ml)	Fractures: intraoperative	Fractures: postoperative	Infection	Nerve injury	Vascular injury	DVT	PE	Duration of operation (minutes)	Length of hospital stay (days)
Howell, 2004[42]									✓		✓		✓					✓	✓	
Li, 2005[44]	✓									✓								✓		
O'Brien, 2005[45]		✓		✓							✓		✓	✓		✓	✓	✓	✓	
Panisello, 2006[74]																			✓	
Pilot, 2006[48]									✓									✓		
Szendrói, 2006[52] (MI/MD)		✓	✓	✓			✓		✓	✓	✓		✓	✓		✓		✓		
Szendrói, 2006[52] (MI/SI)		✓	✓	✓			✓		✓	✓	✓		✓	✓		✓		✓		
Takahira, 2006[78]						✓				✓								✓	✓	
Teet, 2006[54]		✓		✓																
Woolson, 2004[55]		✓	✓	✓			✓		✓		✓		✓	✓		✓		✓	✓	
Wright, 2004[56]	✓	✓	✓	✓			✓		✓				✓	✓				✓	✓	
Case series and registry																				
Flören, 2006[39]	✓	✓		✓	✓		✓						✓						✓	
Hartzband, 2006[41]		✓			✓			✓					✓	✓		✓		✓	✓	
Pipino, 2004[49]	✓		✓	✓	✓	✓			✓			✓	✓	✓				✓		
Siguier, 2004[50]	✓	✓				✓						✓	✓	✓						
Swanson, 2005[51]	✓	✓	✓	✓				✓	✓		✓	✓	✓			✓	✓	✓	✓	
Norwegian Arthroplasty Register, 2005–6[11]	✓																			

continued

Study	Clinical performance								Safety								Resource utility			
	Revision rate (number having revision surgery)	Postoperative dislocation rates	Implant position (cup, number poorly placed)	Implant position (stem, number poorly placed)	Implant migration	Heterotopic ossification (number with ossification)	Cement quality (number with poor quality)	Limb length inequality (number with unequal lengths)	Blood loss (intraoperative, ml)	Blood loss (total, ml)	Fractures: intraoperative	Fractures: postoperative	Infection	Nerve injury	Vascular injury	DVT	PE	Duration of operation (minutes)	Length of hospital stay (days)
Two incisions																			
RCT and quasi-RCT																			
Pagnano, 2007a[72]																			
Pagnano, 2007b[73]																			
Yan, 2005[57]		✓		✓					✓			✓	✓	✓				✓	✓
Comparative studies																			
Duwelius, 2007[38]			✓	✓	✓			✓			✓			✓				✓	✓
Greidanus, 2006[71]									✓										✓
Pagnano, 2006[47]			✓	✓	✓													✓	
Tanavalee, 2006[53]			✓	✓	✓					✓	✓	✓		✓				✓	✓
Yoon, 2005[79]																		✓	✓
Case series																			
Archibeck, 2004[27]	✓	✓									✓	✓	✓	✓				✓	
Duwelius, 2003[37]	✓	✓			✓	✓					✓	✓	✓	✓		✓		✓	

Study	Death (30-days)	Death (long-term)	Short-term patient-controlled anaesthesia (mg)	Short-term total narcotic received (mg)	Short-term narcotic (days)	Short-term pain (no. of patients)	Long-term pain (no. of patients)	Short-term pain (score)	Long-term pain (score)	Time to return to normal activity (days)	Time to return to shopping (days)	Time to return to driving (days)	Use of walking aids: short-term (no. of patients)	Use of walking aids (days)	Limp: short-term (no. of patients)	Limp: long-term (no. of patients)	Harris hip score (≤3 months)	Harris hip score (>3 months)	WOMAC osteoarthritis index (≤3 months)	Oxford hip score (≤3 months)	Merle d'Aubigné–Charnley score (≤3 months)	Merle d'Aubigné–Charnley score (>3 months)	SF-12 physical component (≤3 months)	SF-12 mental component (≤3 months)	SF-36 physical function (≤3 months)	SF-36 physical function (>3 months)	SF-36 mental component (>3 months)	Satisfaction (no. of patients dissatisfied)	Satisfaction (score)	Scar contraction
One incision																														
RCT and quasi-RCT																														
Charles, 2006[69]			✓					✓											✓						✓				✓	
Chimento, 2005[31]		✓	✓										✓		✓	✓		✓												
Chung, 2004[32]					✓									✓				✓												
Hart, 2005[40]																					✓	✓								
Kim, 2006[43]								✓	✓									✓												
Ogonda, 2005[46]	✓		✓					✓									✓		✓	✓			✓	✓						✓
Rachbauer, 2006[75]					✓			✓		✓																				
Sharma, 2006[77]								✓																						
Zhang, 2006[58]																	✓	✓												
Comparative studies																														
Asayama, 2006[28]				✓		✓							✓		✓			✓												
Berger, 2004[29]																														
Chen, 2006[30]										✓								✓												
Ciminiello, 2006[33]	✓	✓		✓		✓											✓													

continued

Study	Death (30-days)	Death (long-term)	Short-term patient-controlled anaesthesia (mg)	Short-term total narcotic received (mg)	Short-term narcotic (days)	Short-term pain (no. of patients)	Long-term pain (no. of patients)	Short-term pain (score)	Long-term pain (score)	Time to return to normal activity (days)	Time to return to shopping (days)	Time to return to driving (days)	Use of walking aids: short-term (no. of patients)	Use of walking aids (days)	Limp: short-term (no. of patients)	Limp: long-term (no. of patients)	Harris hip score (⩽3 months)	Harris hip score (>3 months)	**WOMAC** osteoarthritis index (⩽3 months)	Oxford hip score (⩽3 months)	Merle d'Aubigné–Charnley score (⩽3 months)	Merle d'Aubigné–Charnley score (>3 months)	SF-12 physical component (⩽3 months)	SF-12 mental component (⩽3 months)	SF-36 physical function (⩽3 months)	SF-36 physical function (>3 months)	SF-36 mental component (>3 months)	Satisfaction (no. of patients dissatisfied)	Satisfaction (score)	Scar contraction
de Beer, 2004[34]				✓		✓											✓			✓										
DiGioia, 2003[35]																	✓	✓												
Dorr, 2007[36]																										✓	✓	✓		
Howell, 2004[42]																														
Li, 2005[44]																		✓												
O'Brien, 2005[45]																														
Panisello, 2006[74]																														
Pilot, 2006[48]																														
Szendrói, 2006[52] (MI/MD)								✓																				✓		
Szendrói, 2006[52] (MI/SI)								✓																				✓		
Takahira, 2006[78]																														
Teet, 2006[54]																														
Woolson, 2004[55]																		✓										✓		
Wright, 2004[56]	✓	✓																✓										✓		

continued

Study	Patient-centred measures																													
	Death (30-days)	**Death (long-term)**	**Short-term patient-controlled anaesthesia (mg)**	**Short-term total narcotic received (mg)**	**Short-term narcotic (days)**	**Short-term pain (no. of patients)**	**Long-term pain (no. of patients)**	**Short-term pain (score)**	**Long-term pain (score)**	**Time to return to normal activity (days)**	**Time to return to shopping (days)**	**Time to return to driving (days)**	**Use of walking aids: short-term (no. of patients)**	**Use of walking aids (days)**	**Limp: short-term (no. of patients)**	**Limp: long-term (no. of patients)**	**Harris hip score (≤3 months)**	**Harris hip score (>3 months)**	**WOMAC osteoarthritis index (≤3 months)**	**Oxford hip score (≤3 months)**	**Merle d'Aubigné–Charnley score (≤3 months)**	**Merle d'Aubigné–Charnley score (>3 months)**	**SF-12 physical component (≤3 months)**	**SF-12 mental component (≤3 months)**	**SF-36 physical function (≤3 months)**	**SF-36 physical function (>3 months)**	**SF-36 mental component (>3 months)**	**Satisfaction (no. of patients dissatisfied)**	**Satisfaction (score)**	**Scar contraction**
Case series and registry																														
Flören, 2006[39]							✓											✓												
Hartzband, 2006[41]							✓																							
Pipino, 2004[49]						✓	✓			✓							✓													
Siguier, 2004[50]															✓															
Swanson, 2005[51]										✓								✓												
Two incisions																														
RCT and quasi-RCT																														
Pagnano, 2007a[72]																✓														
Pagnano, 2007b[73]					✓					✓				✓																
Yan, 2005[57]																	✓	✓												
Duwelius, 2007[38]						✓		✓	✓		✓	✓					✓	✓							✓	✓				
Comparative studies																														
Greidanus, 2006[71]				✓																										
Pagnano, 2006[47]												✓		✓														✓		

continued

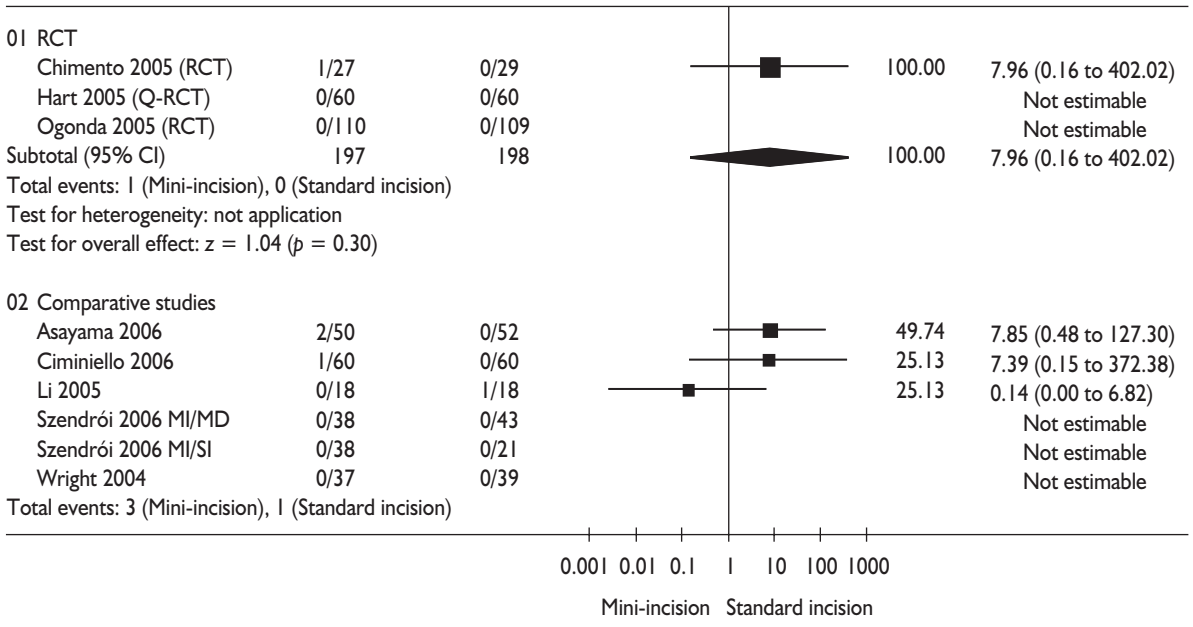
Study	Death (30-days)	Death (long-term)	Short-term patient-controlled anaesthesia (mg)	Short-term total narcotic received (mg)	Short-term narcotic (days)	Short-term pain (no. of patients)	Long-term pain (no. of patients)	Short-term pain (score)	Long-term pain (score)	Time to return to normal activity (days)	Time to return to shopping (days)	Time to return to driving (days)	Use of walking aids: short-term (no. of patients)	Use of walking aids (days)	Limp: short-term (no. of patients)	Limp: long-term (no. of patients)	Harris hip score (≤3 months)	Harris hip score (>3 months)	WOMAC osteoarthritis index (≤3 months)	Oxford hip score (≤3 months)	Merle d'Aubigné–Charnley score (≤3 months)	Merle d'Aubigné–Charnley score (>3 months)	SF-12 physical component (≤3 months)	SF-12 mental component (≤3 months)	SF-36 physical function (≤3 months)	SF-36 physical function (>3 months)	SF-36 mental component (>3 months)	Satisfaction (no. of patients dissatisfied)	Satisfaction (score)	Scar contraction
Patient-centred measures																														
Tanavalee, 2006[53]																		✓												
Yoon, 2005[79]																														
Case series																														
Archibeck, 2004[27]																		✓												
Duwelius, 2003[37]																														

Appendix 10

Results of meta-analyses

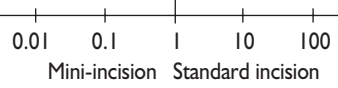
Comparison 01: Single mini-incision versus single standard incision (reported means and SDs)

Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 01 Revision rate (number having revision surgery)



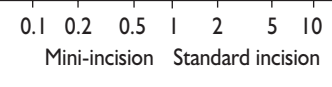
Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 02 Postoperative dislocation rates

Study or subcategory	Mini-incision *n/N*	Standard incision *n/N*	Peto OR 95% CI	Weight %	Peto OR 95% CI
01 RCT					
Chimento 2005 (RCT)	2/28	0/32		24.72	8.84 (0.54 to 145.71)
Chung 2004 (Q-RCT)	0/60	0/60			Not estimable
Hart 2005 (Q-RCT)	1/60	1/60		25.05	1.00 (0.06 to 16.18)
Kim 2006 (Q-RCT)	1/70	1/70		25.08	1.00 (0.06 to 16.15)
Ogonda 2005 (RCT)	1/109	1/110		25.15	1.01 (0.06 to 16.24)
Shama 2006 (Q-RCT)	0/20	0/20			Not estimable
Subtotal (95% CI)	347	352		100.00	1.72 (0.43, 6.92)
Total events: 5 (Mini-incision), 3 (Standard incision)					
Test for heterogeneity: $\chi^2 = 1.75$, df = 3 ($p = 0.63$), $I^2 = 0\%$					
Test for overall effect: $z = 0.76$ ($p = 0.45$)					
02 Comparative studies					
Asayama 2006	0/52	1/50		13.04	0.13 (0.00 to 6.56)
Berger 2004	0/99	0/100			Not estimable
Chen 2006	0/51	0/95			Not estimable
Ciminiello 2006	0/60	0/60			Not estimable
DiGioia 2003	0/33	0/33			Not estimable
O'Brien 2005	0/34	0/53			Not estimable
Szendrói 2006 MI/MD	0/38	0/43			Not estimable
Szendrói 2006 MI/SI	0/38	0/21			Not estimable
Teet 2006	1/73	4/54		61.74	0.21 (0.03 to 1.24)
Woolson 2004	0/50	1/85		12.17	0.20 (0.00 to 11.83)
Wright 2004	0/42	1/42		13.05	0.14 (0.00 to 6.82)
Total events: 1 (Mini-incision), 7 (Standard incision)					

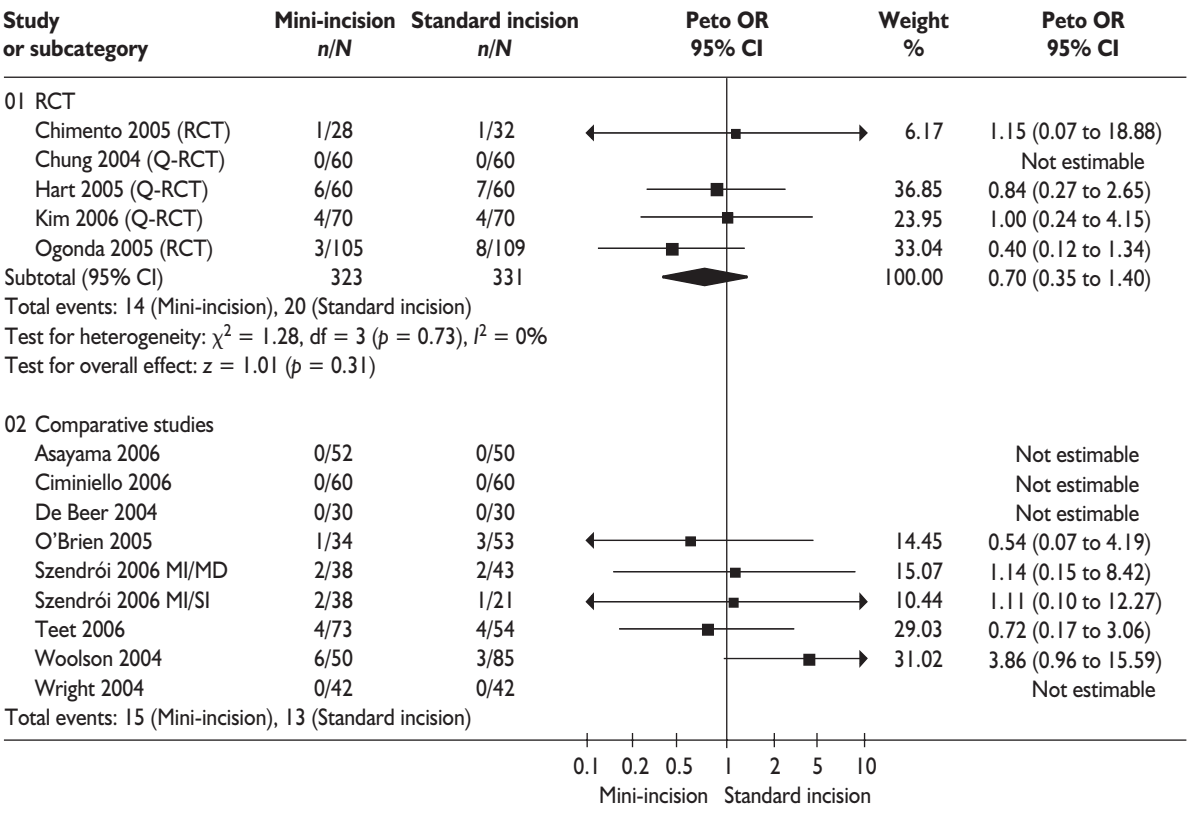


Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 03 Implant position (cup, number poorly placed)

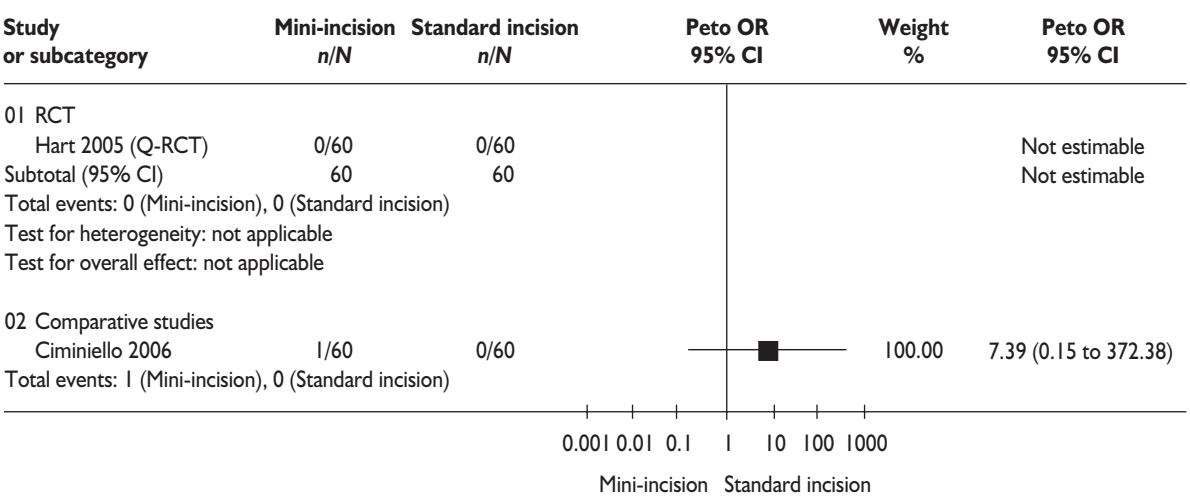
Study or subcategory	Mini-incision *n/N*	Standard incision *n/N*	Peto OR 95% CI	Weight %	Peto OR 95% CI
01 RCT					
Chung 2004 (Q-RCT)	0/60	0/60			Not estimable
Kim 2006 (Q-RCT)	6/70	5/70		25.77	1.22 (0.36 to 4.15)
Ogonda 2005 (RCT)	16/105	19/109		74.23	0.85 (0.41 to 1.76)
Subtotal (95% CI)	235	239		100.00	0.93 (0.50 to 1.74)
Total events: 22 (Mini-incision), 24 (Standard incision)					
Test for heterogeneity: $\chi^2 = 0.24$, df = 1 ($p = 0.62$), $I^2 = 0\%$					
Test for overall effect: $z = 0.21$ ($p = 0.83$)					
02 Comparative studies					Not estimable
Asayama 2006	0/52	0/50			Not estimable
Ciminiello 2006	0/60	0/60		17.39	2.33 (0.44 to 12.21)
Szendrói 2006 MI/MD	4/38	2/43		17.86	0.70 (0.14 to 3.60)
Szendrói 2006 MI/SI	4/38	3/21		64.74	2.43 (1.03 to 5.73)
Woolson 2004	15/50	13/85			Not estimable
Wright 2004	0/42	0/42			
Total events: 23 (Mini-incision), 18 (Standard incision)					



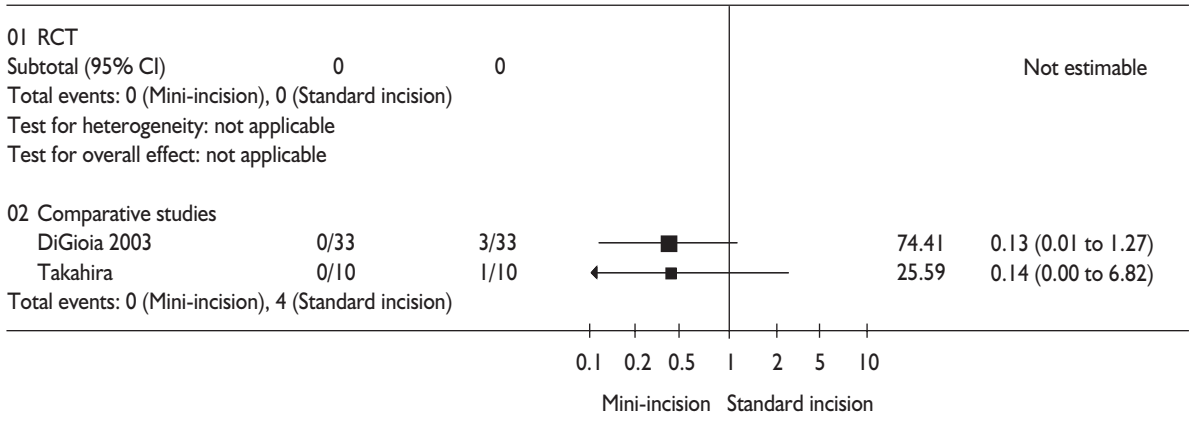
Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 04 Implant postion (stem, number poorly placed)



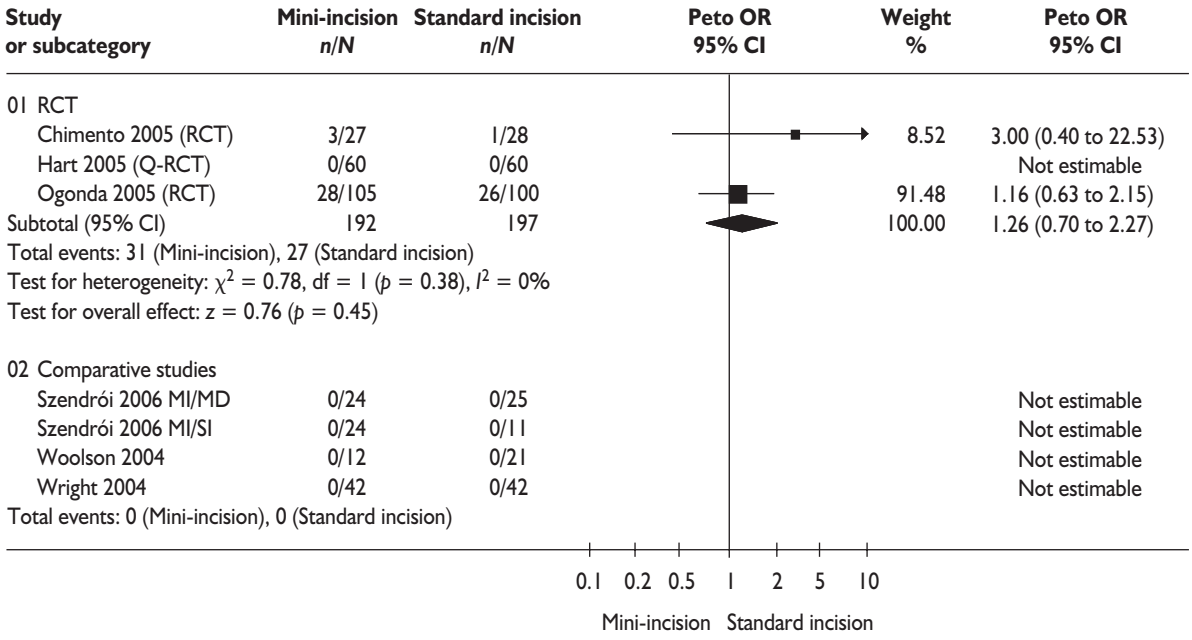
Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 05 Implant migration



Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 06 Heterotopic ossification (number with ossification)

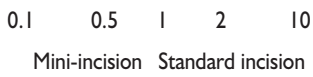


Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 07 Cement quality (number with poor quality)



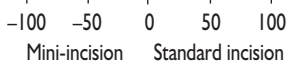
Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 08 Limb length inequality (number with unequal lengths)

Study or subcategory	Mini-incision *n/N*	Standard incision *n/N*	Peto OR 95% CI	Weight %	Peto OR 95% CI
01 RCT					
Subtotal (95% CI)	0	0			Not estimable
Total events: 0 (Mini-incision), 0 (Standard incision)					
Test for heterogeneity: not applicable					
Test for overall effect: not applicable					
02 Comparative studies					
Asayama 2006	0/52	0/50			Not estimable
Total events: 0 (Mini-incision), 0 (Standard incision)					



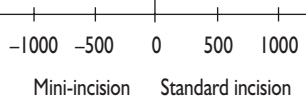
Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 09 Blood loss (intraoperative, ml)

Study or subcategory	Mini-incision N	Mini-incision Mean (SD)	Standard incision N	Standard incision Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Charles 2006 (RCT)	20	460.00 (0.00)	20	462.50 (0.00)			Not estimable
Chimento 2005 (RCT)	28	127.00 (48.00)	32	170.00 (65.00)		31.60	–43.00 (–71.69 to –14.31)
Chung 2004 (Q-RCT)	60	136.00 (41.10)	60	200.50 (65.20)		68.40	–64.50 (–84.00 to –45.00)
Hart 2005 (Q-RCT)	60	318.80 (0.00)	60	544.40 (0.00)			Not estimable
Kim 2006 (Q-RCT)	70	445.80 (0.00)	70	567.50 (0.00)			Not estimable
Ogonda 2005 (RCT)	109	314.20 (0.00)	110	365.80 (0.00)			Not estimable
Subtotal (95% CI)	347		352			100.00	–57.71 (–73.84 to –41.58)
Test for heterogeneity: $\chi^2 = 1.48$, df = 1 ($p = 0.22$), $I^2 = 32.2\%$							
Test for overall effect: $z = 7.01$ ($p < 0.00001$)							
02 Comparative studies							
Asayama 2006	52	217.50 (0.00)	50	247.00 (0.00)			Not estimable
Berger 2004	99	154.00 (0.00)	100	278.00 (0.00)			Not estimable
Chen 2006	51	175.49 (51.90)	95	293.68 (84.50)		37.19	–118.19 (–140.36 to –96.02)
Ciminiello 2006	60	201.67 (0.00)	60	191.73 (0.00)			Not estimable
de Beer 2004	30	180.00 (69.00)	30	246.70 (99.00)		9.81	–66.70 (–109.88 to –23.52)
Howell 2004	50	387.00 (155.00)	57	469.00 (147.00)		5.54	–82.00 (–139.46 to –24.54)
Pilot 2006	10	699.00 (0.00)	10	540.00 (0.00)			Not estimable
Szendrói 2006 MI/MD	38	244.00 (100.00)	43	265.00 (114.00)		8.42	–21.00 (–67.60 to 25.60)
Szendrói 2006 MI/SI	38	244.00 (100.00)	43	304.00 (136.00)		6.87	–60.00 (–111.61 to –8.39)
Woolson 2004	50	603.00 (0.00)	85	507.00 (0.00)			Not estimable
Wright 2004	42	151.80 (53.90)	42	173.20 (57.50)		32.18	–21.40 (–45.24 to 2.44)



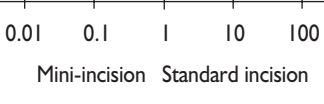
Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 10 Blood loss (total, ml)

Study or subcategory	Mini-incision N	Mini-incision Mean (SD)	Standard incision N	Standard incision Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Chimento 2005 (RCT)	28	378.00 (151.00)	32	504.00 (205.00)		100.00	–126.00 (–216.41 to –35.59)
Hart 2005 (Q-RCT)	60	613.30 (0.00)	60	853.70 (0.00)			Not estimable
Subtotal (95% CI)	88		92			100.00	–126.00 (–216.41 to –35.59)
Test for heterogeneity: not applicable							
Test for overall effect: $z = 2.73$ ($p = 0.008$)							
02 Comparative studies							
Chen 2006	51	369.51 (65.05)	95	509.63 (117.39)		85.21	–140.12 (–169.72 to –110.52)
Li 2005	18	318.00 (223.00)	18	523.00 (210.70)		3.72	–205.00 (–346.73 to –63.27)
Szendrói 2006 MI/MD	38	744.00 (260.00)	43	708.00 (221.00)		6.67	36.00 (–69.82 to 141.82)
Szendrói 2006 MI/SI	38	744.00 (260.00)	21	771.00 (235.00)		4.41	–27.00 (–157.14 to 103.14)
Takahira 2006	10	796.00 (0.00)	10	772.00 (0.00)			Not estimable



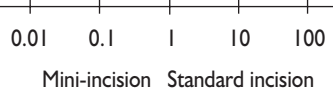
Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 11 Fractures: intraoperative

Study or subcategory	Mini-incision n/N	Standard incision n/N	Peto OR 95% CI	Weight %	Peto OR 95% CI
01 RCT					
Hart 2005 (Q-RCT)	0/60	0/60			Not estimable
Ogonda 2005 (RCT)	0/109	2/110		100.00	0.14 (0.01 to 2.18)
Subtotal (95% CI)	169	170		100.00	0.14 (0.01 to 2.18)
Total events: 0 (Mini-incision), 2 (Standard incision)					
Test for heterogeneity: not applicable					
Test for overall effect: $z = 1.41$ ($p = 0.16$)					
02 Comparative studies					
Asayama 2006	2/52	0/50		17.09	7.25 (0.45 to 117.60)
Beger 2004	1/99	1/100		17.18	1.01 (0.06 to 16.26)
Howell 2004	2/50	0/57		17.03	8.67 (0.53 to 141.36)
O'Brien 2005	2/34	1/53		24.09	3.27 (0.31 to 34.22)
Szendrói 2006 MI/MD	0/38	0/43			Not estimable
Szendrói 2006 MI/SI	0/38	0/21			Not estimable
Takahira 2006	1/10	0/10		8.63	7.39 (0.15 to 372.38)
Woolson 2004	2/50	0/85		15.98	15.18 (0.85 to 270.70)
Total events: 10 (Mini-incision), 12 (Standard incision)					



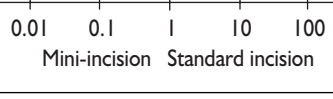
Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 12 Fractures: postoperative

Study or subcategory	Mini-incision *n/N*	Standard incision *n/N*	Peto OR 95% CI	Weight %	Peto OR 95% CI
01 RCT					
Hart 2005 (Q-RCT)	0/60	0/60			Not estimable
Sharma 2006 (Q-RCT)	0/20	0/20			Not estimable
Subtotal (95% CI)	80	80			Not estimable
Total events: 0 (Mini-incision), 0 (Standard incision)					
Test for heterogeneity: not applicable					
Test for overall effect: not applicable					
02 Comparative studies	3/51	4/95		85.92	1.44 (0.29 to 7.03)
Chen 2006	0/60	0/60			Not estimable
Chiminiello 2006	1/30	0/30		14.08	7.39 (0.15 to 372.38)
de Beer 2004					
Total events: 4 (Mini-incision), 4 (Standard incision)					



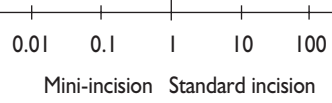
Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 13 Infection

Study or subcategory	Mini-incision *n/N*	Standard incision *n/N*	Peto OR 95% CI	Weight %	Peto OR 95% CI
01 RCT					
Chimento 2005 (RCT)	0/28	0/32			Not estimable
Chung 2004 (Q-RCT)	0/60	0/60			Not estimable
Hart 2005 (Q-RCT)	0/60	0/60			Not estimable
Kim 2006 (Q-RCT)	1/70	0/70		33.44	7.39 (0.15 to 372.38)
Ogonda 2005 (RCT)	2/109	0/110		66.56	7.53 (0.47 to 121.10)
Sharma 2006 (Q-RCT)	0/20	0/20			Not estimable
Zhang 2006 (RCT)	0/60	0/60			Not estimable
Subtotal (95% CI)	407	412		100.00	7.48 (0.78 to 72.16)
Total events: 3 (Mini-incision), 0 (Standard incision)					
Test for heterogeneity: $\chi^2 = 0.00$, df = 1 ($p = 0.99$), $I^2 = 0\%$					
Test for overall effect: $z = 1.74$ ($p = 0.08$)					
02 Comparative studies					
Asayama 2006	0/52	1/50		34.14	0.13 (0.00 to 6.56)
Berger 2004	0/99	0/100			Not estimable
Ciminiello 2006	0/60	0/60			Not estimable
Howell 2004	0/50	1/57		34.01	0.15 (0.00 to 7.78)
O'Brien 2005	0/34	0/53			Not estimable
Szendrói 2006 MI/MD	0/38	0/43			Not estimable
Szendrói 2006 MI/SI	0/38	0/21			Not estimable
Woolson 2004	1/50	0/85		31.86	14.88 (0.26 to 861.53)
Wright 2004	0/42	0/42			Not estimable
Total events: 1 (Mini-incision), 2 (Standard incision)					



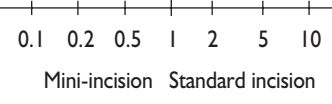
Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 14 Nerve injury

Study or subcategory	Mini-incision n/N	Standard incision n/N	Peto OR 95% CI	Weight %	Peto OR 95% CI
01 RCT					
Charles 2006 (RCT)	1/20	0/20		33.49	7.39 (0.15 to 372.38)
Chimento 2005 (RCT)	0/28	0/32			Not estimable
Chung 2004 (Q-RCT)	0/60	0/60			Not estimable
Hart 2005 (Q-RCT)	0/60	0/60			Not estimable
Kim 2006 (Q-RCT)	1/70	1/70		66.51	1.00 (0.06 to 16.15)
Zhang 2006 (RCT)	0/60	0/60			Not estimable
Subtotal (95% CI)	298	302		100.00	1.95 (0.20 to 18.89)
Total events: 2 (Mini-incision), 1 (Standard incision)					
Test for heterogeneity: $\chi^2 = 0.67$, df = 1 ($p = 0.41$), $I^2 = 0\%$					
Test for overall effect: $z = 0.58$ ($p = 0.56$)					
02 Comparative studies					
Asayama 2006	0/52	0/50			Not estimable
Chen 2006	0/51	2/95		16.14	0.21 (0.01 to 3.93)
DiGioia 2003	0/33	0/33			Not estimable
O'Brien 2005	0/34	0/53			Not estimable
Szendrói 2006 MI/MD	2/38	3/43		42.28	0.75 (0.12 to 4.53)
Szendrói 2006 MI/SI	2/38	0/21		16.10	4.85 (0.26 to 89.99)
Takahira 2006	1/10	0/10		8.94	7.39 (0.15 to 372.38)
Woolson 2004	1/50	1/85		16.54	1.75 (0.10 to 31.21)
Wright 2004	0/42	0/42			Not estimable
Subtotal (95% CI)	348	432		100.00	1.16 (0.36 to 3.76)
Total events: 6 (Mini-incision), 6 (Standard incision)					

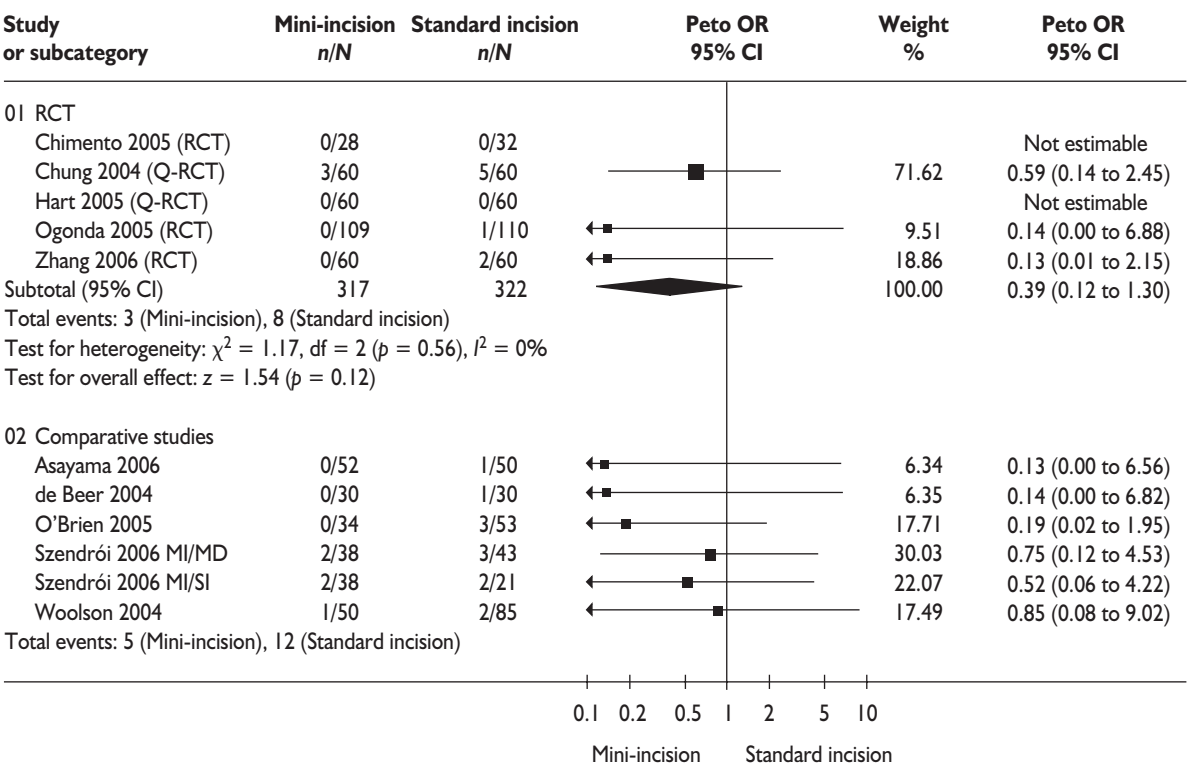


Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 15 Vascular injury

Study or subcategory	Mini-incision n/N	Standard incision n/N	Peto OR 95% CI	Weight %	Peto OR 95% CI
01 RCT					
Zhang 2006 (RCT)	0/60	0/60			Not estimable
Subtotal (95% CI)	60	60			Not estimable
Total events: 0 (Mini-incision), 0 (Standard incision)					
Test for heterogeneity: not applicable					
Test for overall effect: not applicable					
02 Comparative studies					
Subtotal (95% CI)	0	0			Not estimable
Total events: 0 (Mini-incision), 0 (Standard incision)					

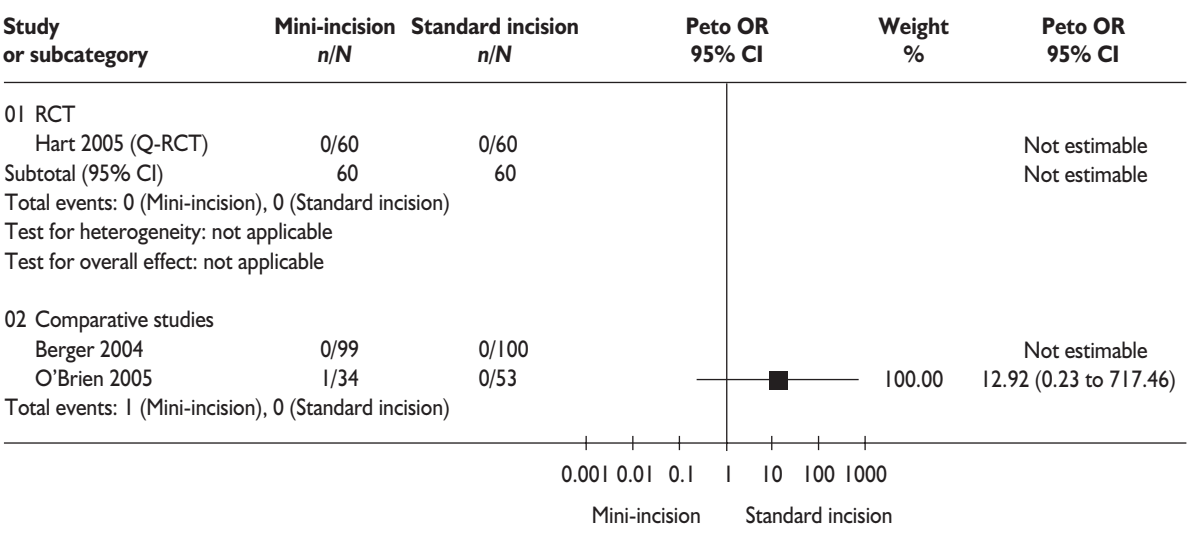


Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 16 DVT (deep venous thrombosis)



Study or subcategory	Mini-incision n/N	Standard incision n/N	Peto OR 95% CI	Weight %	Peto OR 95% CI
01 RCT					
Chimento 2005 (RCT)	0/28	0/32			Not estimable
Chung 2004 (Q-RCT)	3/60	5/60		71.62	0.59 (0.14 to 2.45)
Hart 2005 (Q-RCT)	0/60	0/60			Not estimable
Ogonda 2005 (RCT)	0/109	1/110		9.51	0.14 (0.00 to 6.88)
Zhang 2006 (RCT)	0/60	2/60		18.86	0.13 (0.01 to 2.15)
Subtotal (95% CI)	317	322		100.00	0.39 (0.12 to 1.30)
Total events: 3 (Mini-incision), 8 (Standard incision)					
Test for heterogeneity: $\chi^2 = 1.17$, df = 2 ($p = 0.56$), $I^2 = 0\%$					
Test for overall effect: z = 1.54 ($p = 0.12$)					
02 Comparative studies					
Asayama 2006	0/52	1/50		6.34	0.13 (0.00 to 6.56)
de Beer 2004	0/30	1/30		6.35	0.14 (0.00 to 6.82)
O'Brien 2005	0/34	3/53		17.71	0.19 (0.02 to 1.95)
Szendrói 2006 MI/MD	2/38	3/43		30.03	0.75 (0.12 to 4.53)
Szendrói 2006 MI/SI	2/38	2/21		22.07	0.52 (0.06 to 4.22)
Woolson 2004	1/50	2/85		17.49	0.85 (0.08 to 9.02)
Total events: 5 (Mini-incision), 12 (Standard incision)					

Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 17 Pulmonary embolism



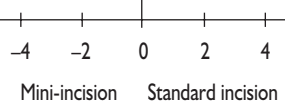
Study or subcategory	Mini-incision n/N	Standard incision n/N	Peto OR 95% CI	Weight %	Peto OR 95% CI
01 RCT					
Hart 2005 (Q-RCT)	0/60	0/60			Not estimable
Subtotal (95% CI)	60	60			Not estimable
Total events: 0 (Mini-incision), 0 (Standard incision)					
Test for heterogeneity: not applicable					
Test for overall effect: not applicable					
02 Comparative studies					
Berger 2004	0/99	0/100			Not estimable
O'Brien 2005	1/34	0/53		100.00	12.92 (0.23 to 717.46)
Total events: 1 (Mini-incision), 0 (Standard incision)					

Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 18 Duration of operation (minutes)

Study or subcategory	Mini-incision N	Mini-incision Mean (SD)	Standard incision N	Standard incision Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Charles 2006 (RCT)	20	95.20 (0.00)	20	87.70 (0.00)			Not estimable
Chimento 2005 (RCT)	28	70.30 (10.70)	32	70.00 (8.50)		21.64	0.30 (–4.64 to 5.24)
Chung 2004 (Q-RCT)	60	49.00 (9.40)	60	55.10 (17.90)		20.16	–6.10 (–11.22 to –0.98)
Hart 2005 (Q-RCT)	60	71.00 (0.00)	60	70.00 (0.00)			Not estimable
Kim 2006 (Q-RCT)	70	52.00 (0.00)	70	61.00 (0.00)			Not estimable
Ogonda 2005 (RCT)	109	60.30 (9.20)	110	65.90 (13.20)		58.19	–5.60 (–8.61 to –2.59)
Sharma 2006 (Q-RCT)	20	0.00 (0.00)	20	0.00 (0.00)			Not estimable
Zhang 2006 (RCT)	60	75.00 (0.00)	60	69.00 (0.00)			Not estimable
Subtotal (95% CI)	427		432			100.00	–4.42 (–6.72 to –2.13)
Test for heterogeneity: $\chi^2 = 4.51$, df = 2 ($p = 0.10$), $I^2 = 55.7\%$							
Test for overall effect: $z = 3.77$ ($p = 0.0002$)							
02 Comparative studies							
Asayama 2006	50	58.60 (0.00)	50	57.90 (0.00)			Not estimable
Berger 2004	99	72.00 (0.00)	100	66.00 (0.00)			Not estimable
Chen 2006	51	88.41 (17.60)	95	90.85 (17.81)		16.97	–2.44 (–8.45 to 3.57)
Ciminiello 2006	60	55.45 (0.00)	60	56.95 (0.00)			Not estimable
de Beer 2004	30	46.60 (0.00)	30	44.50 (0.00)			Not estimable
DiGioia 2003	33	120.00 (0.00)	33	100.00 (0.00)			Not estimable
Howell 2004	50	97.00 (19.00)	57	84.00 (15.00)		14.31	13.00 (6.45 to 19.55)
Li 2005	18	91.00 (16.40)	18	97.00 (15.60)		5.61	–6.00 (–16.46 to 4.46)
O'Brien 2005	32	74.00 (15.00)	51	80.00 (10.00)		17.77	–6.00 (–11.88 to –0.12)
Pilot 2006	10	99.50 (0.00)	10	81.00 (0.00)			Not estimable
Szendrói 2006 MI/MD	38	84.00 (16.00)	43	93.00 (18.00)		11.19	–9.00 (–16.40 to –1.60)
Szendrói 2006 MI/SI	38	84.00 (16.00)	21	102.00 (12.00)		11.75	–18.00 (–25.23 to –10.77)
Takahira 2006	10	126.50 (0.00)	10	119.90 (0.00)			Not estimable
Woolson 2004	50	97.00 (0.00)	85	105.00 (0.00)			Not estimable
Wright 2004	42	71.40 (11.20)	42	77.70 (13.20)		22.39	–6.30 (–11.54 to –1.06)

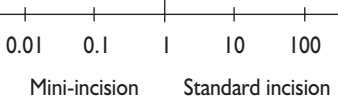
Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 19 Length of hospital stay (days)

Study or subcategory	Mini-incision N	Mini-incision Mean (SD)	Standard incision N	Standard incision Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Charles 2006 (RCT)	20	5.35 (0.00)	20	5.70 (0.00)			Not estimable
Chimento 2005 (RCT)	28	5.80 (0.00)	32	5.50 (0.00)			Not estimable
Chung 2004 (Q-RCT)	60	4.41 (1.10)	60	5.34 (1.40)		63.71	–0.93 (–1.38 to –0.48)
Ogonda 2005 (RCT)	109	3.65 (2.04)	110	3.68 (2.45)		36.29	–0.03 (–0.63 to 0.57)
Sharma 2006 (Q-RCT)	20	0.00 (0.00)	20	0.00 (0.00)			Not estimable
Zhang 2006 (RCT)	60	7.00 (0.00)	60	13.50 (0.00)			Not estimable
Subtotal (95% CI)	297		302			100.00	–0.60 (–0.96 to –0.24)
Test for heterogeneity: $\chi^2 = 5.56$, df = 1 ($p = 0.02$), $I^2 = 82.0\%$							
Test for overall effect: $z = 3.29$ ($p = 0.001$)							
02 Comparative studies							
Asayama 2006	52	2.96 (0.00)	50	2.94 (0.00)			Not estimable
Berger 2004	100	1.90 (0.00)	100	3.50 (0.00)			Not estimable
Chen 2006	51	11.16 (0.83)	95	12.83 (1.96)		73.69	–1.67 (–2.13 to –1.21)
Ciminiello 2006	60	3.70 (0.00)	60	3.63 (0.00)			Not estimable
de Beer 2004	30	5.13 (0.00)	30	5.10 (0.00)			Not estimable
DiGioia 2003	33	3.80 (0.00)	33	3.90 (0.00)			Not estimable
Howell 2004	50	4.40 (2.90)	57	5.70 (3.10)		11.80	–1.30 (–2.44 to –0.16)
O'Brien 2005	35	5.40 (2.10)	53	6.20 (2.80)		14.51	–0.80 (–1.83 to 0.23)
Panisello 2006	40	5.60 (0.00)	40	6.70 (0.00)			Not estimable
Takahira 2006	10	22.00 (0.00)	10	23.40 (0.00)			Not estimable
Woolson 2004	50	4.30 (0.00)	85	4.00 (0.00)			Not estimable
Wright 2004	42	6.12 (0.00)	42	6.07 (0.00)			Not estimable



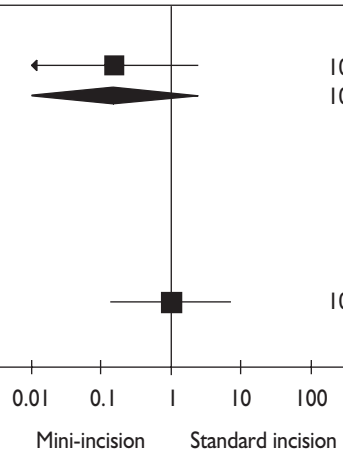
Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 20 Death (30 days)

Study or subcategory	Mini-incision n/N	Standard incision n/N	Peto OR 95% CI	Weight %	Peto OR 95% CI
01 RCT					
Ogonda 2005 (RCT)	0/109	2/110		100.00	0.14 (0.01 to 2.18)
Subtotal (95% CI)	109	110		100.00	0.14 (0.01 to 2.18)
Total events: 0 (Mini-incision), 2 (Standard incision)					
Test for heterogeneity: not applicable					
Test for overall effect: $z = 1.41$ ($p = 0.16$)					
02 Comparative studies					
Ciminiello 2006	0/60	0/60			Not estimable
Wright 2004	0/42	0/42			Not estimable
Total events: 0 (Mini-incision), 0 (Standard incision)					



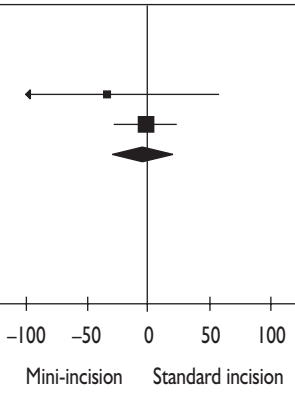
Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 21 Death (long term)

Study or subcategory	Mini-incision *n/N*	Standard incision *n/N*	Peto OR 95% CI	Weight %	Peto OR 95% CI
01 RCT					
Chimento 2005 (RCT)	0/28	2/32		100.00	0.15 (0.01 to 2.45)
Subtotal (95% CI)	28	32		100.00	0.15 (0.01 to 2.45)
Total events: 0 (Mini-incision), 2 (Standard incision)					
Test for heterogeneity: not applicable					
Test for overall effect: $z = 1.33$ ($p = 0.18$)					
02 Comparative studies					
Ciminiello 2006	0/60	0/60			Not estimable
Wright 2004	2/42	2/42		100.00	1.00 (0.14 to 7.36)
Total events: 2 (Mini-incision), 2 (Standard incision)					



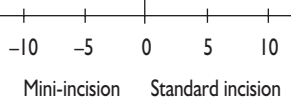
Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 22 Short-term patient-controlled anaesthesia (mg)

Study or subcategory	Mini-incision *N*	Mini-incision Mean (SD)	Standard incision *N*	Standard incision Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Charles 2006 (RCT)	18	22.80 (0.00)	19	19.50 (0.00)			Not estimable
Chimento 2005 (RCT)	28	285.00 (185.00)	32	319.00 (177.00)		7.26	–34.00 (–125.96 to 57.96)
Ogonda 2005 (RCT)	109	42.90 (97.40)	110	45.00 (96.80)		92.74	–2.10 (–27.82 to 23.62)
Subtotal (95% CI)	155		161			100.00	–4.41 (–29.18 to 20.36)
Test for heterogeneity: $\chi^2 = 0.43$, df = 1 ($p = 0.51$), $I^2 = 0\%$							
Test for overall effect: $z = 0.35$ ($p = 0.73$)							
02 Comparative studies							



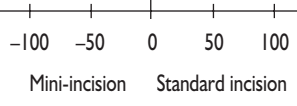
Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 23 short-term total narcotic received (mg)

Study or subcategory	Mini-incision N	Mini-incision Mean (SD)	Standard incision N	Standard incision Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Subtotal (95% CI)	0		0				Not estimable
Test for heterogeneity: not applicable							
Test for overall effect: not applicable							
02 Comparative studies							
Asayama 2006	52	92.70 (0.00)	50	94.90 (0.00)			Not estimable
Ciminiello 2006	60	118.00 (0.00)	60	121.00 (0.00)			Not estimable
de Beer 2004	30	147.70 (0.00)	30	169.30 (0.00)			Not estimable



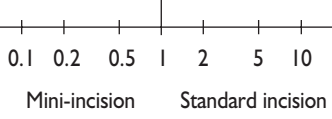
Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 24 Short-term narcotic (days)

Study or subcategory	Mini-incision N	Mini-incision Mean (SD)	Standard incision N	Standard incision Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Chung 2004 (Q-RCT)	60	2.20 (0.00)	60	2.64 (0.00)			Not estimable
Subtotal (95% CI)	60		60				Not estimable
Test for heterogeneity: not applicable							
Test for overall effect: not applicable							
02 Comparative studies							



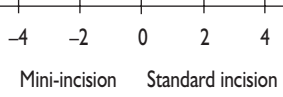
Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 25 Short-term pain (*N* of patients)

Study or subcategory	Mini-incision *n/N*	Standard incision *n/N*	Peto OR 95% CI	Weight %	Peto OR 95% CI
01 RCT					
Subtotal (95% CI)	0	0			Not estimable
Total events: 0 (Mini-incision), 0 (Standard incision)					
Test for heterogeneity: not applicable					
Test for overall effect: not applicable					
02 Comparative studies					
Asayama 2006	2/52	3/49		82.75	0.62 (0.10 to 3.71)
Ciminiello 2006	0/60	0/60			Not estimable
de Beer 2004	0/30	1/30		17.25	0.14 (0.00 to 6.82)
Total events: 2 (Mini-incision), 4 (Standard incision)					



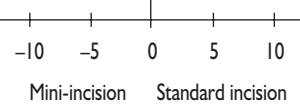
Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 26 Short-term pain (score)

Study or subcategory	Mini-incision *N*	Mini-incision Mean (SD)	Standard incision *N*	Standard incision Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Charles 2006 (RCT)	18	3.94 (0.00)	19	3.68 (0.00)			Not estimable
Kim 2006 (Q-RCT)	70	0.00 (0.00)	70	0.00 (0.00)			Not estimable
Ogonda 2005 (RCT)	109	3.30 (1.80)	110	3.36 (1.96)		100.00	–0.06 (–0.56 to 0.44)
Sharma 2006 (Q-RCT)	20	4.05 (0.00)	20	6.25 (0.00)			Not estimable
Subtotal (95% CI)	217		219			100.00	–0.06 (–0.56 to 0.44)
Test for heterogeneity: not applicable							
Test for overall effect: $z = 0.24$ ($p = 0.81$)							
02 Comparative studies						62.80	–0.65 (–1.16 to –0.14)
Szendrói 2006 MI/MD	38	1.50 (1.15)	43	2.15 (1.20)		37.20	–0.60 (–1.27 to 0.07)
Szendrói 2006 MI/SI	38	1.50 (1.15)	21	2.10 (1.30)			



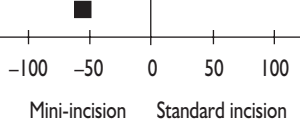
Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 27 Long-term pain (score)

Study or subcategory	Mini-incision N	Mean (SD)	Standard incision N	Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Kim 2006 (Q-RCT)	70	0.00 (0.00)	70	0.00 (0.00)			Not estimable
Subtotal (95% CI)	70		70				Not estimable
Test for heterogeneity: not applicable							
Test for overall effect: not applicable							
02 Comparative studies							



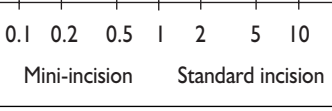
Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 28 Time to return to normal activity (days)

Study or subcategory	Mini-incision N	Mean (SD)	Standard incision N	Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Subtotal (95% CI)	0		0				Not estimable
Test for heterogeneity: not applicable							
Test for overall effect: not applicable							
02 Comparative studies							
Chen 2006	51	60.00 (12.00)	95	116.00 (11.00)		100.00	–56.00 (–59.97 to –52.03)

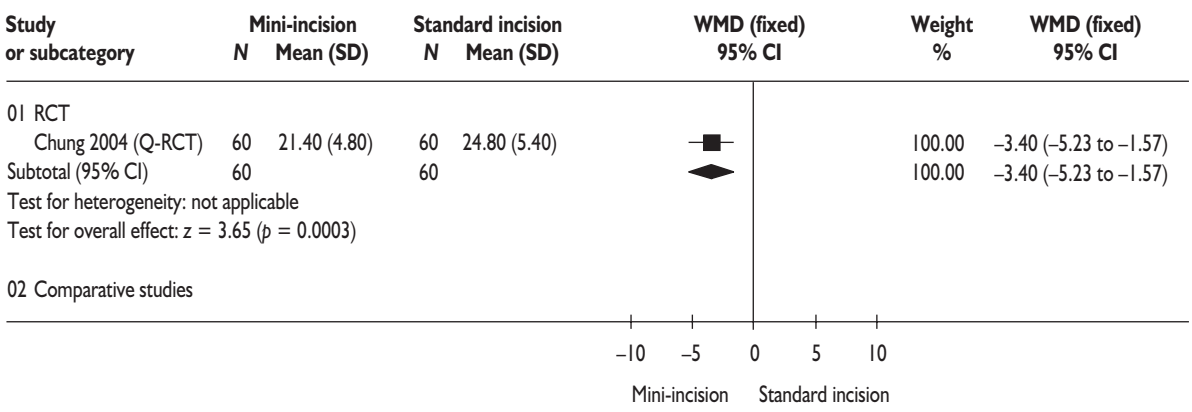


Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 29 Use of walking aids: short-term (*N* of patients)

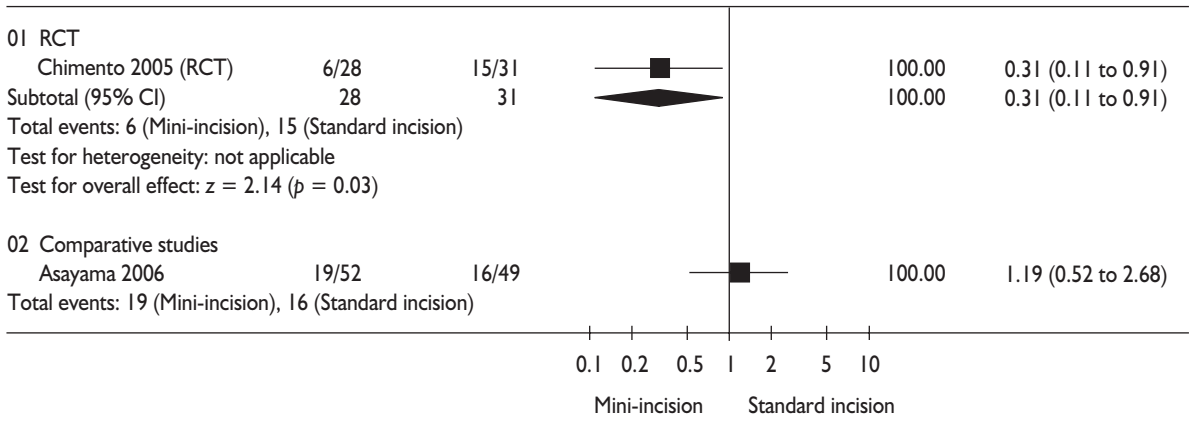
Study or subcategory	Mini-incision n/N	Standard incision n/N	Peto OR 95% CI	Weight %	Peto OR 95% CI
01 RCT					
Chimento 2005 (RCT)	9/28	15/32		100.00	0.55 (0.20 to 1.53)
Subtotal (95% CI)	28	32		100.00	0.55 (0.20 to 1.53)
Total events: 9 (Mini-incision), 15 (Standard incision)					
Test for heterogeneity: not applicable					
Test for overall effect: $z = 1.15$ ($p = 0.25$)					
02 Comparative studies					
Asayama 2006	4/52	4/49		100.00	0.94 (0.22 to 3.95)
Total events: 4 (Mini-incision), 4 (Standard incision)					



Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 30 Use of walking aids (days)

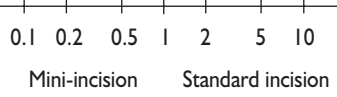


Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 31 Limp: short term (*N* of patients)



Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 32 Limp: long-term (*N* of patients)

Study or subcategory	Mini-incision *n/N*	Standard incision *n/N*	Peto OR 95% CI	Weight %	Peto OR 95% CI
01 RCT					
Chimento 2005 (RCT)	0/27	0/29			Not estimable
Subtotal (95% CI)	27	29			Not estimable
Total events: 0 (Mini-incision), 0 (Standard incision)					
Test for heterogeneity: not applicable					
Test for overall effect: not applicable					
02 Comparative studies					
Total events: 0 (Mini-incision), 0 (Standard incision)					

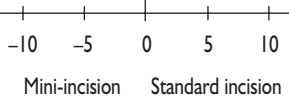


Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 33 Harris hip score (≤3 months)

Study or subcategory	Mini-incision N	Mini-incision Mean (SD)	Standard incision N	Standard incision Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Ogonda 2005 (RCT)	107	–84.15 (10.56)	108	–83.36 (8.33)		100.00	–0.79 (–3.33 to 1.75)
Zhang 2006 (RCT)	60	–91.40 (0.00)	60	–78.50 (0.00)			Not estimable
Subtotal (95% CI)	167		168			100.00	–0.79 (–3.33 to 1.75)
Test for heterogeneity: not applicable							
Test for overall effect: $z = 0.61$ ($p = 0.54$)							
02 Comparative studies							
Ciminiello 2006	60	–91.02 (0.00)	60	–94.93 (0.00)			Not estimable
de Beer 2004	30	–71.10 (9.80)	30	–66.60 (12.20)		100.00	–4.50 (–10.10 to 1.10)
DiGioia 2003	33	–86.29 (0.00)	33	–80.44 (0.00)			Not estimable

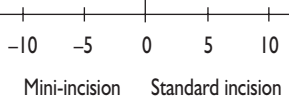
Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 34 Harris hip score (>3 months)

Study or subcategory	Mini-incision N	Mini-incision Mean (SD)	Standard incision N	Standard incision Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Chimento 2005 (RCT)	27	–94.50 (0.00)	29	–94.50 (0.00)			Not estimable
Chung 2004 (Q-RCT)	60	–95.50 (0.00)	60	–93.50 (0.00)			Not estimable
Kim 2006 (Q-RCT)	70	–93.00 (0.00)	70	–91.00 (0.00)			Not estimable
Zhang 2006 (RCT)	60	–95.10 (0.00)	60	–95.60 (0.00)			Not estimable
Subtotal (95% CI)	217		219				Not estimable
Test for heterogeneity: not applicable							
Test for overall effect: not applicable							
02 Comparative studies							
Asayama 2006	52	–96.20 (0.00)	50	–96.20 (0.00)			Not estimable
Chen 2006	51	–89.71 (3.62)	95	–83.78 (8.03)		61.66	–5.93 (–7.83 to –4.03)
DiGioia 2003	33	–96.00 (0.00)	33	–94.00 (0.00)			Not estimable
Li 2005	18	–92.00 (0.00)	18	–90.00 (0.00)			Not estimable
Woolson 2004	20	–99.00 (0.00)	14	–97.00 (0.00)			Not estimable
Wright 2004	37	–86.90 (4.10)	39	–84.20 (6.40)		38.34	–2.70 (–5.10 to –0.30)



Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 35 WOMAC osteoarthritis index (≤3 months)

Study or subcategory	Mini-incision N	Mini-incision Mean (SD)	Standard incision N	Standard incision Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Charles 2006 (RCT)	16	91.99 (0.00)	19	89.60 (0.00)			Not estimable
Ogonda 2005 (RCT)	107	74.40 (13.88)	108	73.95 (12.90)		100.00	0.45 (–3.13 to 4.03)
Subtotal (95% CI)	123		127			100.00	0.45 (–3.13 to 4.03)
Test for heterogeneity: not applicable							
Test for overall effect: $z = 0.25$ ($p = 0.81$)							
02 Comparative studies							



Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 36 Oxford hip score (≤3 months)

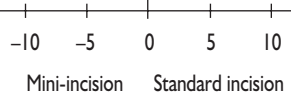
Study or subcategory	Mini-incision N	Mini-incision Mean (SD)	Standard incision N	Standard incision Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Ogonda 2005 (RCT)	107	24.97 (7.33)	108	25.88 (6.29)		100.00	–0.91 (–2.74 to 0.92)
Subtotal (95% CI)	107		108			100.00	–0.91 (–2.74 to 0.92)
Test for heterogeneity: not applicable							
Test for overall effect: $z = 0.98$ ($p = 0.33$)							
02 Comparative studies							
de Beer 2004	30	26.50 (8.40)	30	28.40 (7.50)		100.00	–1.90 (–5.93 to 2.13)

Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 37 Merle d'Aubigne-Charnley Score (≤3 months)

Study or subcategory	Mini-incision N	Mini-incision Mean (SD)	Standard incision N	Standard incision Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Hart 2005 (Q-RCT)	60	–16.60 (0.00)	60	–14.10 (0.00)			Not estimable
Subtotal (95% CI)	60		60				Not estimable
Test for heterogeneity: not applicable							
Test for overall effect: not applicable							
02 Comparative studies							

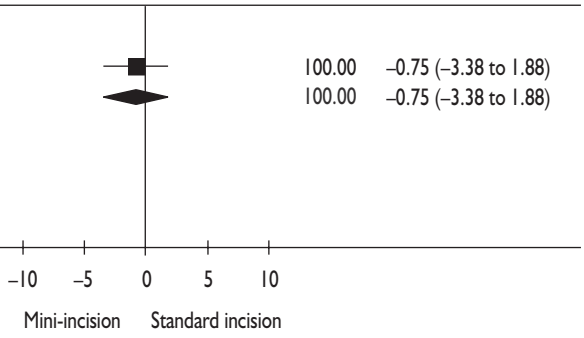
Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 38 Merle d'Aubigne-Charnley Score (>3 months)

Study or subcategory	Mini-incision N	Mini-incision Mean (SD)	Standard incision N	Standard incision Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Hart 2005 (Q-RCT)	60	–17.40 (0.00)	60	–17.30 (0.00)			Not estimable
Subtotal (95% CI)	60		60				Not estimable
Test for heterogeneity: not applicable							
Test for overall effect: not applicable							
02 Comparative studies							



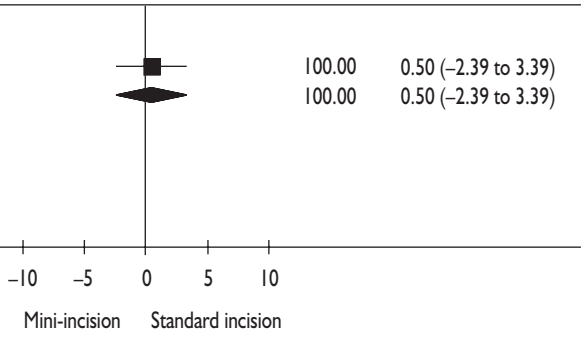
Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 39 SF-12 physical component (≤3 months)

Study or subcategory	Mini-incision N	Mini-incision Mean (SD)	Standard incision N	Standard incision Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Ogonda 2005 (RCT)	107	–38.48 (10.20)	108	–37.73 (9.48)		100.00	–0.75 (–3.38 to 1.88)
Subtotal (95% CI)	107		108			100.00	–0.75 (–3.38 to 1.88)
Test for heterogeneity: not applicable							
Test for overall effect: $z = 0.56$ ($p = 0.58$)							
02 Comparative studies							



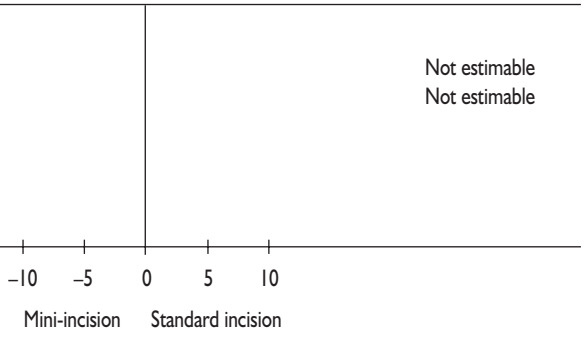
Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 40 SF-12 mental component (>3 months)

Study or subcategory	Mini-incision N	Mini-incision Mean (SD)	Standard incision N	Standard incision Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Ogonda 2005 (RCT)	107	–50.61 (11.05)	108	–51.11 (10.54)		100.00	0.50 (–2.39 to 3.39)
Subtotal (95% CI)	107		108			100.00	0.50 (–2.39 to 3.39)
Test for heterogeneity: not applicable							
Test for overall effect: $z = 0.34$ ($p = 0.73$)							
02 Comparative studies							



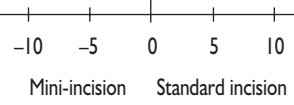
Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 41 SF-36 physical function (≤3 months)

Study or subcategory	Mini-incision N	Mini-incision Mean (SD)	Standard incision N	Standard incision Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Charles 2006 (RCT)	16	–40.80 (0.00)	19	–40.40 (0.00)			Not estimable
Subtotal (95% CI)	16		19				Not estimable
Test for heterogeneity: not applicable							
Test for overall effect: not applicable							
02 Comparative studies							



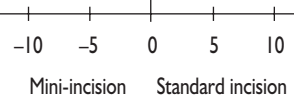
Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 42 SF-36 physical function (>3 months)

Study or subcategory	Mini-incision N	Mini-incision Mean (SD)	Standard incision N	Standard incision Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Subtotal (95% CI)	0		0				Not estimable
Test for heterogeneity: not applicable							
Test for overall effect: not applicable							
02 Comparative studies							
Dorr 2007	109	–54.50 (4.29)	56	–56.24 (3.87)		100.00	1.74 (0.45 to 3.03)



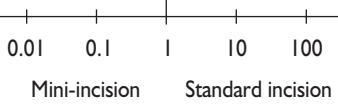
Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 43 SF-36 mental component (>3 months)

Study or subcategory	Mini-incision N	Mini-incision Mean (SD)	Standard incision N	Standard incision Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Subtotal (95% CI)	0		0				Not estimable
Test for heterogeneity: not applicable							
Test for overall effect: not applicable							
02 Comparative studies							
Dorr 2007	109	–60.38 (3.84)	56	–60.74 (3.42)		100.00	0.36 (–0.79 to 1.51)



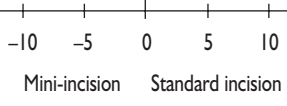
Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 44 Satisfaction (number of patients dissatisfied)

Study or subcategory	Mini-incision *n/N*	Standard incision *n/N*	Peto OR 95% CI	Weight %	Peto OR 95% CI
01 RCT					
Subtotal (95% CI)	0	0			Not estimable
Total events: 0 (Mini-incision), 0 (Standard incision)					
Test for heterogeneity: not applicable					
Test for overall effect: not applicable					
02 Comparative studies					
Corr 2007	0/109	21/56		77.77	0.03 (0.01 to 0.09)
Woolson 2004	0/20	0/14			Not estimable
Wright 2004	0/37	5/37		22.23	0.12 (0.02 to 0.73)
Total events: 0 (Mini-incision), 26 (Standard incision)					



Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 45 Satisfaction (score)

Study or subcategory	Mini-incision *N*	Mini-incision Mean (SD)	Standard incision *N*	Standard incision Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Charles 2006 (RCT)	18	−15.22 (0.00)	19	−14.59 (0.00)			Not estimable
Subtotal (95% CI)	18		19				Not estimable
Test for heterogeneity: not applicable							
Test for overall effect: not applicable							
02 Comparative studies							



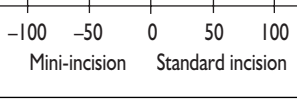
Review: Minimal incision approaches to total hip replacement
Comparison: 01 Mini-incision versus standard incision
Outcome: 46 Scar contraction (% of total wound length from end of surgery)

Study or subcategory	Mini-incision N	Mini-incision Mean (SD)	Standard incision N	Standard incision Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Ogonda 2005 (RCT)	107	11.00 (0.00)	108	12.00 (0.00)			Not estimable
Subtotal (95% CI)	107		108				Not estimable
Test for heterogeneity: not applicable							
Test for overall effect: not applicable							
02 Comparative studies							

Comparison 02: Single mini-incision versus single standard incision (reported means and SDs supplemented with calculated SDs from *p*-values)

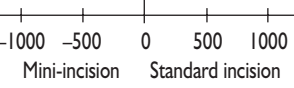
Review: Minimal incision approaches to total hip replacement
Comparison: 02 Mini-incision versus standard incision (*p*-value)
Outcome: 09 Blood loss (intraoperative, ml)

Study or subcategory	Mini-incision N	Mini-incision Mean (SD)	Standard incision N	Standard incision Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Charles 2006 (RCT)	20	460.00 (184.25)	20	462.50 (184.25)		1.73	–2.50 (–116.70 to 111.70)
Chimento 2005 (RCT)	28	127.00 (48.00)	32	170.00 (65.00)		27.48	–43.00 (–71.69 to –14.31)
Chung 2004 (Q-RCT)	60	136.00 (41.10)	60	200.50 (65.20)		59.48	–64.50 (–84.00 to –45.00)
Hart 2005 (Q-RCT)	60	318.80 (0.00)	60	544.40 (0.00)			Not estimable
Kim 2006 (Q-RCT)	70	445.80 (521.95)	70	567.50 (521.95)		0.76	–121.70 (–294.62 to 51.22)
Ogonda 2005 (RCT)	109	314.20 (174.78)	110	365.80 (174.78)		10.55	–51.60 (–97.90 to –5.30)
Subtotal (95% CI)	347		352			100.00	–56.59 (–71.63 to –41.55)
Test for heterogeneity: $\chi^2 = 2.94$, df = 4 ($p = 0.57$), $I^2 = 0\%$							
Test for overall effect: $z = 7.37$ ($p < 0.00001$)							
02 Comparative studies							
Asayama 2006	52	217.50 (0.00)	50	247.00 (0.00)			Not estimable
Berger 2004	99	154.00 (443.49)	100	278.00 (443.49)		1.14	–124.00 (–247.24 to –0.76)
Chen 2006	51	175.49 (51.90)	95	293.68 (84.50)		35.27	–118.19 (–140.36 to –96.02)
Ciminiello 2006	60	201.67 (228.39)	60	191.73 (228.39)		2.60	9.94 (–71.79 to 91.67)
de Beer 2004	30	180.00 (69.00)	30	246.70 (99.00)		9.30	–66.70 (–109.88 to –23.52)
Howell 2004	50	387.00 (155.00)	57	469.00 (147.00)		5.25	–82.00 (–139.46 to –24.54)
Pilot 2006	10	699.00 (319.20)	10	540.00 (319.20)		0.22	159.00 (–120.79 to 438.79)
Szendrói 2006 MI/MD	38	244.00 (100.00)	43	265.00 (114.00)		7.98	–21.00 (–67.60 to 25.60)
Szendrói 2006 MI/SI	38	244.00 (100.00)	43	304.00 (136.00)		6.51	–60.00 (–111.61 to –8.39)
Woolson 2004	50	603.00 (344.21)	85	507.00 (344.21)		1.20	96.00 (–24.24 to 216.24)
Wright 2004	42	151.80 (53.90)	42	173.20 (57.50)		30.52	–21.40 (–45.24 to 2.44)



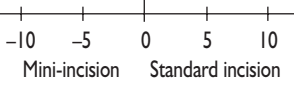
Review: Minimal incision approaches to total hip replacement
Comparison: 02 Mini-incision versus standard incision (*p*-value)
Outcome: 10 Blood loss (total, ml)

Study or subcategory	Mini-incision N	Mini-incision Mean (SD)	Standard incision N	Standard incision Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Chimento 2005 (RCT)	28	378.00 (151.00)	32	504.00 (205.00)		100.00	–126.00 (–216.41 to –35.59)
Hart 2005 (Q-RCT)	60	613.30 (0.00)	60	853.70 (0.00)			Not estimable
Subtotal (95% CI)	88		92			100.00	–126.00 (–216.41 to –35.59)
Test for heterogeneity: not applicable							
Test for overall effect: z = 2.73 (*p* = 0.006)							
02 Comparative studies							
Chen 2006	51	369.51 (65.05)	95	509.63 (117.39)		85.21	–140.12 (–169.72 to –110.52)
Li 2005	18	318.00 (223.00)	18	523.00 (210.70)		3.72	–205.00 (–346.73 to –63.27)
Szendrói 2006 MI/MD	38	744.00 (260.00)	43	708.00 (221.00)		6.67	36.00 (–69.82 to 141.82)
Szendrói 2006 MI/SI	38	744.00 (260.00)	21	771.00 (235.00)		4.41	–27.00 (–157.14 to 103.14)
Takahira 2006	10	796.00 (0.00)	10	772.00 (0.00)			Not estimable
						100.00	–125.80 (–153.13 to –98.48)



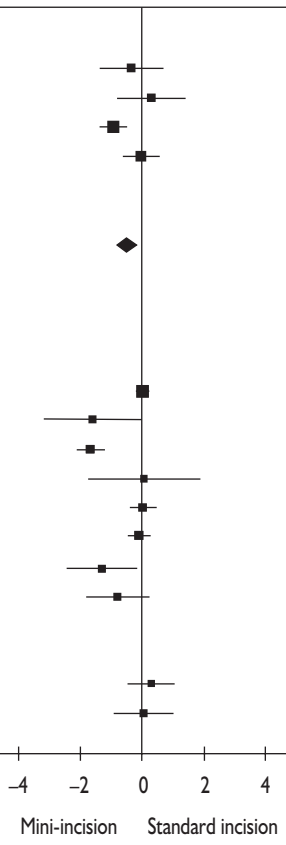
Review: Minimal incision approaches to total hip replacement
Comparison: 02 Mini-incision versus standard incision (*p*-value)
Outcome: 18 Duration of operation (minutes)

Study or subcategory	Mini-incision N	Mini-incision Mean (SD)	Standard incision N	Standard incision Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Charles 2006 (RCT)	20	95.20 (23.29)	20	87.70 (23.29)		1.85	7.50 (–6.94 to 21.94)
Chimento 2005 (RCT)	28	70.30 (10.70)	32	70.00 (8.50)		15.84	0.30 (–4.64 to 5.24)
Chung 2004 (Q-RCT)	60	49.00 (9.40)	60	55.10 (17.90)		14.76	–6.10 (–11.22 to –0.98)
Hart 2005 (Q-RCT)	60	71.00 (0.00)	60	70.00 (0.00)			Not estimable
Kim 2006 (Q-RCT)	70	52.00 (15.84)	70	61.00 (15.84)		14.02	–9.00 (–14.25 to –3.75)
Ogonda 2005 (RCT)	109	60.30 (9.20)	110	65.90 (13.20)		42.59	–5.60 (–8.61 to –2.59)
Sharma 2006 (Q-RCT)	20	0.00 (0.00)	20	0.00 (0.00)			Not estimable
Zhang 2006 (RCT)	60	75.00 (16.60)	60	69.00 (16.60)		10.94	6.00 (–0.06 to 11.94)
Subtotal (95% CI)	427		432			100.00	–3.70 (–5.67 to –1.74)
Test for heterogeneity: χ^2 = 21.37, df = 5 (*p* = 0.0007), I^2 = 76.6%							
Test for overall effect: z = 3.69 (*p* < 0.0002)							
02 Comparative studies							
Asayama 2006	50	58.60 (0.00)	50	57.90 (0.00)			Not estimable
Berger 2004	99	72.00(0.00)	100	66.00 (0.00)			Not estimable
Chen 2006	51	88.41 (17.60)	95	90.85 (17.81)		5.33	–2.44 (–8.45 to 3.57)
Ciminiello 2006	60	55.45 (4.91)	60	56.95 (4.91)		62.47	–1.50 (–3.26 to 0.26)
de Beer 2004	30	46.60 (14.31)	30	44.50 (14.31)		3.68	2.10 (–5.14 to 9.34)
DiGioia 2003	33	120.00 (0.00)	33	100.00 (0.00)			Not estimable
Howell 2004	50	97.00 (19.00)	57	84.00 (15.00)		4.50	13.00 (6.45 to 19.55)
Li 2005	18	91.00 (16.40)	18	97.00 (15.60)		1.76	–6.00 (–16.46 to 4.46)
O'Brien 2005	32	74.00 (15.00)	51	80.00 (10.00)		5.58	–6.00 (–11.88 to –0.12)
Pilot 2006	10	99.50 (20.25)	10	81.00 (20.25)		0.61	18.50 (0.75 to 36.25)
Szendrói 2006 MI/MD	38	84.00 (16.00)	43	93.00 (18.00)		3.52	–9.00 (–16.40 to –1.60)
Szendrói 2006 MI/SI	38	84.00 (16.00)	21	102.00 (12.00)		3.69	–18.00 (–25.23 to –10.77)
Takahira 2006	10	126.50 (0.00)	10	119.90 (0.00)			Not estimable
Woolson 2004	50	97.00 (29.46)	85	105.00 (29.46)		1.82	–8.00 (–18.29 to 2.29)
Wright 2004	42	71.40 (11.20)	42	77.70 (13.20)		7.04	–6.30 (–11.54 to –1.06)



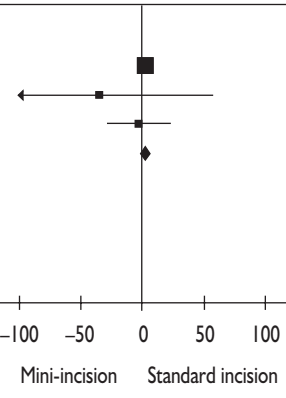
Review: Minimal incision approaches to total hip replacement
Comparison: 02 Mini-incision versus standard incision (*p*-value)
Outcome: 19 Length of hospital stay (days)

Study or subcategory	Mini-incision N	Mini-incision Mean (SD)	Standard incision N	Standard incision Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Charles 2006 (RCT)	20	5.35 (1.63)	20	5.70 (1.63)		10.30	–0.35 (–1.36 to 0.66)
Chimento 2005 (RCT)	28	5.80 (2.20)	32	5.50 (2.20)		8.44	0.30 (–0.82 to 1.42)
Chung 2004 (Q-RCT)	60	4.41 (1.10)	60	5.34 (1.40)		51.77	–0.93 (–1.38 to –0.48)
Ogonda 2005 (RCT)	109	3.65 (2.04)	110	3.68 (2.45)		29.49	–0.03 (–0.63 to 0.57)
Sharma 2006 (Q-RCT)	20	0.00 (0.00)	20	0.00 (0.00)			Not estimable
Zhang 2006 (RCT)	60	7.00 (0.00)	60	13.50 (0.00)			Not estimable
Subtotal (95% CI)	297		302			100.00	–0.50 (–0.83 to –0.18)
Test for heterogeneity: $\chi^2 = 7.94$, df = 3 ($p = 0.05$), $I^2 = 62.2\%$							
Test for overall effect: $z = 3.03$ ($p < 0.002$)							
02 Comparative studies							
Asayama 2006	52	2.96 (0.56)	50	2.94 (0.56)		48.52	0.02 (–0.20 to 0.24)
Berger 2004	100	1.90 (5.74)	100	3.50 (5.74)		0.91	–1.60 (–3.19 to –0.01)
Chen 2006	51	11.16 (0.83)	95	12.83 (1.96)		11.07	–1.67 (–2.13 to –1.21)
Ciminiello 2006	60	3.70 (5.08)	60	3.63 (5.08)		0.69	0.07 (–1.75 to 1.89)
de Beer 2004	30	5.13 (0.87)	30	5.10 (0.87)		11.83	0.03 (–0.41 to 0.47)
DiGioia 2003	33	3.80 (0.77)	33	3.90 (0.77)		16.61	–0.10 (–0.47 to 0.27)
Howell 2004	50	4.40 (2.90)	57	5.70 (3.10)		1.77	–1.30 (–2.44 to –0.16)
O'Brien 2005	35	5.40 (2.10)	53	6.20 (2.80)		2.18	–0.80 (–1.83 to 0.23)
Panisello 2006	40	5.60 (0.00)	40	6.70 (0.00)			Not estimable
Takahira 2006	10	22.00 (0.00)	10	23.40 (0.00)			Not estimable
Woolson 2004	50	4.30 (2.17)	85	4.00 (2.17)		3.99	0.30 (–0.46 to 1.06)
Wright 2004	42	6.12 (2.27)	42	6.07 (2.27)		2.43	0.05 (–0.92 to 1.02)



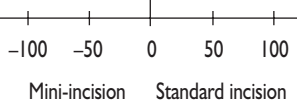
Review: Minimal incision approaches to total hip replacement
Comparison: 02 Mini-incision versus standard incision (*p*-value)
Outcome: 22 Short-term patient-controlled anaesthesia (mg)

Study or subcategory	Mini-incision N	Mini-incision Mean (SD)	Standard incision N	Standard incision Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Charles 2006 (RCT)	18	22.80 (6.03)	19	19.50 (6.03)		97.60	3.30 (–0.59 to 7.19)
Chimento 2005 (RCT)	28	285.00 (185.00)	32	319.00 (177.00)		0.17	–34.00 (–125.96 to 57.96)
Ogonda 2005 (RCT)	109	42.90 (97.40)	110	45.00 (96.80)		2.23	–2.10 (–27.82 to 23.62)
Subtotal (95% CI)	155		161			100.00	3.11 (–0.73 to 6.95)
Test for heterogeneity: $\chi^2 = 0.79$, df = 2 ($p = 0.67$), $I^2 = 0\%$							
Test for overall effect: $z = 1.59$ ($p = 0.11$)							
02 Comparative studies							



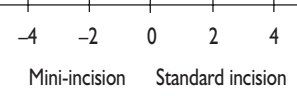
Review: Minimal incision approaches to total hip replacement
Comparison: 02 Mini-incision versus standard incision (*p*-value)
Outcome: 23 Short-term total narcotic received (mg)

Study or subcategory	Mini-incision N	Mini-incision Mean (SD)	Standard incision N	Standard incision Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Subtotal (95% CI)	0		0				Not estimable
Test for heterogeneity: $\chi^2 = 0.79$, df = 2 ($p = 0.67$), $I^2 = 0\%$							
Test for overall effect: $z = 1.59$ ($p < 0.11$)							
02 Comparative studies							
Asayama 2006	52	92.70 (0.00)	50	94.90 (0.00)			Not estimable
Ciminiello 2006	60	118.00 (41.12)	60	121.00 (41.12)		89.90	–3.00 (–17.71 to 11.71)
de Beer 2004	30	147.70 (86.75)	30	169.30 (86.75)		10.10	–21.60 (–65.50 to 22.30)



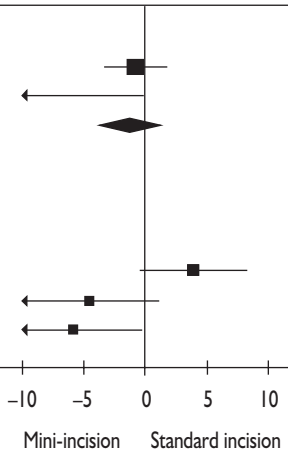
Review: Minimal incision approaches to total hip replacement
Comparison: 02 Mini-incision versus standard incision (*p*-value)
Outcome: 26 Short-term pain (score)

Study or subcategory	Mini-incision N	Mini-incision Mean (SD)	Standard incision N	Standard incision Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Charles 2006 (RCT)	18	3.94 (0.51)	19	3.68 (0.51)		67.59	0.26 (–0.07 to 0.59)
Kim 2006 (Q-RCT)	70	0.00 (0.00)	70	0.00 (0.00)			Not estimable
Ogonda 2005 (RCT)	109	3.30 (1.80)	110	3.36 (1.96)		29.42	–0.06 (–0.56 to 0.44)
Sharma 2006 (Q-RCT)	20	4.05 (2.52)	20	6.25 (2.52)		2.99	–2.20 (–3.76 to –0.64)
Subtotal (95% CI)	217		219			100.00	0.09 (–0.18 to 0.36)
Test for heterogeneity: $\chi^2 = 9.63$, df = 2 ($p = 0.008$), $I^2 = 79.2\%$							
Test for overall effect: $z = 0.67$ ($p = 0.50$)							
02 Comparative studies							
Szendrói 2006 MI/MD	38	1.50 (1.15)	43	2.15 (1.20)		62.80	–0.65 (–1.16 to –0.14)
Szendrói 2006 MI/SI	38	1.50 (1.15)	21	2.10 (1.30)		37.20	–0.60 (–1.27 to 0.07)



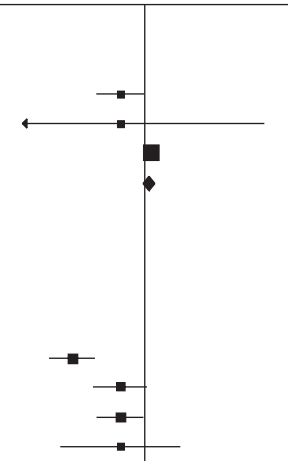
Review: Minimal incision approaches to total hip replacement
Comparison: 02 Mini-incision versus standard incision (*p*-value)
Outcome: 33 Harris hip score (≤3 months)

Study or subcategory	Mini-incision N	Mini-incision Mean (SD)	Standard incision N	Standard incision Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Ogonda 2005 (RCT)	107	–84.15 (10.56)	108	–83.36 (8.33)		96.18	–0.79 (–3.33 to 1.75)
Zhang 2006 (RCT)	60	–91.40 (35.68)	60	–78.50 (35.68)		3.82	–12.90 (–25.67 to –0.13)
Subtotal (95% CI)	167		168			100.00	–1.25 (–3.75 to 1.24)
Test for heterogeneity: $\chi^2 = 3.32$, df = 1 ($p = 0.07$), $I^2 = 69.9\%$							
Test for overall effect: $z = 0.67$ ($p = 0.50$)							
02 Comparative studies							
Ciminiello 2006	60	–91.02 (12.17)	60	–94.93 (12.17)		45.29	3.91 (–0.44 to 8.26)
de Beer 2004	30	–71.10 (9.80)	30	–66.60 (12.20)		27.39	–4.50 (–10.10 to 1.10)
DiGioia 2003	33	–86.29 (11.62)	33	–80.44 (11.62)		27.32	–5.85 (–11.46 to –0.24)



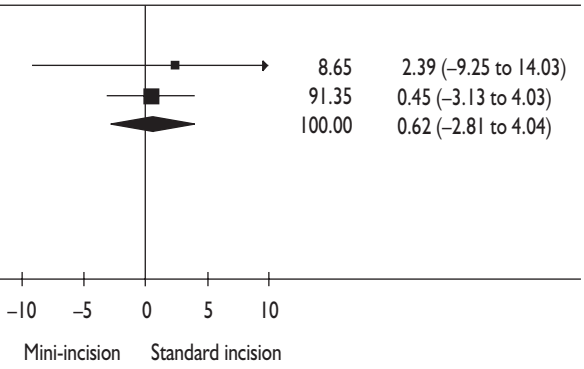
Review: Minimal incision approaches to total hip replacement
Comparison: 02 Mini-incision versus standard incision (*p*-value)
Outcome: 34 Harris hip score (>3 months)

Study or subcategory	Mini-incision N	Mini-incision Mean (SD)	Standard incision N	Standard incision Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Chimento 2005 (RCT)	27	–94.50 (0.00)	29	–94.50 (0.00)			Not estimable
Chung 2004 (Q-RCT)	60	–95.50 (5.53)	60	–93.50 (5.53)		5.85	–2.00 (–3.98 to –0.02)
Kim 2006 (Q-RCT)	70	–93.00 (35.58)	70	–91.00 (35.58)		0.16	–2.00 (–13.79 to 9.79)
Zhang 2006 (RCT)	60	–95.10 (1.38)	60	–95.60 (1.38)		93.98	0.50 (0.01 to 0.99)
Subtotal (95% CI)	217		219			100.00	0.35 (–0.13 to 0.83)
Test for heterogeneity: $\chi^2 = 5.92$, df = 2 ($p = 0.05$), $I^2 = 66.2\%$							
Test for overall effect: $z = 1.43$ ($p = 0.15$)							
02 Comparative studies							
Asayama 2006	52	–96.20 (0.00)	50	–96.20 (0.00)			Not estimable
Chen 2006	51	–89.71 (3.62)	95	–83.78 (8.03)		28.75	–5.93 (–7.83 to –4.03)
DiGioia 2003	33	–96.00 (4.57)	33	–94.00 (4.57)		21.25	–2.00 (–4.21 to 0.21)
Li 2005	18	–92.00 (2.95)	18	–90.00 (2.95)		27.82	–2.00 (–3.93 to –0.07)
Woolson 2004	20	–99.00 (7.18)	14	–97.00 (7.18)		4.30	–2.00 (–6.90 to 2.90)
Wright 2004	37	–86.90 (4.10)	39	–84.20 (6.40)		17.88	–2.70 (–5.10 to –0.30)



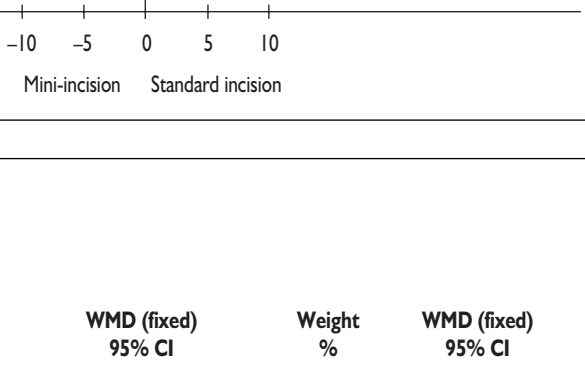
Review: Minimal incision approaches to total hip replacement
Comparison: 02 Mini-incision versus standard incision (*p*-value)
Outcome: 35 WOMAC osteoarthritis index (≤3 months)

Study or subcategory	Mini-incision N	Mini-incision Mean (SD)	Standard incision N	Standard incision Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Charles 2006 (RCT)	16	91.99 (17.51)	19	89.60 (17.51)		8.65	2.39 (–9.25 to 14.03)
Ogonda 2005 (RCT)	107	74.40 (13.88)	108	73.95 (12.90)		91.35	0.45 (–3.13 to 4.03)
Subtotal (95% CI)	123		127			100.00	0.62 (–2.81 to 4.04)
Test for heterogeneity: $\chi^2 = 0.10$, df = 1 ($p = 0.75$), $I^2 = 0\%$							
Test for overall effect: $z = 0.35$ ($p = 0.72$)							
02 Comparative studies							



Review: Minimal incision approaches to total hip replacement
Comparison: 02 Mini-incision versus standard incision (*p*-value)
Outcome: 37 Merle d'Aubigne-Charnley Score (≤3 months)

Study or subcategory	Mini-incision N	Mini-incision Mean (SD)	Standard incision N	Standard incision Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Hart 2005 (Q-RCT)	60	–16.60 (5.80)	60	–14.10 (5.80)		100.00	–2.50 (–4.58 to –0.42)
Subtotal (95% CI)	60		60			100.00	–2.50 (–4.58 to –0.42)
Test for heterogeneity: not applicable							
Test for overall effect: $z = 2.36$ ($p = 0.02$)							
02 Comparative studies							

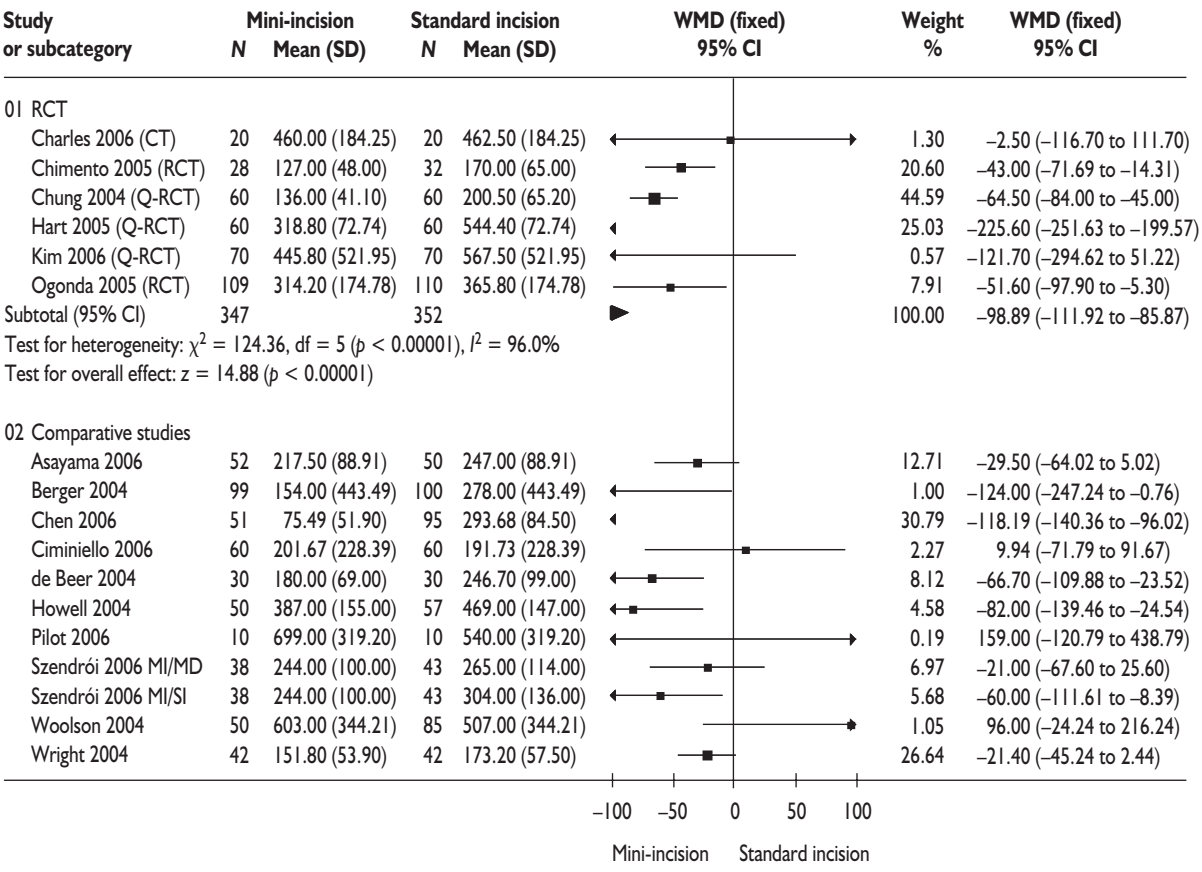


Review: Minimal incision approaches to total hip replacement
Comparison: 02 Mini-incision versus standard incision (*p*-value)
Outcome: 41 SF-36 physical function (≤3 months)

Study or subcategory	Mini-incision N	Mini-incision Mean (SD)	Standard incision N	Standard incision Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Charles 2006 (RCT)	16	–40.80 (2.13)	19	–40.40 (2.13)		100.00	–0.40 (–1.82 to 1.02)
Subtotal (95% CI)	16		19			100.00	–0.40 (–1.82 to 1.02)
Test for heterogeneity: not applicable							
Test for overall effect: $z = 0.55$ ($p = 0.58$)							
02 Comparative studies							

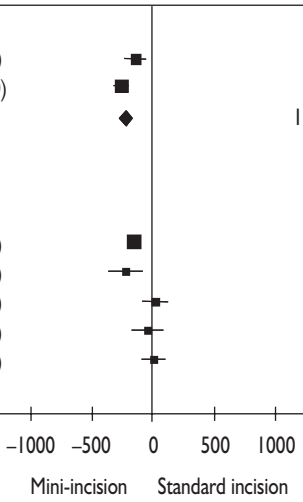
Comparison 03: Single mini-incision versus single standard incision (reported means and SDs supplemented with calculated SDs from *p*-values and imputed SDs)

Review: Minimal incision approaches to total hip replacement
Comparison: 03 Mini-incision versus standard incision (dummy)
Outcome: 09 Blood loss (intraoperative, ml)



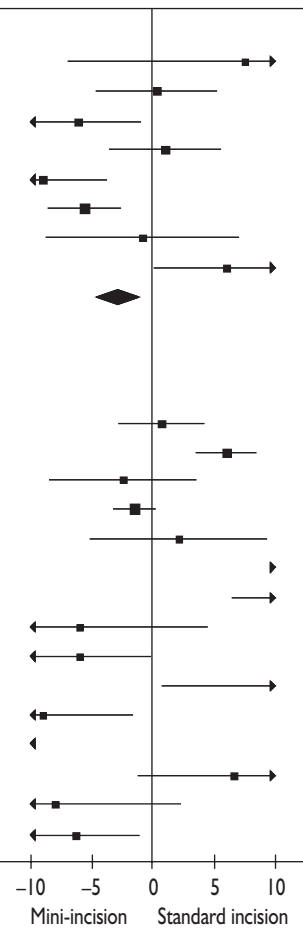
Review: Minimal incision approaches to total hip replacement
Comparison: 03 Mini-incision versus standard incision (dummy)
Outcome: 10 Blood loss (total, ml)

Study or subcategory	Mini-incision N	Mini-incision Mean (SD)	Standard incision N	Standard incision Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Chimento 2005 (RCT)	28	378.00 (151.00)	32	504.00 (205.00)		33.17	–126.00 (–216.41 to –35.59)
Hart 2005 (Q-RCT)	60	613.30 (178.00)	60	853.70 (178.00)		66.83	–240.40 (–304.10 to –176.70)
Subtotal (95% CI)	88		92			100.00	–202.45 (–254.52 to –150.38)
Test for heterogeneity: $\chi^2 = 4.11$, df = 1 ($p = 0.04$), $I^2 = 75.7\%$							
Test for overall effect: $z = 7.62$ ($p < 0.00001$)							
02 Comparative studies							
Chen 2006	51	369.51 (65.05)	95	509.63 (117.39)		79.16	–140.12 (–169.72 to –110.52)
Li 2005	18	318.00 (223.00)	18	523.00 (210.70)		3.45	–205.00 (–346.73 to –63.27)
Szendrói 2006 MI/MD	38	744.00 (260.00)	43	708.00 (221.00)		6.19	36.00 (–69.82 to 141.82)
Szendrói 2006 MI/SI	38	744.00 (260.00)	21	771.00 (235.00)		4.07	–27.00 (–157.14 to 103.14)
Takahira 2006	10	796.00 (112.72)	10	772.00 (112.72)		7.10	24.00 (–74.80 to 122.80]
Test for heterogeneity: $\chi^2 = 21.50$, df = 4 ($p = 0.0003$), $I^2 = 81.4\%$							



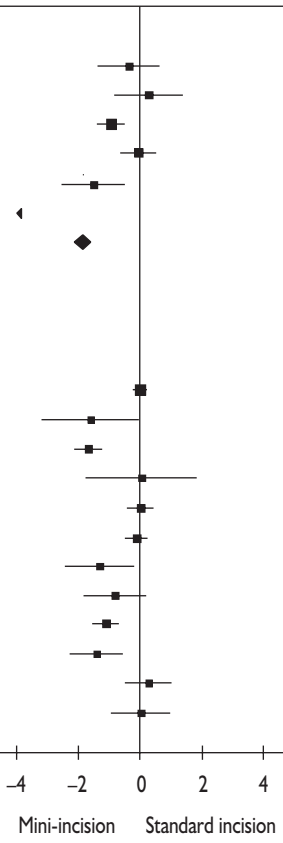
Review: Minimal incision approaches to total hip replacement
Comparison: 03 Mini-incision versus standard incision (dummy)
Outcome: 18 Duration of operation (minutes)

Study or subcategory	Mini-incision N	Mini-incision Mean (SD)	Standard incision N	Standard incision Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Charles 2006 (CT)	20	95.20 (23.29)	20	87.70 (23.29)		1.49	7.50 (–6.94 to 21.94)
Chimento 2005 (RCT)	28	70.30 (10.70)	32	70.00 (8.50)		12.71	0.30 (–4.64 to 5.24)
Chung 2004 (Q-RCT)	60	49.00 (9.40)	60	55.10 (17.90)		11.84	–6.10 (–11.22 to –0.98)
Hart 2005 (Q-RCT)	60	71.00 (12.77)	60	70.00 (12.77)		14.84	1.00 (–3.57 to 5.57)
Kim 2006 (Q-RCT)	70	52.00 (15.84)	70	61.00 (15.84)		11.25	–9.00 (–14.25 to –3.75)
Ogonda 2005 (RCT)	109	60.30 (9.20)	110	65.90 (13.20)		34.16	–5.60 (–8.61 to –2.59)
Sharma 2006 (Q-RCT)	20	67.54 (12.77)	20	68.38 (12.77)		4.95	–0.84 (–8.75 to 7.07)
Zhang 2006 (RCT)	60	75.00 (16.60)	60	69.00 (16.60)		8.78	6.00 (0.06 to 11.94)
Subtotal (95% CI)	427		432			100.00	–2.86 (–4.62 to –1.10)
Test for heterogeneity: $\chi^2 = 25.07$, df = 5 ($p = 0.0007$), $I^2 = 72.1\%$							
Test for overall effect: $z = 3.19$ ($p = 0.001$)							
02 Comparative studies							
Asayama 2006	50	58.60 (8.91)	50	57.90 (8.91)		9.83	0.70 (–2.79 to 4.19)
Berger 2004	99	72.00 (8.91)	100	66.00 (8.91)		19.56	6.00 (3.52 to 8.48)
Chen 2006	51	88.41 (17.60)	95	90.85 (17.81)		3.32	–2.44 (–8.45 to 3.57)
Ciminiello 2006	60	55.45 (4.91)	60	56.95(4.91)		38.83	–1.50 (–3.26 to 0.26)
de Beer 2004	30	46.60 (14.31)	30	44.50 (14.31)		2.29	2.10 (–5.14 to 9.34)
DiGioia 2003	33	120.00 (8.91)	33	100.00 (8.91)		6.49	20.00 (15.70 to 24.30)
Howell 2004	50	97.00 (19.00)	57	84.00 (15.00)		2.79	13.00 (6.45 to 19.55)
Li 2005	18	91.00 (16.40)	18	97.00 (15.60)		1.10	–6.00 (–16.46 to 4.46)
O'Brien 2005	32	74.00 (15.00)	51	80.00 (10.00)		3.47	–6.00 (–11.88 to –0.12)
Pilot 2006	10	99.50 (20.25)	10	81.00 (20.25)		0.38	18.50 (0.75 to 36.25)
Szendrói 2006 MI/MD	38	84.00 16.00)	43	93.00 (18.00)		2.19	–9.00 (–16.40 to –1.60)
Szendrói 2006 MI/SI	38	84.00 (16.00)	21	102.00 (12.00)		2.30	–18.00 (–25.23 to –10.77)
Takahira 2006	10	126.50 (8.91)	10	119.90 (8.91)		1.97	6.60 (–1.21 to 14.41)
Woolson 2004	50	97.00 (29.46)	85	105.00 (29.46)		1.13	–8.00 (–18.29 to 2.29)
Wright 2004	42	71.40 (11.20)	42	77.70 (13.20)		4.37	–6.30 (–11.54 to –1.06)



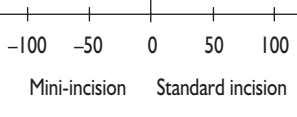
Review: Minimal incision approaches to total hip replacement
Comparison: 03 Mini-incision versus standard incision (dummy)
Outcome: 19 Length of hospital stay (days)

Study or subcategory	Mini-incision N	Mini-incision Mean (SD)	Standard incision N	Standard incision Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Charles 2006 (RCT)	20	5.35 (1.63)	20	5.70 (1.63)		7.37	–0.35 (–1.36 to 0.66)
Chimento 2005 (RCT)	28	5.80 (2.20)	32	5.50 (2.20)		6.04	0.30 (–0.82 to 1.42)
Chung 2004 (Q-RCT)	60	4.41 (1.10)	60	5.34 (1.40)		37.06	–0.93 (–1.38 to –0.48)
Ogonda 2005 (RCT)	109	3.65 (2.04)	110	3.68 (2.45)		21.11	–0.03 (–0.63 to 0.57)
Sharma 2006 (Q-RCT)	20	5.24 (1.66)	20	6.74 (1.66)		7.11	–1.50 (–2.53 to –0.47)
Zhang 2006 (RCT)	60	7.00 (1.66)	60	13.50 (1.66)		21.32	–6.50 (–7.09 to –5.91)
Subtotal (95% CI)	297		302			100.00	–1.85 (–2.13 to –1.58)
Test for heterogeneity: $\chi^2 = 310.31$, df = 5 ($p < 0.00001$), $I^2 = 98.4\%$							
Test for overall effect: $z = 13.23$ ($p < 0.00001$)							
02 Comparative studies							
Asayama 2006	52	2.96 (0.56)	50	2.94 (0.56)		42.11	0.02 (–0.20 to 0.24)
Berger 2004	100	1.90 (5.74)	100	3.50 (5.74)		0.79	–1.60 (–3.19 to –0.01)
Chen 2006	51	11.16 (0.83)	95	12.83 (1.96)		9.60	–1.67 (–2.13 to –1.21)
Ciminiello 2006	60	3.70 (5.08)	60	3.63 (5.08)		0.60	0.07 (–1.75 to 1.89)
de Beer 2004	30	5.13 (0.87)	30	5.10 (0.87)		10.27	0.03 (–0.41 to 0.47)
DiGioia 2003	33	3.80 (0.77)	33	3.90 (0.77)		14.42	–0.10 (–0.47 to 0.27)
Howell 2004	50	4.40 (2.90)	57	5.70 (3.10)		1.54	–1.30 (–2.44 to –0.16)
O'Brien 2005	35	5.40 (2.10)	53	6.20 (2.80)		1.89	–0.80 (–1.83 to 0.23)
Panisello 2006	40	5.60 (0.99)	40	6.70 (0.99)		10.57	–1.10 (–1.53 to –0.67)
Takahira 2006	10	22.00 (0.99)	10	23.40 (0.99)		2.64	–1.40 (–2.27 to –0.53)
Woolson 2004	50	4.30 (2.17)	85	4.00 (2.17)		3.46	0.30 (–0.46 to 1.06)
Wright 2004	42	6.12 (2.27)	42	6.07 (2.27)		2.11	0.05 (–0.92 to 1.02)



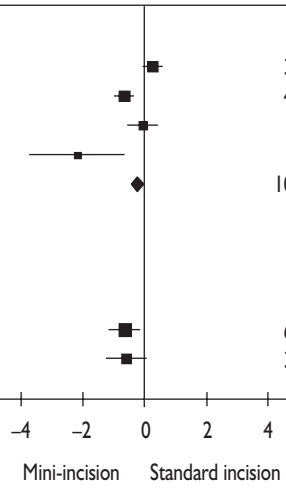
Review: Minimal incision approaches to total hip replacement
Comparison: 03 Mini-incision versus standard incision (dummy)
Outcome: 23 Short-term total narcotic received (mg)

Study or subcategory	Mini-incision N	Mini-incision Mean (SD)	Standard incision N	Standard incision Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Subtotal (95% CI)	0		0				Not estimable
Test for heterogeneity: not applicable							
Test for overall effect: not applicable							
02 Comparative studies							
Asayama 2006	52	92.70 (45.73)	50	94.90 (45.73)		38.18	–2.20 (–19.95 to 15.55)
Ciminiello 2006	60	118.00 (41.12)	60	121.00 (41.12)		55.58	–3.00 (–17.71 to 11.71)
de Beer 2004	30	147.70 (86.75)	30	169.30 (86.75)		6.24	–21.60 (–65.50 to 22.30)



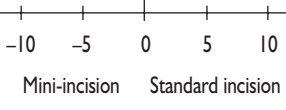
Review: Minimal incision approaches to total hip replacement
Comparison: 03 Mini-incision versus standard incision (dummy)
Outcome: 26 Short-term pain (score)

Study or subcategory	Mini-incision N	Mini-incision Mean (SD)	Standard incision N	Standard incision Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Charles 2006 (RCT)	18	3.94 (0.51)	19	3.68 (0.51)		39.58	0.26 (–0.07 to 0.59)
Kim 2006 (Q-RCT)	70	3.76 (0.97)	70	4.43 (0.97)		41.43	–0.67 (–0.99 to –0.35)
Ogonda 2005 (RCT)	109	3.30 (1.80)	110	3.36 (1.96)		17.23	–0.06 (–0.56 to 0.44)
Sharma 2006 (Q-RCT)	20	4.05 (2.52)	20	6.25 (2.52)		1.75	–2.20 (–3.76 to –0.64)
Subtotal (95% CI)	217		219			100.00	–0.22 (–0.43 to –0.02)
Test for heterogeneity: $\chi^2 = 22.29$, df = 3 ($p < 0.0001$), $I^2 = 86.5\%$							
Test for overall effect: $z = 2.12$ ($p = 0.03$)							
02 Comparative studies							
Szendrói 2006 MI/MD	38	1.50 (1.15)	43	2.15 (1.20)		62.80	–0.65 (–1.16 to –0.14)
Szendrói 2006 MI/SI	38	1.50 (1.15)	21	2.10 (1.30)		37.20	–0.60 (–1.27 to 0.07)



Review: Minimal incision approaches to total hip replacement
Comparison: 03 Mini-incision versus standard incision (dummy)
Outcome: 34 Harris hip score (>3 months)

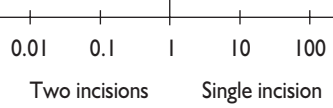
Study or subcategory	Mini-incision N	Mini-incision Mean (SD)	Standard incision N	Standard incision Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Chimento 2005 (RCT)	27	–94.50 (1.68)	29	–94.50 (1.68)		22.81	0.00 (–0.88 to 0.88)
Chung 2004 (Q-RCT)	60	–95.50 (5.53)	60	–93.50 (5.53)		4.52	–2.00 (–3.98 to –0.02)
Kim 2006 (Q-RCT)	70	–93.00 (35.58)	70	–91.00 (35.58)		0.13	–2.00 (–13.79 to 9.79)
Zhang 2006 (RCT)	60	–95.10 (1.38)	60	–95.60 (1.38)		72.54	0.50 (0.01 to 0.99)
Subtotal (95% CI)	217		219			100.00	0.27 (–0.15 to 0.69)
Test for heterogeneity: $\chi^2 = 6.39$, df = 3 ($p < 0.09$), $I^2 = 53.1\%$							
Test for overall effect: $z = 1.26$ ($p = 0.21$)							
02 Comparative studies							
Asayama 2006	52	–96.20 (4.72)	50	–96.20 (4.72)		23.54	0.00 (–1.83 to 1.83)
Chen 2006	51	–89.71 (3.62)	95	–83.78 (8.03)		21.98	–5.93 (–7.83 to –4.03)
DiGioia 2003	33	–96.00 (4.57)	33	–94.00 (4.57)		16.25	–2.00 (–4.21 to 0.21)
Li 2005	18	–92.00 (2.95)	18	–90.00 (2.95)		21.27	–2.00 (–3.93 to –0.07)
Woolson 2004	20	–99.00 (7.18)	14	–97.00 (7.18)		3.29	–2.00 (–6.90 to 2.90)
Wright 2004	37	–86.90 (4.10)	39	–84.20 (6.40)		13.67	–2.70 (–5.10 to –0.30)



Comparison 04: Two incisions versus single standard or mini-incision (reported means and SDs)

Review: Minimal incision approaches to total hip replacement
Comparison: 04 Two incisions versus single standard or mini-incision
Outcome: 01 Revision rate (number having revision surgery)

Study or subcategory	Two incisions *n/N*	Single incision *n/N*	Peto OR 95% CI	Weight %	Peto OR 95% CI
01 RCT					
02 Comparative studies					
Duwelius 2007	0/43	0/43			Not estimable

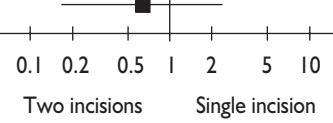


Review: Minimal incision approaches to total hip replacement
Comparison: 04 Two incisions versus single standard or mini-incision
Outcome: 02 Postoperative dislocation rates

Study or subcategory	Two incisions *n/N*	Single incision *n/N*	Peto OR 95% CI	Weight %	Peto OR 95% CI
01 RCT					
Yan 2005 (Q-RCT)	0/15	0/15			Not estimable
02 Comparative studies					

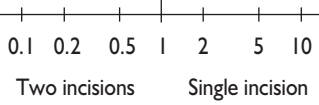
Review: Minimal incision approaches to total hip replacement
Comparison: 04 Two incisions versus single standard or mini-incision
Outcome: 03 Implant position (cup, number poorly placed)

Study or subcategory	Two incisions *n/N*	Single incision *n/N*	Peto OR 95% CI	Weight %	Peto OR 95% CI
01 RCT					
02 Comparative studies					
Duwelius 2007	4/43	2/43		39.37	2.03 (0.39 to 10.57)
Tanavalee 2006	4/35	6/35		60.63	0.63 (0.17 to 2.39)



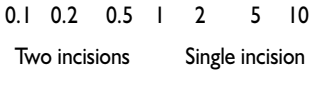
Review: Minimal incision approaches to total hip replacement
Comparison: 04 Two incisions versus single standard or mini-incision
Outcome: 04 Implant position (stem, number poorly placed)

Study or subcategory	Two incisions n/N	Single incision n/N	Peto OR 95% CI	Weight %	Peto OR 95% CI
01 RCT					
Yan 2005 (Q-RCT)	0/15	0/15			Not estimable
02 Comparative studies					
Duwelius 2007	1/43	1/43		15.54	1.00 (0.06 to 16.25)
Tanavalee 2006	7/35	6/35		84.46	1.20 (0.36 to 3.98)



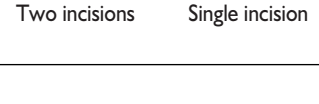
Review: Minimal incision approaches to total hip replacement
Comparison: 04 Two incisions versus single standard or mini-incision
Outcome: 05 Implant migration

Study or subcategory	Two incisions n/N	Single incision n/N	Peto OR 95% CI	Weight %	Peto OR 95% CI
01 RCT					
02 Comparative studies					
Duwelius 2007	0/43	0/43			Not estimable
Tanavalee 2006	0/35	0/35			Not estimable



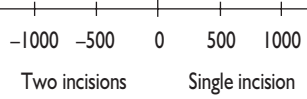
Review: Minimal incision approaches to total hip replacement
Comparison: 04 Two incisions versus single standard or mini-incision
Outcome: 06 Limb length inequality (number with unequal lengths)

Study or subcategory	Two incisions n/N	Single incision n/N	Peto OR 95% CI	Weight %	Peto OR 95% CI
01 RCT					
02 Comparative studies					
Duwelius 2007	6/39	6/38		100.00	0.97 (0.29 to 3.30)



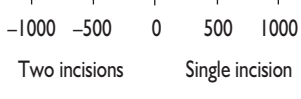
Review: Minimal incision approaches to total hip replacement
Comparison: 04 Two incisions versus single standard or mini-incision
Outcome: 07 Blood loss (intra-operative, ml)

Study or subcategory	Two incisions N	Mean (SD)	Single incision N	Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Yan 2005 (Q-RCT)	15	760.00 (0.00)	15	650.00 (0.00)			Not estimable
02 Comparative studies							
Duwelius 2007	43	366.00 (215.00)	43	247.00 (90.00)		100.00	119.00 (49.34 to 188.66)



Review: Minimal incision approaches to total hip replacement
Comparison: 04 Two incisions versus single standard or mini-incision
Outcome: 08 Blood loss (total, ml)

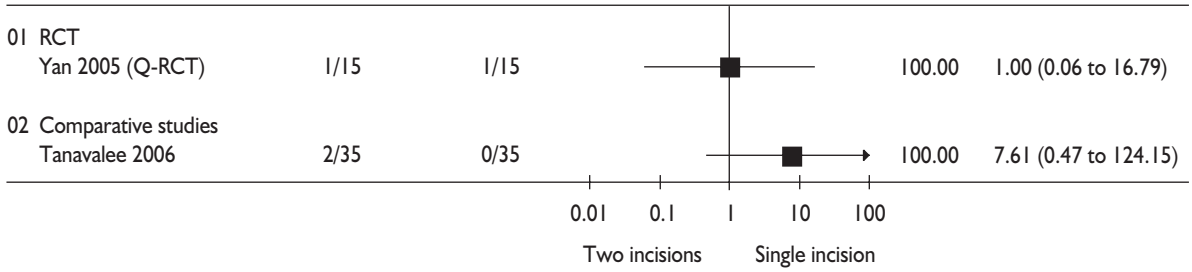
Study or subcategory	Two incisions N	Mean (SD)	Single incision N	Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
02 Comparative studies							
Tanavalee 2006	35	699.00 (0.00)	35	603.00 (0.00)			Not estimable



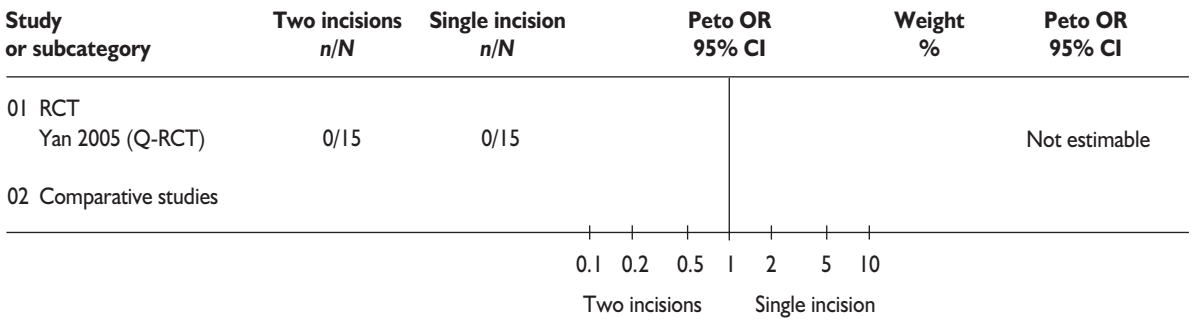
Review: Minimal incision approaches to total hip replacement
Comparison: 04 Two incisions versus single standard or mini-incision
Outcome: 09 Fractures: intra-operative

Study or subcategory	Two incisions n/N	Single incision n/N	Peto OR 95% CI	Weight %	Peto OR 95% CI
01 RCT					
02 Comparative studies					
Duwelius 2007	3/43	1/43		66.19	2.82 (0.38 to 20.74)
Tanavalee 2006	2/35	0/35		33.81	7.61 (0.47 to 124.15)

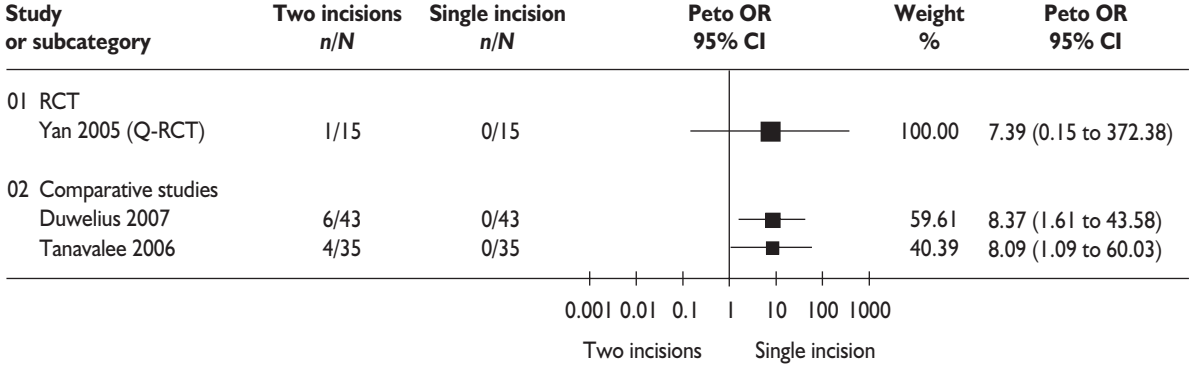
Review: Minimal incision approaches to total hip replacement
Comparison: 04 Two incisions versus single standard or mini-incision
Outcome: 10 Fractures: post-operative



Review: Minimal incision approaches to total hip replacement
Comparison: 04 Two incisions versus single standard or mini-incision
Outcome: 11 Infection



Review: Minimal incision approaches to total hip replacement
Comparison: 04 Two incisions versus single standard or mini-incision
Outcome: 12 Nerve injury

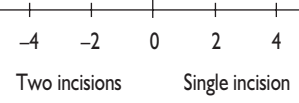


Review: Minimal incision approaches to total hip replacement
Comparison: 04 Two incisions versus single standard or mini-incision
Outcome: 13 Duration of operation (minutes)

Study or subcategory	Two incisions N	Two incisions Mean (SD)	Single incision N	Single incision Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Yan 2005 (Q-RCT)	15	100.00 (0.00)	15	80.00 (0.00)			Not estimable
02 Comparative studies							
Duwelius 2007	43	93.70 (90.00)	43	61.70 (60.00)		100.00	32.00 (–0.33 to 64.33)
Tanavalee 2006	35	168.00 (0.00)	35	113.00 (0.00)			Not estimable
Yoon 2005	100	72.00 (0.00)	118	52.00 (0.00)			Not estimable

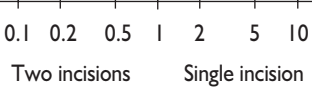
Review: Minimal incision approaches to total hip replacement
Comparison: 04 Two incisions versus single standard or mini-incision
Outcome: 14 Length of hospital stay (days)

Study or subcategory	Two incisions N	Two incisions Mean (SD)	Single incision N	Single incision Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Yan 2005 (Q-RCT)	15	6.00 (0.00)	15	13.00 (0.00)			Not estimable
02 Comparative studies							
Duwelius 2007	43	1.25 (0.00)	43	1.90 (0.00)			Not estimable



Review: Minimal incision approaches to total hip replacement
Comparison: 04 Two incisions versus single standard or mini-incision
Outcome: 15 Short-term pain (*N* of patients)

Study or subcategory	Two incisions n/N	Single incision n/N	Peto OR 95% CI	Weight %	Peto OR 95% CI
01 RCT					
02 Comparative studies					
Duwelius 2007	20/43	10/43		100.00	2.75 (1.14 to 6.64)



Review: Minimal incision approaches to total hip replacement
Comparison: 04 Two incisions versus single standard or mini-incision
Outcome: 16 Short-term pain (score)

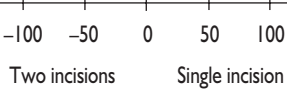
Study or subcategory	Two incisions N	Mean (SD)	Single incision N	Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
02 Comparative studies							
Duwelius 2007	43	2.00 (0.00)	43	2.50 (0.00)			Not estimable

Review: Minimal incision approaches to total hip replacement
Comparison: 04 Two incisions versus single standard or mini-incision
Outcome: 17 Long-term pain (score)

Study or subcategory	Two incisions N	Mean (SD)	Single incision N	Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
02 Comparative studies							
Duwelius 2007	37	1.60 (0.00)	30	1.60 (0.00)			Not estimable

Review: Minimal incision approaches to total hip replacement
Comparison: 04 Two incisions versus single standard or mini-incision
Outcome: 18 Time to return to shopping (days)

Study or subcategory	Two incisions N	Mean (SD)	Single incision N	Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
02 Comparative studies							
Duwelius 2007	43	14.00 (0.00)	43	26.00 (0.00)			Not estimable



Review: Minimal incision approaches to total hip replacement
Comparison: 04 Two incisions versus single standard or mini-incision
Outcome: 19 Time to return to driving (days)

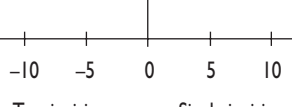
Study or subcategory	Two incisions N	Two incisions Mean (SD)	Single incision N	Single incision Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
02 Comparative studies							
Duwelius 2007	43	13.00 (0.00)	43	24.00 (0.00)			Not estimable
Pagnano 2006	26	32.00 (0.00)	26	34.00 (0.00)			Not estimable

Review: Minimal incision approaches to total hip replacement
Comparison: 04 Two incisions versus single standard or mini-incision
Outcome: 20 Use of walking aids (days)

Study or subcategory	Mini-incision N	Mini-incision Mean (SD)	Standard incision N	Standard incision Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
02 Comparative studies							
Pagnano 2006	26	28.00 (0.00)	26	27.00 (0.00)			Not estimable

Review: Minimal incision approaches to total hip replacement
Comparison: 04 Two incisions versus single standard or mini-incision
Outcome: 21 Harris hip score (⩽3 months)

Study or subcategory	Two incisions N	Two incisions Mean (SD)	Single incision N	Single incision Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Yan 2005 (Q-RCT)	15	–89.00 (0.00)	15	–86.00 (0.00)			Not estimable
02 Comparative studies							
Duwelius 2007	43	–89.00 (0.00)	43	–88.00 (0.00)			Not estimable



Review: Minimal incision approaches to total hip replacement
Comparison: 04 Two incisions versus single standard or mini-incision
Outcome: 22 Harris hip score (>3 months)

Study or subcategory	Two incisions N	Mean (SD)	Single incision N	Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Yan 2005 (Q-RCT)	15	–93.00 (0.00)	15	–93.00 (0.00)			Not estimable
02 Comparative studies							
Duwelius 2007	43	–94.00 (0.00)	43	–88.00 (0.00)			Not estimable
Tanavalee 2006	35	–94.50 (4.70)	35	–94.60 (4.50)		100.00	0.10 (–2.06 to 2.26)

Review: Minimal incision approaches to total hip replacement
Comparison: 04 Two incisions versus single standard or mini-incision
Outcome: 23 SF-36 physical function (≤3 months)

Study or subcategory	Two incisions N	Mean (SD)	Single incision N	Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
02 Comparative studies							
Duwelius 2007	43	–80.00 (0.00)	43	–70.00 (0.00)			Not estimable

Review: Minimal incision approaches to total hip replacement
Comparison: 04 Two incisions versus single standard or mini-incision
Outcome: 24 SF-36 physical function (>3 months)

Study or subcategory	Two incisions N	Mean (SD)	Single incision N	Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
02 Comparative studies							
Duwelius 2007	37	–80.00 (0.00)	30	–85.00 (0.00)			Not estimable

Comparison 05: Two incisions versus single standard or mini-incision (reported means and SDs supplemented with calculated SDs from *p*-values)

Review: Minimal incision approaches to total hip replacement
Comparison: 05 Two incisions versus single standard or mini-incision (*p*-value)
Outcome: 07 Blood loss (intra-operative, ml)

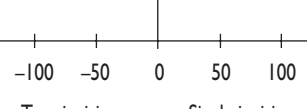
Study or subcategory	Two incisions N	Mean (SD)	Single incision N	Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Yan 2005 (Q-RCT)	15	760.00 (147.06)	15	650.00 (147.06)		100.00	110.00 (4.75 to 215.25)
02 Comparative studies							
Duwelius 2007	43	366.00 (215.00)	43	247.00 (90.00)		100.00	119.00 (49.34 to 188.66)

Review: Minimal incision approaches to total hip replacement
Comparison: 05 Two incisions versus single standard or mini-incision (*p*-value)
Outcome: 08 Blood loss (total, ml)

Study or subcategory	Two incisions N	Mean (SD)	Single incision N	Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
02 Comparative studies							
Tanavalee 2006	35	699.00 (168.56)	35	603.00 (168.56)		100.00	96.00 (17.03 to 174.97)

Review: Minimal incision approaches to total hip replacement
Comparison: 05 Two incisions versus single standard or mini-incision (*p*-value)
Outcome: 13 Duration of operation (minutes)

Study or subcategory	Two incisions N	Mean (SD)	Single incision N	Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Yan 2005 (Q-RCT)	15	100.00 (26.74)	15	80.00 (26.74)		100.00	20.00 (0.86 to 39.14)
02 Comparative studies							
Duwelius 2007	43	93.70 (90.00)	43	61.70 (60.00)		61.29	32.00 (–0.33 to 64.33)
Tanavalee 2006	35	168.00 (86.82)	35	113.00 (86.82)		38.71	55.00 (14.32 to 95.68)
Yoon 2005	100	72.00 (0.00)	118	52.00 (0.00)			Not estimable



Review: Minimal incision approaches to total hip replacement
Comparison: 05 Two incisions versus single standard or mini-incision (*p*-value)
Outcome: 14 Length of hospital stay (days)

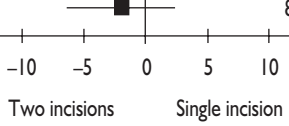
Study or subcategory	Two incisions N	Mean (SD)	Single incision N	Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
Yan 2005 (Q-RCT)	15	6.00 (5.22)	15	13.00 (5.22)		100.00	–7.00 (–10.74 to –3.26)
02 Comparative studies							
Duwelius 2007	43	1.25 (0.88)	43	1.90 (0.88)		100.00	–0.65 (–1.02 to –0.28)

Review: Minimal incision approaches to total hip replacement
Comparison: 05 Two incisions versus single standard or mini-incision (*p*-value)
Outcome: 18 Time to return to shopping (days)

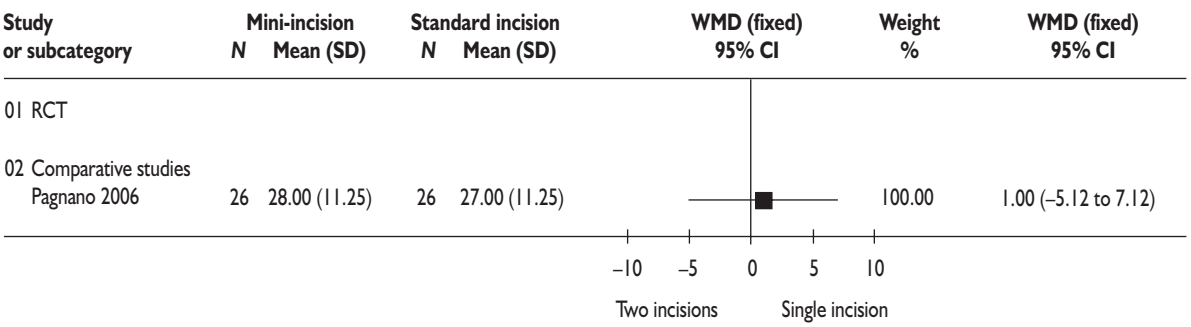
Study or subcategory	Two incisions N	Mean (SD)	Single incision N	Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
02 Comparative studies							
Duwelius 2007	43	14.00 (21.11)	43	26.00 (21.11)		100.00	–12.00 (–20.92 to –3.08)

Review: Minimal incision approaches to total hip replacement
Comparison: 05 Two incisions versus single standard or mini-incision (*p*-value)
Outcome: 19 Time to return to driving (days)

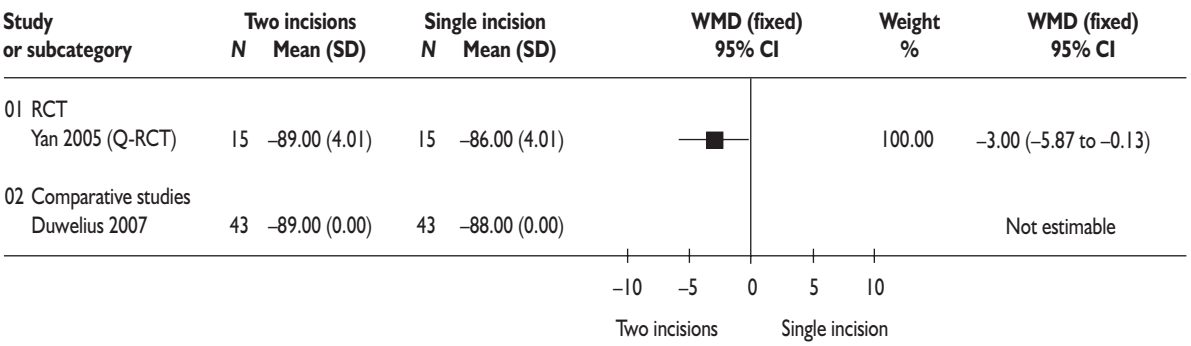
Study or subcategory	Two incisions N	Mean (SD)	Single incision N	Mean (SD)	WMD (fixed) 95% CI	Weight %	WMD (fixed) 95% CI
01 RCT							
02 Comparative studies							
Duwelius 2007	43	13.00 (24.45)	43	24.00 (24.45)		15.49	–11.00 (–21.33 to –0.67)
Pagnano 2006	26	32.00 (8.14)	26	34.00 (8.14)		84.51	–2.00 (–6.42 to 2.42)



Review: Minimal incision approaches to total hip replacement
Comparison: 05 Two incisions versus single standard or mini-incision (*p*-value)
Outcome: 20 Use of walking aids (days)



Review: Minimal incision approaches to total hip replacement
Comparison: 05 Two incisions versus single standard or mini-incision (*p*-value)
Outcome: 21 Harris hip score (≤3 months)



Appendix 11

Detailed analyses of SF-6D scores based on the trial by Charles and colleagues[69]

(Coyle D and Coyle K, University of Ottawa: personal communication, 18 May 2007)

Based on the completed SF-36 questionnaire data, SF-6D scores were calculated using the algorithm of Brazier and colleagues.[80] Overall data were collected for the 40 participants within the study. There were, however, a number of individuals with missing data. To look at the impact of this, three analyses were conducted, each using a different approach to missing values.

In the first analysis, a last value carried forward approach was used. There were, however, four participants who did not have any data for the baseline assessment and these individuals were therefore removed from the analysis, leaving 36 participants in the analysis. In the second analysis, data from all participants were included without regard to whether or not they had complete data. Consequently, the number of participants with data to analyse changes from one analysis period to the next. In the final analysis, all cases that did not have a complete data set were deleted, which left only 24 individuals within the analysis.

In each of these three analyses, mean scores of each time point were compared in an analysis of covariance adjusting for baseline SF-6D scores.

Overall, the differences between the minimally invasive arm and the control arm were small and the different approaches to handling missing values did not significantly affect the results (*Tables 55–57*).

TABLE 55 *Analysis using last value carried forward approach to missing values*

Period	Group	*N*	Mean	SD	SE of mean	Adjusted difference (SE)	*p*-Value
Preoperation	Control	18	0.6527	0.15075	0.03553		
	MIS	18	0.5722	0.16453	0.03878		
3 months postoperation	Control	18	0.7632	0.10304	0.02429		
	MIS	18	0.7924	0.08298	0.01956		
	Difference					0.045 (0.31)	0.158
6 months postoperation	Control	18	0.8014	0.09470	0.02232		
	MIS	18	0.8001	0.07565	0.01783		
	Difference					0.001 (0.030)	0.963
1 year postoperation	Control	18	0.8139	0.11936	0.02813		
	MIS	18	0.7895	0.06912	0.01629		
	Difference					–0.011 (0.033)	0.731
2 years postoperation	Control	18	0.8186	0.09312	0.02195		
	MIS	18	0.8026	0.07627	0.01798		
	Difference					–0.006 (0.029)	0.842

SD, standard deviation; SE, standard error.

TABLE 56 *Analysis of complete dataset without regard to missing values*

Period	Group	*N*	Mean	SD	SE of mean	Adjusted difference (SE)	*p*-Value
Preoperation	Control	18	0.6527	0.15075	0.03553		
	MIS	18	0.5722	0.16453	0.03878		
3 months postoperation	Control	18	0.7687	0.10421	0.02456		
	MIS	19	0.7884	0.08419	0.01932		
	Difference					0.047 (0.031)	0.142
6 months postoperation	Control	18	0.8151	0.08430	0.01987		
	MIS	17	0.7954	0.07376	0.01789		
	Difference					–0.002 (0.028)	0.936
1 year postoperation	Control	20	0.8149	0.11301	0.02527		
	MIS	19	0.7906	0.06473	0.01485		
	Difference					–0.005 (0.032)	0.880
2 years postoperation	Control	16	0.8371	0.07071	0.01768		
	MIS	14	0.8101	0.06748	0.01803		
	Difference					–0.011 (0.029)	0.719

SD, standard deviation; SE, standard error.

TABLE 57 *Analysis of cases with complete datasets*

Period	Group	*N*	Mean	SD	SE of mean	Adjusted difference (SE)	*p*-Value
Preoperation	Control	14	0.6722	0.13263	0.03545		
	MIS	10	0.5762	0.17112	0.05411		
3 months postoperation	Control	14	0.7844	0.08720	0.02330		
	MIS	10	0.7915	0.09543	0.03018		
	Difference					0.030 (0.037)	0.437
6 months postoperation	Control	14	0.7902	0.07735	0.02067		
	MIS	10	0.8170	0.05719	0.01808		
	Difference					0.028 (0.031)	0.371
1 year postoperation	Control	14	0.8415	0.10403	0.02780		
	MIS	10	0.7899	0.04939	0.01562		
	Difference					–0.031 (0.035)	0.398
2 years postoperation	Control	14	0.8350	0.07544	0.02016		
	MIS	10	0.8066	0.07307	0.02311		
	Difference					–0.015 (0.032)	0.644

SD, standard deviation; SE, standard error.

Appendix 12

Summary of included economic evaluations

Study identification	Author and year	Duwelius, 2006 (unpublished)
	Interventions studied/ comparators	Mini-incision and MIS 2-incision total hip replacement (THR)/ standard THR
	Hypothesis/question	To evaluate the cost-effectiveness at 6 weeks of minimally invasive THR (mini-incision and two mini-incision) relative to the standard technique in patients with advanced degenerative joint disease
Key elements of the study	Type of study	Cost-effectiveness analysis based on data from 10 hospitals in various geographic locations in the USA. Non-randomised, unmatched cohorts
	Target population/ study sample	Patients with advanced degenerative joint disease in 10 USA hospitals
	Setting	Secondary care with inclusion of some community costs. 10 unspecified US hospitals and 14 orthopaedic surgeons
	Dates to which data relate	2002–5
	Source of effectiveness data	Effectiveness data derived from a prospective unmatched comparative cohort study
	Modelling	NA
	Link between effectiveness and cost data	The costing was undertaken retrospectively on the same sample as that used for the effectiveness study. Charge data provided by 9 of 10 hospitals regarding initial hospitalisation and for complications requiring re-hospitalisation and cost-to-charge ratios were used to convert billed charges into estimated costs
		Indirect costs in terms of productivity losses from time away from work linked to time to WWOS, which is assumed as an indicator of ability to return to work
Details about clinical evidence: study design and main outcomes	Eligibility/patient group/ study sample	No specified eligibility criteria or patient group stated/14 surgeons at 10 hospitals provided data on 591 patients (235 MIS two-incision, 325 mini-incision, 31 standard THR)
	Study design	Prospective unmatched cohort study
	Analysis of effectiveness	The main clinical outcomes were time to WWOS, psychometric health status as measured through SF-36, postoperative recovery approximated by WWOS from the Harris hip score and HRQoL. SF-6D estimated from the SF-36 scores using UK algorithm
	Effectiveness results/ outcome measures	Significantly different ($p \leq 0.05$) demographics between groups at time of surgery. MIS 2-incision hip procedure had greatest operating time averaging 20 minutes more than standard technique. Duration of acute hospital stay for MIS 2-incision patients was 2.4 days shorter than standard cases ($p \leq 0.05$). Compared with standard surgery, MIS 2-incision and mini-incision patients had a 60 and 44% decline in hospital length of stay, respectively; discharges to facility-based rehabilitation declined by 97 and 80%, respectively; and WWOS at 6 weeks increased by 209 and 123%, respectively. Intraoperative and postoperative complications were low for all groups. Dislocation related complications, resulting in re-hospitalisation within 6 months post-surgery, reported for 2 ($n = 325$) mini-incision cases

continued

	Clinical conclusions	The MIS 2-incision and mini-incision cases had a similar or better postoperative quality of life than standard technique cases and experienced a significantly earlier recovery from THR
Economic analysis	Measure of health benefits used in the economic analysis	QALYs estimated as the product of the surgical technique-specific HRQoL estimates by the proportion of subjects able to WWOS at 6 weeks (used as predictive of ability to return to work). In the calculation of QALYs, patient selection was compensated by three methods: WWOS multiplied by average HRQoL, HRQoL within each stratum and stratified HRQoL including covariance analysis. It is unclear if this is an appropriate approach to calculate QALYs
	Direct costs	Surgeon costs estimated from the Medicare unadjusted national average rate for primary THR, weighted for annual volume. Charge data provided by 9 of 10 hospitals regarding initial hospitalisation and for complications requiring re-hospitalisation for 518 of 591 cases (201 MIS 2-incision, 296 mini-incision and 21 standard technique); one hospital did not release any charge data. Two hospitals provided only technique-specific annual average charges. Hospital cost-to-charge ratios were used to convert billed charges into estimated costs. Post-acute rehabilitation provider costs were modelled from inpatient hospital discharge and Medicare reimbursement schedules. Hospital discharge data were obtained from the study for the minimally invasive techniques (189 MIS 2-incision, 291 mini-incision) and from publicly available survey data for the standard technique
	Indirect costs	Wages foregone by employed THR patients during recovery from surgery were estimated as indirect costs and modelled from the patient being able to WWOS, THR incidence and employment data
	Currency	US$. Unclear what the price year is and if prices have been adjusted for differential timing, although sensitivity analysis around inflation rates has been performed
	Statistical analysis of quantities/costs	HRQoL was calculated using two propensity scoring methods to minimise selection bias. 1st method: average HRQoL within five strata formed from percentiles of pooled preoperative SF-6D scores estimated followed by weighted averaging over strata. 2nd method: propensity scores estimated from two logistic models followed by covariance analysis of HRQoL, adjusted for propensity scores to reflect differences in case mix. QALYs estimated using a non-standard method; the validity of this approach is unclear
	Sensitivity analysis	Two-way sensitivity analysis of all costs and utility values. Inpatient rehabilitation facility, skilled nursing facility, home healthcare, home only (no rehabilitation) and physician costs all varied by either +30% or –30% of BC values. Wages and hospital cost-to-charge ratio varied by either +10% or –10% of BC values. Inflation varied by +5% or –5% of BC values. Combined incremental effectiveness presented, although it is unclear what has been combined in order to calculate this measure. Minimum incremental effectiveness and maximum incremental effectiveness of minimally invasive procedures relative to standard procedure also presented. Four methods of imputing data for missing HRQoL entries performed; imputation using last observation carried forward, imputation of the interval-by-approach average, use of all available data and restriction to complete cases with no missing data. BC, minimum incremental effectiveness and maximum incremental effectiveness are presented

continued

Results	Estimated benefits used in the economic evaluation	6-week QALYs for all techniques: 0.053 QALYs for 2-incision, 0.039 QALYs for mini-incision and 0.016 QALYs for standard technique. Incremental effectiveness of minimally invasive techniques compared with standard techniques: BC 0.037 QALYs for 2-incision and 0.023 QALYs for mini-incision. Minimum incremental effectiveness: 0.037 QALYs for MIS 2-incision and 0.021 QALYs for mini-incision. Maximum incremental effectiveness: 0.040 QALYs for 2-incision and 0.023 QALYs for mini-incision. Note: differences in QALYs are not statistically significant and it is likely that CIs would be wide. Some attempt to adjust for case mix was performed. It is also worth noting that the effectiveness measure used to calculate utilities (SF-6D), based on postoperative recovery, may not capture all the potential gains that patients who receive MIS might benefit from
	Costs results	Total costs were lower for the MIS 2-incision hip procedure and highest for the standard technique (MIS 2-incision, $16,085; mini-incision, $16,615 and standard technique, $21,705). Rate adjusting surgical technique costs suggest nearly identical hospital cost for the MIS 2-incision and the mini-incision technique (MIS 2-incision, $12,725; mini-incision, $12,720; and standard technique, $14,903). Lowest indirect costs reported for MIS 2-incision patients as they were able, at higher proportions, to walk without support earlier than mini-incision and standard technique patients (MIS 2-incision, $1433; mini-incision, $1790 and standard technique, $2254). Rehabilitation resource utilisation reflected the need for and intensity of post-acute care treatment (MIS 2-incision, $540; mini-incision, $719; and standard technique, $3161). Surgeon costs for all three procedures were identical; $1386. It is not stated if differences in costs are statistically significant and no confidence intervals are reported. No adjustments have been made for case mix
	Synthesis of costs and benefits	Incremental costs and incremental QALYs are reported for the two minimally invasive procedures relative to the standard procedure, but no attempt is made to combine these into cost-effectiveness ratios as MIS is assumed to be cost saving and more effective although the difference in QALYs is not statistically significant and differences in cost are not tested. Furthermore, it is unclear if the method of converting for case mix adequately corrects for selection biases. Principle cost drivers are hospital, rehabilitation and indirect costs
	Authors' conclusions	Even under conservative assumptions, MIS 2-incision and mini-incision THR techniques have better 6-week outcomes at less cost than the standard technique
Study identification	**Author and year**	**Straumann, 2006[82]**
	Interventions studied/ comparators	Minimal invasive surgery total hip replacement (MIS THR) vs standard THR
	Hypothesis/question	To evaluate and illustrate the cost-effectiveness, economic consequences and QALYs of MIS THR in Switzerland using a model-based and quantitative analysis
Key elements of the study	Type of study	Modelling with retrospective costing exercise of standard THR. Effectiveness data and cost difference based on a US study
	Target population/ study sample	Cost data estimated for standard THR patients originating from the Balgrist Orthopaedic University Hospital of Zurich. This figure was then applied to the total number of THRs performed in Switzerland to obtain the aggregate cost
	Setting	Secondary care with inclusion of some community costs

continued

	Dates to which data relate	Cost data from Switzerland taken for the year 2003.
	Source of effectiveness data	No effectiveness data are presented in the paper, assumed MIS better based on US study. Differences in indirect costs (productivity losses) utilised by applying the human capital accounting method to estimate benefit in terms of productivity savings
	Modelling	Applied mean difference in cost between minimally invasive and standard THR from previous US-based cost-effectiveness analysis and applied this mean difference in cost to total cost data for all standard THR
	Link between effectiveness and cost data	Effectiveness taken from a US-based unpublished cost-effectiveness analysis (Duwelius and colleagues, 2006). Little information on this paper is reported
Details about clinical evidence: study design and main outcomes	Eligibility/patient group/ study sample	13,101 primary THRs performed in Switzerland in 2003. Aggregate estimation of savings following MIS techniques, estimated from decreases in productivity losses and rehabilitation costs at indication rates of 30% (conservative) and 50% (optimistic)
	Study design	Data based on an unpublished US study with potential serious biases in assessment of effectiveness
	Analysis of effectiveness	Productivity losses are only measure of benefit
	Effectiveness results/ outcome measures	NA
	Clinical conclusions	No primary clinical outcomes sought as part of this study, although stated that early postoperative recovery is apparent after MIS techniques (assumed from results of unpublished data which are utilised heavily) and suffers from serious selection bias
Economic analysis	Measure of health benefits used in the economic analysis	Human capital accounting method applied to determine gains in productivity following MIS techniques
	Direct costs	2003 average cost total cost data for THR originating from the Balgrist Orthopaedic University Hospital of Zurich. Definitive cost difference between standard and MIS techniques taken from an unpublished cost-effectiveness analysis and applied to Swiss cost data to obtain cost of operation for a standard and minimally invasive patient relevant to Switzerland. For rehabilitation costs, it is assumed 50% patients (n = 6550) need outpatient rehabilitation at €1335 per patient. 40% (n = 5240) take advantage of a rehabilitation programme outside a hospital (€3335 per patient) and 10% (n = 1311) need in-hospital rehabilitation (€13,335 per patient). It should be noted that it is unclear what biases these assumptions have
	Indirect costs	Productivity losses incurred from inability to return to work measured and applied to standard and minimally invasive groups to estimate potential productivity losses that might be avoided by adopting MIS techniques. 80.1% reduction in productivity loss from MIS estimated from average work disability (assumed 45 days) with unemployment rate of 4.4% for the employed age category (n = 6547) and an employment rate of 7.4% for patients older than 70 years (n = 464). Total number of days saved is 252,324, which is multiplied by average GDP per work day/person (€315) to obtain the potential reduction of productivity losses. Assumed average disability of 45 days, but unclear why this assumption is made. Figure of 80.1% reduction is productivity losses given, but it is unclear where this number has come from

continued

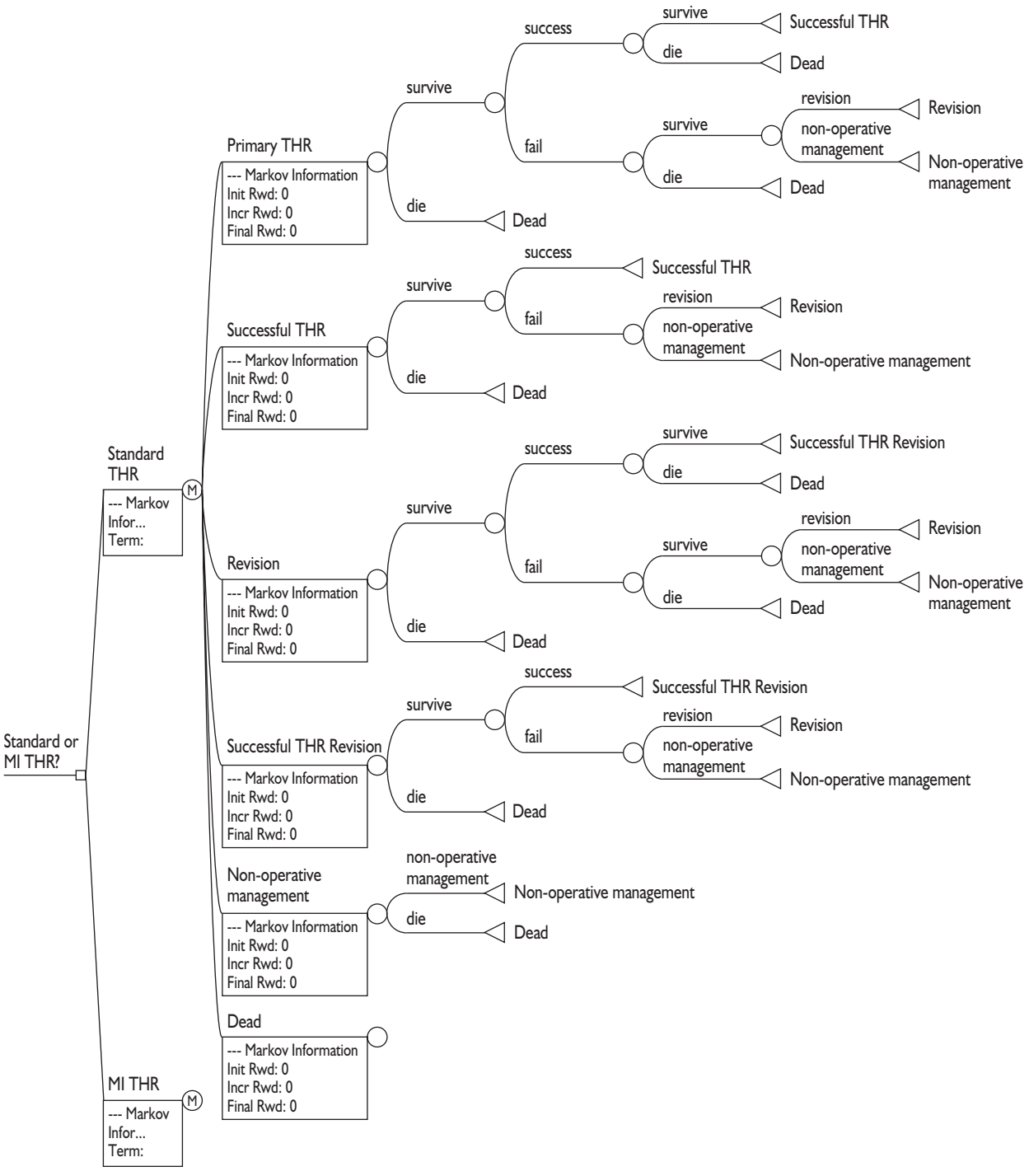
	Currency	Euros. 2003 prices
	Statistical analysis of quantities/costs	None performed
	Sensitivity analysis	Two indication rates for MIS used, 30% (conservative) and 50% (optimistic). Both presented as part of main analysis
Results	Estimated benefits used in the economic evaluation	No measure of benefit other than cost savings from reduction in productivity losses
	Costs results	Indirect costs, assumed to be productivity losses, totalling €79.4 million (if 100% of THRs are performed using minimally invasive methods). For the assumed MIS indication rates the effective reduction of productivity losses ranges between €23.8 million (conservative) and €39.7 million (optimistic)
		There were 36 fewer work days lost per employed patient with MIS THR than with the standard THR technique
		Average hospital costs per patient were €13,511 for standard THR and €11,534.40 for MIS THR. Given the total THRs in Switzerland (€13,101) and indications rates of THR of 30 and 50%, calculated effective hospital cost savings are €7.8 million and €12.9 million
		Overall rehabilitation costs are €43.7 million. Rehabilitation costs are 82.9% lower with MIS 2-incision and 77.3% lower with mini-incision technique. Using assumed MIS indication rates, the effective cost savings range between €10.9 million and €18.1 million for MIS 2-incision procedure and between €10.1 million and €16.9 million for mini-incision technique
	Synthesis of costs and benefits	No attempt is made to synthesise cost and benefits as the main benefit measure "productivity loss" is measured as a cost. Assumption made of equal or better outcomes and application of cost saving rate from USA assumes that data are correct even for the USA and the data might be applicable to Switzerland
	Authors' conclusions	Recommendation of adoption of MIS techniques in THR as they may allow the reduction of healthcare costs

BC, base-case; HRQoL, health-related quality of life; NA, not applicable; WWOS, walking without support.

Appendix 13

Markov model for the management of arthritic disease of the hip

The diagram below displays the unpopulated model for the standard THR arm. The tree structures for both the standard and minimal incision arms are identical.



Appendix 14

Balanced life table for general mortality (40% male, 60% female)

Mortality is weighted by sex as the National Joint Registry reports that 60% of all primary total hip replacements are performed on women; therefore, the all-cause mortality for the model cohort was weighted to reflect this.

Age (years)	Mortality	Age (years)	Mortality
68	0.016562	89	0.153176
69	0.018324	90	0.164534
70	0.019946	91	0.179646
71	0.022501	92	0.196954
72	0.02522	93	0.217126
73	0.027967	94	0.232363
74	0.031561	95	0.255651
75	0.035162	96	0.27421
76	0.039297	97	0.29536
77	0.043814	98	0.314326
78	0.048593	99	0.329341
79	0.054145	100	0.356988
80	0.059932	101	0.356988
81	0.066966	102	0.356988
82	0.073952	103	0.356988
83	0.081779	104	0.356988
84	0.088514	105	0.356988
85	0.098279	106	0.356988
86	0.109397	107	0.356988
87	0.126424	108	0.356988
88	0.138485		

Appendix 15

Cohort analysis showing 1000 patients as they progress through the 40-year model for both standard and mini-incision THR

Both standard and mini-incision THR patients would move through the model as shown. It is the cost and outcomes associated with the two forms of surgery that drive the cost–utility results.

Stage	Primary THR	Successful THR	Revision	Successful THR (revision)	Non-operative management	Dead
0	1000	0	0	0	0	0
1	0	968	7	0	0	26
2	0	938	12	7	0	43
3	0	903	16	18	0	63
4	0	865	18	33	0	84
5	0	820	24	49	0	107
6	0	769	29	70	0	132
7	0	713	33	94	0	160
8	0	654	37	120	0	190
9	0	591	41	147	0	222
10	0	523	45	175	0	256
11	0	456	47	204	0	293
12	0	389	48	231	0	332
13	0	325	48	255	0	372
14	0	265	46	274	0	415
15	0	212	43	287	0	458
16	0	166	39	292	0	503
17	0	127	36	290	0	547
18	0	94	31	282	0	592
19	0	68	27	267	0	637
20	0	48	23	246	0	683
21	0	33	20	220	0	727
22	0	22	16	193	0	769
23	0	14	13	165	0	807
24	0	9	11	138	0	842
25	0	6	9	112	0	873
26	0	3	7	89	0	901
27	0	2	5	69	0	924
28	0	1	4	51	0	943
29	0	1	3	38	0	959
30	0	0	2	27	0	971
31	0	0	1	18	0	980
32	0	0	1	12	0	987
33	0	0	1	8	0	991
34	0	0	0	5	0	995
35	0	0	0	3	0	996
36	0	0	0	2	0	998
37	0	0	0	1	0	999
38	0	0	0	1	0	999
39	0	0	0	1	0	999
40	0	0	0	0	0	1000

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No. 25
A rapid and systematic review of the evidence for the clinical effectiveness and cost-effectiveness of irinotecan, oxaliplatin and raltitrexed for the treatment of advanced colorectal cancer.
By Lloyd Jones M, Hummel S, Bansback N, Orr B, Seymour M.

No. 26
Comparison of the effectiveness of inhaler devices in asthma and chronic obstructive airways disease: a systematic review of the literature.
By Brocklebank D, Ram F, Wright J, Barry P, Cates C, Davies L, *et al*.

No. 27
The cost-effectiveness of magnetic resonance imaging for investigation of the knee joint.
By Bryan S, Weatherburn G, Bungay H, Hatrick C, Salas C, Parry D, *et al*.

No. 28
A rapid and systematic review of the clinical effectiveness and cost-effectiveness of topotecan for ovarian cancer.
By Forbes C, Shirran L, Bagnall A-M, Duffy S, ter Riet G.

No. 29
Superseded by a report published in a later volume.

No. 30
The role of radiography in primary care patients with low back pain of at least 6 weeks duration: a randomised (unblinded) controlled trial.
By Kendrick D, Fielding K, Bentley E, Miller P, Kerslake R, Pringle M.

No. 31
Design and use of questionnaires: a review of best practice applicable to surveys of health service staff and patients.
By McColl E, Jacoby A, Thomas L, Soutter J, Bamford C, Steen N, *et al*.

No. 32
A rapid and systematic review of the clinical effectiveness and cost-effectiveness of paclitaxel, docetaxel, gemcitabine and vinorelbine in non-small-cell lung cancer.
By Clegg A, Scott DA, Sidhu M, Hewitson P, Waugh N.

No. 33
Subgroup analyses in randomised controlled trials: quantifying the risks of false-positives and false-negatives.
By Brookes ST, Whitley E, Peters TJ, Mulheran PA, Egger M, Davey Smith G.

No. 34
Depot antipsychotic medication in the treatment of patients with schizophrenia: (1) Meta-review; (2) Patient and nurse attitudes.
By David AS, Adams C.

No. 35
A systematic review of controlled trials of the effectiveness and cost-effectiveness of brief psychological treatments for depression.
By Churchill R, Hunot V, Corney R, Knapp M, McGuire H, Tylee A, *et al*.

No. 36
Cost analysis of child health surveillance.
By Sanderson D, Wright D, Acton C, Duree D.

Volume 6, 2002

No. 1
A study of the methods used to select review criteria for clinical audit.
By Hearnshaw H, Harker R, Cheater F, Baker R, Grimshaw G.

No. 2
Fludarabine as second-line therapy for B cell chronic lymphocytic leukaemia: a technology assessment.
By Hyde C, Wake B, Bryan S, Barton P, Fry-Smith A, Davenport C, *et al*.

No. 3
Rituximab as third-line treatment for refractory or recurrent Stage III or IV follicular non-Hodgkin's lymphoma: a systematic review and economic evaluation.
By Wake B, Hyde C, Bryan S, Barton P, Song F, Fry-Smith A, *et al*.

No. 4
A systematic review of discharge arrangements for older people.
By Parker SG, Peet SM, McPherson A, Cannaby AM, Baker R, Wilson A, *et al*.

No. 5
The clinical effectiveness and cost-effectiveness of inhaler devices used in the routine management of chronic asthma in older children: a systematic review and economic evaluation.
By Peters J, Stevenson M, Beverley C, Lim J, Smith S.

No. 6
The clinical effectiveness and cost-effectiveness of sibutramine in the management of obesity: a technology assessment.
By O'Meara S, Riemsma R, Shirran L, Mather L, ter Riet G.

No. 7
The cost-effectiveness of magnetic resonance angiography for carotid artery stenosis and peripheral vascular disease: a systematic review.
By Berry E, Kelly S, Westwood ME, Davies LM, Gough MJ, Bamford JM, *et al*.

No. 8
Promoting physical activity in South Asian Muslim women through 'exercise on prescription'.
By Carroll B, Ali N, Azam N.

No. 9
Zanamivir for the treatment of influenza in adults: a systematic review and economic evaluation.
By Burls A, Clark W, Stewart T, Preston C, Bryan S, Jefferson T, *et al*.

No. 10
A review of the natural history and epidemiology of multiple sclerosis: implications for resource allocation and health economic models.
By Richards RG, Sampson FC, Beard SM, Tappenden P.

No. 11
Screening for gestational diabetes: a systematic review and economic evaluation.
By Scott DA, Loveman E, McIntyre L, Waugh N.

No. 12
The clinical effectiveness and cost-effectiveness of surgery for people with morbid obesity: a systematic review and economic evaluation.
By Clegg AJ, Colquitt J, Sidhu MK, Royle P, Loveman E, Walker A.

No. 13
The clinical effectiveness of trastuzumab for breast cancer: a systematic review.
By Lewis R, Bagnall A-M, Forbes C, Shirran E, Duffy S, Kleijnen J, *et al*.

No. 14
The clinical effectiveness and cost-effectiveness of vinorelbine for breast cancer: a systematic review and economic evaluation.
By Lewis R, Bagnall A-M, King S, Woolacott N, Forbes C, Shirran L, *et al*.

No. 15
A systematic review of the effectiveness and cost-effectiveness of metal-on-metal hip resurfacing arthroplasty for treatment of hip disease.
By Vale L, Wyness L, McCormack K, McKenzie L, Brazzelli M, Stearns SC.

No. 16
The clinical effectiveness and cost-effectiveness of bupropion and nicotine replacement therapy for smoking cessation: a systematic review and economic evaluation.
By Woolacott NF, Jones L, Forbes CA, Mather LC, Sowden AJ, Song FJ, *et al*.

No. 17
A systematic review of effectiveness and economic evaluation of new drug treatments for juvenile idiopathic arthritis: etanercept.
By Cummins C, Connock M, Fry-Smith A, Burls A.

No. 18
Clinical effectiveness and cost-effectiveness of growth hormone in children: a systematic review and economic evaluation.
By Bryant J, Cave C, Mihaylova B, Chase D, McIntyre L, Gerard K, *et al*.

No. 19
Clinical effectiveness and cost-effectiveness of growth hormone in adults in relation to impact on quality of life: a systematic review and economic evaluation.
By Bryant J, Loveman E, Chase D, Mihaylova B, Cave C, Gerard K, *et al*.

No. 20
Clinical medication review by a pharmacist of patients on repeat prescriptions in general practice: a randomised controlled trial.
By Zermansky AG, Petty DR, Raynor DK, Lowe CJ, Freementle N, Vail A.

No. 21
The effectiveness of infliximab and etanercept for the treatment of rheumatoid arthritis: a systematic review and economic evaluation.
By Jobanputra P, Barton P, Bryan S, Burls A.

No. 22
A systematic review and economic evaluation of computerised cognitive behaviour therapy for depression and anxiety.
By Kaltenthaler E, Shackley P, Stevens K, Beverley C, Parry G, Chilcott J.

No. 23
A systematic review and economic evaluation of pegylated liposomal doxorubicin hydrochloride for ovarian cancer.
By Forbes C, Wilby J, Richardson G, Sculpher M, Mather L, Reimsma R.

No. 24
A systematic review of the effectiveness of interventions based on a stages-of-change approach to promote individual behaviour change.
By Riemsma RP, Pattenden J, Bridle C, Sowden AJ, Mather L, Watt IS, *et al*.

No. 25
A systematic review update of the clinical effectiveness and cost-effectiveness of glycoprotein IIb/IIIa antagonists.
By Robinson M, Ginnelly L, Sculpher M, Jones L, Riemsma R, Palmer S, *et al*.

No. 26
A systematic review of the effectiveness, cost-effectiveness and barriers to implementation of thrombolytic and neuroprotective therapy for acute ischaemic stroke in the NHS.
By Sandercock P, Berge E, Dennis M, Forbes J, Hand P, Kwan J, *et al*.

No. 27
A randomised controlled crossover trial of nurse practitioner versus doctor-led outpatient care in a bronchiectasis clinic.
By Caine N, Sharples LD, Hollingworth W, French J, Keogan M, Exley A, *et al*.

No. 28
Clinical effectiveness and cost – consequences of selective serotonin reuptake inhibitors in the treatment of sex offenders.
By Adi Y, Ashcroft D, Browne K, Beech A, Fry-Smith A, Hyde C.

No. 29
Treatment of established osteoporosis: a systematic review and cost–utility analysis.
By Kanis JA, Brazier JE, Stevenson M, Calvert NW, Lloyd Jones M.

No. 30
Which anaesthetic agents are cost-effective in day surgery? Literature review, national survey of practice and randomised controlled trial.
By Elliott RA Payne K, Moore JK, Davies LM, Harper NJN, St Leger AS, *et al*.

No. 31
Screening for hepatitis C among injecting drug users and in genitourinary medicine clinics: systematic reviews of effectiveness, modelling study and national survey of current practice.
By Stein K, Dalziel K, Walker A, McIntyre L, Jenkins B, Horne J, *et al*.

No. 32
The measurement of satisfaction with healthcare: implications for practice from a systematic review of the literature.
By Crow R, Gage H, Hampson S, Hart J, Kimber A, Storey L, *et al*.

No. 33
The effectiveness and cost-effectiveness of imatinib in chronic myeloid leukaemia: a systematic review.
By Garside R, Round A, Dalziel K, Stein K, Royle R.

No. 34
A comparative study of hypertonic saline, daily and alternate-day rhDNase in children with cystic fibrosis.
By Suri R, Wallis C, Bush A, Thompson S, Normand C, Flather M, *et al*.

No. 35
A systematic review of the costs and effectiveness of different models of paediatric home care.
By Parker G, Bhakta P, Lovett CA, Paisley S, Olsen R, Turner D, *et al*.

Volume 7, 2003

No. 1
How important are comprehensive literature searches and the assessment of trial quality in systematic reviews? Empirical study.
By Egger M, Jüni P, Bartlett C, Holenstein F, Sterne J.

No. 2
Systematic review of the effectiveness and cost-effectiveness, and economic evaluation, of home versus hospital or satellite unit haemodialysis for people with end-stage renal failure.
By Mowatt G, Vale L, Perez J, Wyness L, Fraser C, MacLeod A, *et al*.

No. 3
Systematic review and economic evaluation of the effectiveness of infliximab for the treatment of Crohn's disease.
By Clark W, Raftery J, Barton P, Song F, Fry-Smith A, Burls A.

No. 4
A review of the clinical effectiveness and cost-effectiveness of routine anti-D prophylaxis for pregnant women who are rhesus negative.
By Chilcott J, Lloyd Jones M, Wight J, Forman K, Wray J, Beverley C, *et al*.

No. 5
Systematic review and evaluation of the use of tumour markers in paediatric oncology: Ewing's sarcoma and neuroblastoma.
By Riley RD, Burchill SA, Abrams KR, Heney D, Lambert PC, Jones DR, *et al*.

No. 6
The cost-effectiveness of screening for *Helicobacter pylori* to reduce mortality and morbidity from gastric cancer and peptic ulcer disease: a discrete-event simulation model.
By Roderick P, Davies R, Raftery J, Crabbe D, Pearce R, Bhandari P, *et al*.

No. 7
The clinical effectiveness and cost-effectiveness of routine dental checks: a systematic review and economic evaluation.
By Davenport C, Elley K, Salas C, Taylor-Weetman CL, Fry-Smith A, Bryan S, *et al*.

No. 8
A multicentre randomised controlled trial assessing the costs and benefits of using structured information and analysis of women's preferences in the management of menorrhagia.
By Kennedy ADM, Sculpher MJ, Coulter A, Dwyer N, Rees M, Horsley S, *et al*.

No. 9
Clinical effectiveness and cost–utility of photodynamic therapy for wet age-related macular degeneration: a systematic review and economic evaluation.
By Meads C, Salas C, Roberts T, Moore D, Fry-Smith A, Hyde C.

No. 10
Evaluation of molecular tests for prenatal diagnosis of chromosome abnormalities.
By Grimshaw GM, Szczepura A, Hultén M, MacDonald F, Nevin NC, Sutton F, *et al*.

No. 11
First and second trimester antenatal screening for Down's syndrome: the results of the Serum, Urine and Ultrasound Screening Study (SURUSS).
By Wald NJ, Rodeck C, Hackshaw AK, Walters J, Chitty L, Mackinson AM.

No. 12
The effectiveness and cost-effectiveness of ultrasound locating devices for central venous access: a systematic review and economic evaluation.
By Calvert N, Hind D, McWilliams RG, Thomas SM, Beverley C, Davidson A.

No. 13
A systematic review of atypical antipsychotics in schizophrenia.
By Bagnall A-M, Jones L, Lewis R, Ginnelly L, Glanville J, Torgerson D, *et al*.

No. 14
Prostate Testing for Cancer and Treatment (ProtecT) feasibility study.
By Donovan J, Hamdy F, Neal D, Peters T, Oliver S, Brindle L, *et al*.

No. 15
Early thrombolysis for the treatment of acute myocardial infarction: a systematic review and economic evaluation.
By Boland A, Dundar Y, Bagust A, Haycox A, Hill R, Mujica Mota R, *et al*.

No. 16
Screening for fragile X syndrome: a literature review and modelling.
By Song FJ, Barton P, Sleightholme V, Yao GL, Fry-Smith A.

No. 17
Systematic review of endoscopic sinus surgery for nasal polyps.
By Dalziel K, Stein K, Round A, Garside R, Royle P.

No. 18
Towards efficient guidelines: how to monitor guideline use in primary care.
By Hutchinson A, McIntosh A, Cox S, Gilbert C.

No. 19
Effectiveness and cost-effectiveness of acute hospital-based spinal cord injuries services: systematic review.
By Bagnall A-M, Jones L, Richardson G, Duffy S, Riemsma R.

No. 20
Prioritisation of health technology assessment. The PATHS model: methods and case studies.
By Townsend J, Buxton M, Harper G.

No. 21
Systematic review of the clinical effectiveness and cost-effectiveness of tension-free vaginal tape for treatment of urinary stress incontinence.
By Cody J, Wyness L, Wallace S, Glazener C, Kilonzo M, Stearns S, *et al*.

No. 22
The clinical and cost-effectiveness of patient education models for diabetes: a systematic review and economic evaluation.
By Loveman E, Cave C, Green C, Royle P, Dunn N, Waugh N.

No. 23
The role of modelling in prioritising and planning clinical trials.
By Chilcott J, Brennan A, Booth A, Karnon J, Tappenden P.

No. 24
Cost–benefit evaluation of routine influenza immunisation in people 65–74 years of age.
By Allsup S, Gosney M, Haycox A, Regan M.

No. 25
The clinical and cost-effectiveness of pulsatile machine perfusion versus cold storage of kidneys for transplantation retrieved from heart-beating and non-heart-beating donors.
By Wight J, Chilcott J, Holmes M, Brewer N.

No. 26
Can randomised trials rely on existing electronic data? A feasibility study to explore the value of routine data in health technology assessment.
By Williams JG, Cheung WY, Cohen DR, Hutchings HA, Longo MF, Russell IT.

No. 27
Evaluating non-randomised intervention studies.
By Deeks JJ, Dinnes J, D'Amico R, Sowden AJ, Sakarovitch C, Song F, *et al*.

No. 28
A randomised controlled trial to assess the impact of a package comprising a patient-orientated, evidence-based self-help guidebook and patient-centred consultations on disease management and satisfaction in inflammatory bowel disease.
By Kennedy A, Nelson E, Reeves D, Richardson G, Roberts C, Robinson A, *et al*.

No. 29
The effectiveness of diagnostic tests for the assessment of shoulder pain due to soft tissue disorders: a systematic review.
By Dinnes J, Loveman E, McIntyre L, Waugh N.

No. 30
The value of digital imaging in diabetic retinopathy.
By Sharp PF, Olson J, Strachan F, Hipwell J, Ludbrook A, O'Donnell M, *et al*.

No. 31
Lowering blood pressure to prevent myocardial infarction and stroke: a new preventive strategy.
By Law M, Wald N, Morris J.

No. 32
Clinical and cost-effectiveness of capecitabine and tegafur with uracil for the treatment of metastatic colorectal cancer: systematic review and economic evaluation.
By Ward S, Kaltenthaler E, Cowan J, Brewer N.

No. 33
Clinical and cost-effectiveness of new and emerging technologies for early localised prostate cancer: a systematic review.
By Hummel S, Paisley S, Morgan A, Currie E, Brewer N.

No. 34
Literature searching for clinical and cost-effectiveness studies used in health technology assessment reports carried out for the National Institute for Clinical Excellence appraisal system.
By Royle P, Waugh N.

No. 35
Systematic review and economic decision modelling for the prevention and treatment of influenza A and B.
By Turner D, Wailoo A, Nicholson K, Cooper N, Sutton A, Abrams K.

No. 36
A randomised controlled trial to evaluate the clinical and cost-effectiveness of Hickman line insertions in adult cancer patients by nurses.
By Boland A, Haycox A, Bagust A, Fitzsimmons L.

No. 37
Redesigning postnatal care: a randomised controlled trial of protocol-based midwifery-led care focused on individual women's physical and psychological health needs.
By MacArthur C, Winter HR, Bick DE, Lilford RJ, Lancashire RJ, Knowles H, *et al*.

No. 38
Estimating implied rates of discount in healthcare decision-making.
By West RR, McNabb R, Thompson AGH, Sheldon TA, Grimley Evans J.

No. 39
Systematic review of isolation policies in the hospital management of methicillin-resistant *Staphylococcus aureus*: a review of the literature with epidemiological and economic modelling.
By Cooper BS, Stone SP, Kibbler CC, Cookson BD, Roberts JA, Medley GF, *et al*.

No. 40
Treatments for spasticity and pain in multiple sclerosis: a systematic review.
By Beard S, Hunn A, Wight J.

No. 41
The inclusion of reports of randomised trials published in languages other than English in systematic reviews.
By Moher D, Pham B, Lawson ML, Klassen TP.

No. 42
The impact of screening on future health-promoting behaviours and health beliefs: a systematic review.
By Bankhead CR, Brett J, Bukach C, Webster P, Stewart-Brown S, Munafo M, *et al*.

Volume 8, 2004

No. 1
What is the best imaging strategy for acute stroke?
By Wardlaw JM, Keir SL, Seymour J, Lewis S, Sandercock PAG, Dennis MS, *et al*.

No. 2
Systematic review and modelling of the investigation of acute and chronic chest pain presenting in primary care.
By Mant J, McManus RJ, Oakes RAL, Delaney BC, Barton PM, Deeks JJ, *et al*.

No. 3
The effectiveness and cost-effectiveness of microwave and thermal balloon endometrial ablation for heavy menstrual bleeding: a systematic review and economic modelling.
By Garside R, Stein K, Wyatt K, Round A, Price A.

No. 4
A systematic review of the role of bisphosphonates in metastatic disease.
By Ross JR, Saunders Y, Edmonds PM, Patel S, Wonderling D, Normand C, *et al*.

No. 5
Systematic review of the clinical effectiveness and cost-effectiveness of capecitabine (Xeloda®) for locally advanced and/or metastatic breast cancer.
By Jones L, Hawkins N, Westwood M, Wright K, Richardson G, Riemsma R.

No. 6
Effectiveness and efficiency of guideline dissemination and implementation strategies.
By Grimshaw JM, Thomas RE, MacLennan G, Fraser C, Ramsay CR, Vale L, *et al*.

No. 7
Clinical effectiveness and costs of the Sugarbaker procedure for the treatment of pseudomyxoma peritonei.
By Bryant J, Clegg AJ, Sidhu MK, Brodin H, Royle P, Davidson P.

No. 8
Psychological treatment for insomnia in the regulation of long-term hypnotic drug use.
By Morgan K, Dixon S, Mathers N, Thompson J, Tomeny M.

No. 9
Improving the evaluation of therapeutic interventions in multiple sclerosis: development of a patient-based measure of outcome.
By Hobart JC, Riazi A, Lamping DL, Fitzpatrick R, Thompson AJ.

No. 10
A systematic review and economic evaluation of magnetic resonance cholangiopancreatography compared with diagnostic endoscopic retrograde cholangiopancreatography.
By Kaltenthaler E, Bravo Vergel Y, Chilcott J, Thomas S, Blakeborough T, Walters SJ, *et al*.

No. 11
The use of modelling to evaluate new drugs for patients with a chronic condition: the case of antibodies against tumour necrosis factor in rheumatoid arthritis.
By Barton P, Jobanputra P, Wilson J, Bryan S, Burls A.

No. 12
Clinical effectiveness and cost-effectiveness of neonatal screening for inborn errors of metabolism using tandem mass spectrometry: a systematic review.
By Pandor A, Eastham J, Beverley C, Chilcott J, Paisley S.

No. 13
Clinical effectiveness and cost-effectiveness of pioglitazone and rosiglitazone in the treatment of type 2 diabetes: a systematic review and economic evaluation.
By Czoski-Murray C, Warren E, Chilcott J, Beverley C, Psyllaki MA, Cowan J.

No. 14
Routine examination of the newborn: the EMREN study. Evaluation of an extension of the midwife role including a randomised controlled trial of appropriately trained midwives and paediatric senior house officers.
By Townsend J, Wolke D, Hayes J, Davé S, Rogers C, Bloomfield L, *et al*.

No. 15
Involving consumers in research and development agenda setting for the NHS: developing an evidence-based approach.
By Oliver S, Clarke-Jones L, Rees R, Milne R, Buchanan P, Gabbay J, *et al*.

No. 16
A multi-centre randomised controlled trial of minimally invasive direct coronary bypass grafting versus percutaneous transluminal coronary angioplasty with stenting for proximal stenosis of the left anterior descending coronary artery.
By Reeves BC, Angelini GD, Bryan AJ, Taylor FC, Cripps T, Spyt TJ, *et al*.

No. 17
Does early magnetic resonance imaging influence management or improve outcome in patients referred to secondary care with low back pain? A pragmatic randomised controlled trial.
By Gilbert FJ, Grant AM, Gillan MGC, Vale L, Scott NW, Campbell MK, *et al*.

No. 18
The clinical and cost-effectiveness of anakinra for the treatment of rheumatoid arthritis in adults: a systematic review and economic analysis.
By Clark W, Jobanputra P, Barton P, Burls A.

No. 19
A rapid and systematic review and economic evaluation of the clinical and cost-effectiveness of newer drugs for treatment of mania associated with bipolar affective disorder.
By Bridle C, Palmer S, Bagnall A-M, Darba J, Duffy S, Sculpher M, *et al*.

No. 20
Liquid-based cytology in cervical screening: an updated rapid and systematic review and economic analysis.
By Karnon J, Peters J, Platt J, Chilcott J, McGoogan E, Brewer N.

No. 21
Systematic review of the long-term effects and economic consequences of treatments for obesity and implications for health improvement.
By Avenell A, Broom J, Brown TJ, Poobalan A, Aucott L, Stearns SC, *et al*.

No. 22
Autoantibody testing in children with newly diagnosed type 1 diabetes mellitus.
By Dretzke J, Cummins C, Sandercock J, Fry-Smith A, Barrett T, Burls A.

No. 23
Clinical effectiveness and cost-effectiveness of prehospital intravenous fluids in trauma patients.
By Dretzke J, Sandercock J, Bayliss S, Burls A.

No. 24
Newer hypnotic drugs for the short-term management of insomnia: a systematic review and economic evaluation.
By Dündar Y, Boland A, Strobl J, Dodd S, Haycox A, Bagust A, *et al*.

No. 25
Development and validation of methods for assessing the quality of diagnostic accuracy studies.
By Whiting P, Rutjes AWS, Dinnes J, Reitsma JB, Bossuyt PMM, Kleijnen J.

No. 26
EVALUATE hysterectomy trial: a multicentre randomised trial comparing abdominal, vaginal and laparoscopic methods of hysterectomy.
By Garry R, Fountain J, Brown J, Manca A, Mason S, Sculpher M, *et al*.

No. 27
Methods for expected value of information analysis in complex health economic models: developments on the health economics of interferon-β and glatiramer acetate for multiple sclerosis.
By Tappenden P, Chilcott JB, Eggington S, Oakley J, McCabe C.

No. 28
Effectiveness and cost-effectiveness of imatinib for first-line treatment of chronic myeloid leukaemia in chronic phase: a systematic review and economic analysis.
By Dalziel K, Round A, Stein K, Garside R, Price A.

No. 29
VenUS I: a randomised controlled trial of two types of bandage for treating venous leg ulcers.
By Iglesias C, Nelson EA, Cullum NA, Torgerson DJ on behalf of the VenUS Team.

No. 30
Systematic review of the effectiveness and cost-effectiveness, and economic evaluation, of myocardial perfusion scintigraphy for the diagnosis and management of angina and myocardial infarction.
By Mowatt G, Vale L, Brazzelli M, Hernandez R, Murray A, Scott N, *et al*.

No. 31
A pilot study on the use of decision theory and value of information analysis as part of the NHS Health Technology Assessment programme.
By Claxton K, Ginnelly L, Sculpher M, Philips Z, Palmer S.

No. 32
The Social Support and Family Health Study: a randomised controlled trial and economic evaluation of two alternative forms of postnatal support for mothers living in disadvantaged inner-city areas.
By Wiggins M, Oakley A, Roberts I, Turner H, Rajan L, Austerberry H, *et al*.

No. 33
Psychosocial aspects of genetic screening of pregnant women and newborns: a systematic review.
By Green JM, Hewison J, Bekker HL, Bryant, Cuckle HS.

No. 34
Evaluation of abnormal uterine bleeding: comparison of three outpatient procedures within cohorts defined by age and menopausal status.
By Critchley HOD, Warner P, Lee AJ, Brechin S, Guise J, Graham B.

No. 35
Coronary artery stents: a rapid systematic review and economic evaluation.
By Hill R, Bagust A, Bakhai A, Dickson R, Dündar Y, Haycox A, *et al*.

No. 36
Review of guidelines for good practice in decision-analytic modelling in health technology assessment.
By Philips Z, Ginnelly L, Sculpher M, Claxton K, Golder S, Riemsma R, *et al*.

No. 37
Rituximab (MabThera®) for aggressive non-Hodgkin's lymphoma: systematic review and economic evaluation.
By Knight C, Hind D, Brewer N, Abbott V.

No. 38
Clinical effectiveness and cost-effectiveness of clopidogrel and modified-release dipyridamole in the secondary prevention of occlusive vascular events: a systematic review and economic evaluation.
By Jones L, Griffin S, Palmer S, Main C, Orton V, Sculpher M, *et al.*

No. 39
Pegylated interferon α-2a and -2b in combination with ribavirin in the treatment of chronic hepatitis C: a systematic review and economic evaluation.
By Shepherd J, Brodin H, Cave C, Waugh N, Price A, Gabbay J.

No. 40
Clopidogrel used in combination with aspirin compared with aspirin alone in the treatment of non-ST-segment-elevation acute coronary syndromes: a systematic review and economic evaluation.
By Main C, Palmer S, Griffin S, Jones L, Orton V, Sculpher M, *et al.*

No. 41
Provision, uptake and cost of cardiac rehabilitation programmes: improving services to under-represented groups.
By Beswick AD, Rees K, Griebsch I, Taylor FC, Burke M, West RR, *et al.*

No. 42
Involving South Asian patients in clinical trials.
By Hussain-Gambles M, Leese B, Atkin K, Brown J, Mason S, Tovey P.

No. 43
Clinical and cost-effectiveness of continuous subcutaneous insulin infusion for diabetes.
By Colquitt JL, Green C, Sidhu MK, Hartwell D, Waugh N.

No. 44
Identification and assessment of ongoing trials in health technology assessment reviews.
By Song FJ, Fry-Smith A, Davenport C, Bayliss S, Adi Y, Wilson JS, *et al*.

No. 45
Systematic review and economic evaluation of a long-acting insulin analogue, insulin glargine
By Warren E, Weatherley-Jones E, Chilcott J, Beverley C.

No. 46
Supplementation of a home-based exercise programme with a class-based programme for people with osteoarthritis of the knees: a randomised controlled trial and health economic analysis.
By McCarthy CJ, Mills PM, Pullen R, Richardson G, Hawkins N, Roberts CR, *et al*.

No. 47
Clinical and cost-effectiveness of once-daily versus more frequent use of same potency topical corticosteroids for atopic eczema: a systematic review and economic evaluation.
By Green C, Colquitt JL, Kirby J, Davidson P, Payne E.

No. 48
Acupuncture of chronic headache disorders in primary care: randomised controlled trial and economic analysis.
By Vickers AJ, Rees RW, Zollman CE, McCarney R, Smith CM, Ellis N, *et al*.

No. 49
Generalisability in economic evaluation studies in healthcare: a review and case studies.
By Sculpher MJ, Pang FS, Manca A, Drummond MF, Golder S, Urdahl H, *et al*.

No. 50
Virtual outreach: a randomised controlled trial and economic evaluation of joint teleconferenced medical consultations.
By Wallace P, Barber J, Clayton W, Currell R, Fleming K, Garner P, *et al*.

Volume 9, 2005

No. 1
Randomised controlled multiple treatment comparison to provide a cost-effectiveness rationale for the selection of antimicrobial therapy in acne.
By Ozolins M, Eady EA, Avery A, Cunliffe WJ, O'Neill C, Simpson NB, *et al*.

No. 2
Do the findings of case series studies vary significantly according to methodological characteristics?
By Dalziel K, Round A, Stein K, Garside R, Castelnuovo E, Payne L.

No. 3
Improving the referral process for familial breast cancer genetic counselling: findings of three randomised controlled trials of two interventions.
By Wilson BJ, Torrance N, Mollison J, Wordsworth S, Gray JR, Haites NE, *et al*.

No. 4
Randomised evaluation of alternative electrosurgical modalities to treat bladder outflow obstruction in men with benign prostatic hyperplasia.
By Fowler C, McAllister W, Plail R, Karim O, Yang Q.

No. 5
A pragmatic randomised controlled trial of the cost-effectiveness of palliative therapies for patients with inoperable oesophageal cancer.
By Shenfine J, McNamee P, Steen N, Bond J, Griffin SM.

No. 6
Impact of computer-aided detection prompts on the sensitivity and specificity of screening mammography.
By Taylor P, Champness J, Given-Wilson R, Johnston K, Potts H.

No. 7
Issues in data monitoring and interim analysis of trials.
By Grant AM, Altman DG, Babiker AB, Campbell MK, Clemens FJ, Darbyshire JH, *et al*.

No. 8
Lay public's understanding of equipoise and randomisation in randomised controlled trials.
By Robinson EJ, Kerr CEP, Stevens AJ, Lilford RJ, Braunholtz DA, Edwards SJ, *et al*.

No. 9
Clinical and cost-effectiveness of electroconvulsive therapy for depressive illness, schizophrenia, catatonia and mania: systematic reviews and economic modelling studies.
By Greenhalgh J, Knight C, Hind D, Beverley C, Walters S.

No. 10
Measurement of health-related quality of life for people with dementia: development of a new instrument (DEMQOL) and an evaluation of current methodology.
By Smith SC, Lamping DL, Banerjee S, Harwood R, Foley B, Smith P, *et al*.

No. 11
Clinical effectiveness and cost-effectiveness of drotrecogin alfa (activated) (Xigris®) for the treatment of severe sepsis in adults: a systematic review and economic evaluation.
By Green C, Dinnes J, Takeda A, Shepherd J, Hartwell D, Cave C, *et al*.

No. 12
A methodological review of how heterogeneity has been examined in systematic reviews of diagnostic test accuracy.
By Dinnes J, Deeks J, Kirby J, Roderick P.

No. 13
Cervical screening programmes: can automation help? Evidence from systematic reviews, an economic analysis and a simulation modelling exercise applied to the UK.
By Willis BH, Barton P, Pearmain P, Bryan S, Hyde C.

No. 14
Laparoscopic surgery for inguinal hernia repair: systematic review of effectiveness and economic evaluation.
By McCormack K, Wake B, Perez J, Fraser C, Cook J, McIntosh E, *et al*.

No. 15
Clinical effectiveness, tolerability and cost-effectiveness of newer drugs for epilepsy in adults: a systematic review and economic evaluation.
By Wilby J, Kainth A, Hawkins N, Epstein D, McIntosh H, McDaid C, *et al*.

No. 16
A randomised controlled trial to compare the cost-effectiveness of tricyclic antidepressants, selective serotonin reuptake inhibitors and lofepramine.
By Peveler R, Kendrick T, Buxton M, Longworth L, Baldwin D, Moore M, *et al*.

No. 17
Clinical effectiveness and cost-effectiveness of immediate angioplasty for acute myocardial infarction: systematic review and economic evaluation.
By Hartwell D, Colquitt J, Loveman E, Clegg AJ, Brodin H, Waugh N, *et al*.

No. 18
A randomised controlled comparison of alternative strategies in stroke care.
By Kalra L, Evans A, Perez I, Knapp M, Swift C, Donaldson N.

No. 19
The investigation and analysis of critical incidents and adverse events in healthcare.
By Woloshynowych M, Rogers S, Taylor-Adams S, Vincent C.

No. 20
Potential use of routine databases in health technology assessment.
By Raftery J, Roderick P, Stevens A.

No. 21
Clinical and cost-effectiveness of newer immunosuppressive regimens in renal transplantation: a systematic review and modelling study.
By Woodroffe R, Yao GL, Meads C, Bayliss S, Ready A, Raftery J, *et al*.

No. 22
A systematic review and economic evaluation of alendronate, etidronate, risedronate, raloxifene and teriparatide for the prevention and treatment of postmenopausal osteoporosis.
By Stevenson M, Lloyd Jones M, De Nigris E, Brewer N, Davis S, Oakley J.

No. 23
A systematic review to examine the impact of psycho-educational interventions on health outcomes and costs in adults and children with difficult asthma.
By Smith JR, Mugford M, Holland R, Candy B, Noble MJ, Harrison BDW, *et al*.

No. 24
An evaluation of the costs, effectiveness and quality of renal replacement therapy provision in renal satellite units in England and Wales.
By Roderick P, Nicholson T, Armitage A, Mehta R, Mullee M, Gerard K, *et al*.

No. 25
Imatinib for the treatment of patients with unresectable and/or metastatic gastrointestinal stromal tumours: systematic review and economic evaluation.
By Wilson J, Connock M, Song F, Yao G, Fry-Smith A, Raftery J, *et al*.

No. 26
Indirect comparisons of competing interventions.
By Glenny AM, Altman DG, Song F, Sakarovitch C, Deeks JJ, D'Amico R, *et al*.

No. 27
Cost-effectiveness of alternative strategies for the initial medical management of non-ST elevation acute coronary syndrome: systematic review and decision-analytical modelling.
By Robinson M, Palmer S, Sculpher M, Philips Z, Ginnelly L, Bowens A, *et al*.

No. 28
Outcomes of electrically stimulated gracilis neosphincter surgery.
By Tillin T, Chambers M, Feldman R.

No. 29
The effectiveness and cost-effectiveness of pimecrolimus and tacrolimus for atopic eczema: a systematic review and economic evaluation.
By Garside R, Stein K, Castelnuovo E, Pitt M, Ashcroft D, Dimmock P, *et al*.

No. 30
Systematic review on urine albumin testing for early detection of diabetic complications.
By Newman DJ, Mattock MB, Dawnay ABS, Kerry S, McGuire A, Yaqoob M, *et al*.

No. 31
Randomised controlled trial of the cost-effectiveness of water-based therapy for lower limb osteoarthritis.
By Cochrane T, Davey RC, Matthes Edwards SM.

No. 32
Longer term clinical and economic benefits of offering acupuncture care to patients with chronic low back pain.
By Thomas KJ, MacPherson H, Ratcliffe J, Thorpe L, Brazier J, Campbell M, *et al*.

No. 33
Cost-effectiveness and safety of epidural steroids in the management of sciatica.
By Price C, Arden N, Coglan L, Rogers P.

No. 34
The British Rheumatoid Outcome Study Group (BROSG) randomised controlled trial to compare the effectiveness and cost-effectiveness of aggressive versus symptomatic therapy in established rheumatoid arthritis.
By Symmons D, Tricker K, Roberts C, Davies L, Dawes P, Scott DL.

No. 35
Conceptual framework and systematic review of the effects of participants' and professionals' preferences in randomised controlled trials.
By King M, Nazareth I, Lampe F, Bower P, Chandler M, Morou M, *et al*.

No. 36
The clinical and cost-effectiveness of implantable cardioverter defibrillators: a systematic review.
By Bryant J, Brodin H, Loveman E, Payne E, Clegg A.

No. 37
A trial of problem-solving by community mental health nurses for anxiety, depression and life difficulties among general practice patients. The CPN-GP study.
By Kendrick T, Simons L, Mynors-Wallis L, Gray A, Lathlean J, Pickering R, *et al*.

No. 38
The causes and effects of socio-demographic exclusions from clinical trials.
By Bartlett C, Doyal L, Ebrahim S, Davey P, Bachmann M, Egger M, *et al*.

No. 39
Is hydrotherapy cost-effective? A randomised controlled trial of combined hydrotherapy programmes compared with physiotherapy land techniques in children with juvenile idiopathic arthritis.
By Epps H, Ginnelly L, Utley M, Southwood T, Gallivan S, Sculpher M, *et al*.

No. 40
A randomised controlled trial and cost-effectiveness study of systematic screening (targeted and total population screening) versus routine practice for the detection of atrial fibrillation in people aged 65 and over. The SAFE study.
By Hobbs FDR, Fitzmaurice DA, Mant J, Murray E, Jowett S, Bryan S, *et al*.

No. 41
Displaced intracapsular hip fractures in fit, older people: a randomised comparison of reduction and fixation, bipolar hemiarthroplasty and total hip arthroplasty.
By Keating JF, Grant A, Masson M, Scott NW, Forbes JF.

No. 42
Long-term outcome of cognitive behaviour therapy clinical trials in central Scotland.
By Durham RC, Chambers JA, Power KG, Sharp DM, Macdonald RR, Major KA, *et al*.

No. 43
The effectiveness and cost-effectiveness of dual-chamber pacemakers compared with single-chamber pacemakers for bradycardia due to atrioventricular block or sick sinus syndrome: systematic review and economic evaluation.
By Castelnuovo E, Stein K, Pitt M, Garside R, Payne E.

No. 44
Newborn screening for congenital heart defects: a systematic review and cost-effectiveness analysis.
By Knowles R, Griebsch I, Dezateux C, Brown J, Bull C, Wren C.

No. 45
The clinical and cost-effectiveness of left ventricular assist devices for end-stage heart failure: a systematic review and economic evaluation.
By Clegg AJ, Scott DA, Loveman E, Colquitt J, Hutchinson J, Royle P, *et al*.

No. 46
The effectiveness of the Heidelberg Retina Tomograph and laser diagnostic glaucoma scanning system (GDx) in detecting and monitoring glaucoma.
By Kwartz AJ, Henson DB, Harper RA, Spencer AF, McLeod D.

No. 47
Clinical and cost-effectiveness of autologous chondrocyte implantation for cartilage defects in knee joints: systematic review and economic evaluation.
By Clar C, Cummins E, McIntyre L, Thomas S, Lamb J, Bain L, *et al*.

No. 48
Systematic review of effectiveness of different treatments for childhood retinoblastoma.
By McDaid C, Hartley S, Bagnall A-M, Ritchie G, Light K, Riemsma R.

No. 49
Towards evidence-based guidelines for the prevention of venous thromboembolism: systematic reviews of mechanical methods, oral anticoagulation, dextran and regional anaesthesia as thromboprophylaxis.
By Roderick P, Ferris G, Wilson K, Halls H, Jackson D, Collins R, *et al*.

No. 50
The effectiveness and cost-effectiveness of parent training/education programmes for the treatment of conduct disorder, including oppositional defiant disorder, in children.
By Dretzke J, Frew E, Davenport C, Barlow J, Stewart-Brown S, Sandercock J, *et al*.

Volume 10, 2006

No. 1
The clinical and cost-effectiveness of donepezil, rivastigmine, galantamine and memantine for Alzheimer's disease.
By Loveman E, Green C, Kirby J, Takeda A, Picot J, Payne E, *et al*.

No. 2
FOOD: a multicentre randomised trial evaluating feeding policies in patients admitted to hospital with a recent stroke.
By Dennis M, Lewis S, Cranswick G, Forbes J.

No. 3
The clinical effectiveness and cost-effectiveness of computed tomography screening for lung cancer: systematic reviews.
By Black C, Bagust A, Boland A, Walker S, McLeod C, De Verteuil R, *et al*.

No. 4
A systematic review of the effectiveness and cost-effectiveness of neuroimaging assessments used to visualise the seizure focus in people with refractory epilepsy being considered for surgery.
By Whiting P, Gupta R, Burch J, Mujica Mota RE, Wright K, Marson A, *et al*.

No. 5
Comparison of conference abstracts and presentations with full-text articles in the health technology assessments of rapidly evolving technologies.
By Dundar Y, Dodd S, Dickson R, Walley T, Haycox A, Williamson PR.

No. 6
Systematic review and evaluation of methods of assessing urinary incontinence.
By Martin JL, Williams KS, Abrams KR, Turner DA, Sutton AJ, Chapple C, *et al*.

No. 7
The clinical effectiveness and cost-effectiveness of newer drugs for children with epilepsy. A systematic review.
By Connock M, Frew E, Evans B-W, Bryan S, Cummins C, Fry-Smith A, *et al*.

No. 8
Surveillance of Barrett's oesophagus: exploring the uncertainty through systematic review, expert workshop and economic modelling.
By Garside R, Pitt M, Somerville M, Stein K, Price A, Gilbert N.

No. 9
Topotecan, pegylated liposomal doxorubicin hydrochloride and paclitaxel for second-line or subsequent treatment of advanced ovarian cancer: a systematic review and economic evaluation.
By Main C, Bojke L, Griffin S, Norman G, Barbieri M, Mather L, *et al*.

No. 10
Evaluation of molecular techniques in prediction and diagnosis of cytomegalovirus disease in immunocompromised patients.
By Szczepura A, Westmoreland D, Vinogradova Y, Fox J, Clark M.

No. 11
Screening for thrombophilia in high-risk situations: systematic review and cost-effectiveness analysis. The Thrombosis: Risk and Economic Assessment of Thrombophilia Screening (TREATS) study.
By Wu O, Robertson L, Twaddle S, Lowe GDO, Clark P, Greaves M, *et al*.

No. 12
A series of systematic reviews to inform a decision analysis for sampling and treating infected diabetic foot ulcers.
By Nelson EA, O'Meara S, Craig D, Iglesias C, Golder S, Dalton J, *et al*.

No. 13
Randomised clinical trial, observational study and assessment of cost-effectiveness of the treatment of varicose veins (REACTIV trial).
By Michaels JA, Campbell WB, Brazier JE, MacIntyre JB, Palfreyman SJ, Ratcliffe J, *et al*.

No. 14
The cost-effectiveness of screening for oral cancer in primary care.
By Speight PM, Palmer S, Moles DR, Downer MC, Smith DH, Henriksson M *et al*.

No. 15
Measurement of the clinical and cost-effectiveness of non-invasive diagnostic testing strategies for deep vein thrombosis.
By Goodacre S, Sampson F, Stevenson M, Wailoo A, Sutton A, Thomas S, *et al*.

No. 16
Systematic review of the effectiveness and cost-effectiveness of HealOzone® for the treatment of occlusal pit/fissure caries and root caries.
By Brazzelli M, McKenzie L, Fielding S, Fraser C, Clarkson J, Kilonzo M, *et al*.

No. 17
Randomised controlled trials of conventional antipsychotic versus new atypical drugs, and new atypical drugs versus clozapine, in people with schizophrenia responding poorly to, or intolerant of, current drug treatment.
By Lewis SW, Davies L, Jones PB, Barnes TRE, Murray RM, Kerwin R, *et al*.

No. 18
Diagnostic tests and algorithms used in the investigation of haematuria: systematic reviews and economic evaluation.
By Rodgers M, Nixon J, Hempel S, Aho T, Kelly J, Neal D, *et al*.

No. 19
Cognitive behavioural therapy in addition to antispasmodic therapy for irritable bowel syndrome in primary care: randomised controlled trial.
By Kennedy TM, Chalder T, McCrone P, Darnley S, Knapp M, Jones RH, *et al*.

No. 20
A systematic review of the clinical effectiveness and cost-effectiveness of enzyme replacement therapies for Fabry's disease and mucopolysaccharidosis type 1.
By Connock M, Juarez-Garcia A, Frew E, Mans A, Dretzke J, Fry-Smith A, *et al*.

No. 21
Health benefits of antiviral therapy for mild chronic hepatitis C: randomised controlled trial and economic evaluation.
By Wright M, Grieve R, Roberts J, Main J, Thomas HC on behalf of the UK Mild Hepatitis C Trial Investigators.

No. 22
Pressure relieving support surfaces: a randomised evaluation.
By Nixon J, Nelson EA, Cranny G, Iglesias CP, Hawkins K, Cullum NA, *et al*.

No. 23
A systematic review and economic model of the effectiveness and cost-effectiveness of methylphenidate, dexamfetamine and atomoxetine for the treatment of attention deficit hyperactivity disorder in children and adolescents.
By King S, Griffin S, Hodges Z, Weatherly H, Asseburg C, Richardson G, *et al*.

No. 24
The clinical effectiveness and cost-effectiveness of enzyme replacement therapy for Gaucher's disease: a systematic review.
By Connock M, Burls A, Frew E, Fry-Smith A, Juarez-Garcia A, McCabe C, *et al*.

No. 25
Effectiveness and cost-effectiveness of salicylic acid and cryotherapy for cutaneous warts. An economic decision model.
By Thomas KS, Keogh-Brown MR, Chalmers JR, Fordham RJ, Holland RC, Armstrong SJ, *et al*.

No. 26
A systematic literature review of the effectiveness of non-pharmacological interventions to prevent wandering in dementia and evaluation of the ethical implications and acceptability of their use.
By Robinson L, Hutchings D, Corner L, Beyer F, Dickinson H, Vanoli A, *et al*.

No. 27
A review of the evidence on the effects and costs of implantable cardioverter defibrillator therapy in different patient groups, and modelling of cost-effectiveness and cost–utility for these groups in a UK context.
By Buxton M, Caine N, Chase D, Connelly D, Grace A, Jackson C, *et al*.

No. 28
Adefovir dipivoxil and pegylated interferon alfa-2a for the treatment of chronic hepatitis B: a systematic review and economic evaluation.
By Shepherd J, Jones J, Takeda A, Davidson P, Price A.

No. 29
An evaluation of the clinical and cost-effectiveness of pulmonary artery catheters in patient management in intensive care: a systematic review and a randomised controlled trial.
By Harvey S, Stevens K, Harrison D, Young D, Brampton W, McCabe C, *et al*.

No. 30
Accurate, practical and cost-effective assessment of carotid stenosis in the UK.
By Wardlaw JM, Chappell FM, Stevenson M, De Nigris E, Thomas S, Gillard J, *et al*.

No. 31
Etanercept and infliximab for the treatment of psoriatic arthritis: a systematic review and economic evaluation.
By Woolacott N, Bravo Vergel Y, Hawkins N, Kainth A, Khadjesari Z, Misso K, *et al*.

No. 32
The cost-effectiveness of testing for hepatitis C in former injecting drug users.
By Castelnuovo E, Thompson-Coon J, Pitt M, Cramp M, Siebert U, Price A, *et al*.

No. 33
Computerised cognitive behaviour therapy for depression and anxiety update: a systematic review and economic evaluation.
By Kaltenthaler E, Brazier J, De Nigris E, Tumur I, Ferriter M, Beverley C, *et al*.

No. 34
Cost-effectiveness of using prognostic information to select women with breast cancer for adjuvant systemic therapy.
By Williams C, Brunskill S, Altman D, Briggs A, Campbell H, Clarke M, *et al*.

No. 35
Psychological therapies including dialectical behaviour therapy for borderline personality disorder: a systematic review and preliminary economic evaluation.
By Brazier J, Tumur I, Holmes M, Ferriter M, Parry G, Dent-Brown K, *et al*.

No. 36
Clinical effectiveness and cost-effectiveness of tests for the diagnosis and investigation of urinary tract infection in children: a systematic review and economic model.
By Whiting P, Westwood M, Bojke L, Palmer S, Richardson G, Cooper J, *et al*.

No. 37
Cognitive behavioural therapy in chronic fatigue syndrome: a randomised controlled trial of an outpatient group programme.
By O'Dowd H, Gladwell P, Rogers CA, Hollinghurst S, Gregory A.

No. 38
A comparison of the cost-effectiveness of five strategies for the prevention of non-steroidal anti-inflammatory drug-induced gastrointestinal toxicity: a systematic review with economic modelling.
By Brown TJ, Hooper L, Elliott RA, Payne K, Webb R, Roberts C, *et al*.

No. 39
The effectiveness and cost-effectiveness of computed tomography screening for coronary artery disease: systematic review.
By Waugh N, Black C, Walker S, McIntyre L, Cummins E, Hillis G.

No. 40
What are the clinical outcome and cost-effectiveness of endoscopy undertaken by nurses when compared with doctors? A Multi-Institution Nurse Endoscopy Trial (MINuET).
By Williams J, Russell I, Durai D, Cheung W-Y, Farrin A, Bloor K, *et al*.

No. 41
The clinical and cost-effectiveness of oxaliplatin and capecitabine for the adjuvant treatment of colon cancer: systematic review and economic evaluation.
By Pandor A, Eggington S, Paisley S, Tappenden P, Sutcliffe P.

No. 42
A systematic review of the effectiveness of adalimumab, etanercept and infliximab for the treatment of rheumatoid arthritis in adults and an economic evaluation of their cost-effectiveness.
By Chen Y-F, Jobanputra P, Barton P, Jowett S, Bryan S, Clark W, *et al*.

No. 43
Telemedicine in dermatology: a randomised controlled trial.
By Bowns IR, Collins K, Walters SJ, McDonagh AJG.

No. 44
Cost-effectiveness of cell salvage and alternative methods of minimising perioperative allogeneic blood transfusion: a systematic review and economic model.
By Davies L, Brown TJ, Haynes S, Payne K, Elliott RA, McCollum C.

No. 45
Clinical effectiveness and cost-effectiveness of laparoscopic surgery for colorectal cancer: systematic reviews and economic evaluation.
By Murray A, Lourenco T, de Verteuil R, Hernandez R, Fraser C, McKinley A, *et al*.

No. 46
Etanercept and efalizumab for the treatment of psoriasis: a systematic review.
By Woolacott N, Hawkins N, Mason A, Kainth A, Khadjesari Z, Bravo Vergel Y, *et al*.

No. 47
Systematic reviews of clinical decision tools for acute abdominal pain.
By Liu JLY, Wyatt JC, Deeks JJ, Clamp S, Keen J, Verde P, *et al*.

No. 48
Evaluation of the ventricular assist device programme in the UK.
By Sharples L, Buxton M, Caine N, Cafferty F, Demiris N, Dyer M, *et al*.

No. 49
A systematic review and economic model of the clinical and cost-effectiveness of immunosuppressive therapy for renal transplantation in children.
By Yao G, Albon E, Adi Y, Milford D, Bayliss S, Ready A, *et al*.

No. 50
Amniocentesis results: investigation of anxiety. The ARIA trial.
By Hewison J, Nixon J, Fountain J, Cocks K, Jones C, Mason G, *et al*.

Volume 11, 2007

No. 1
Pemetrexed disodium for the treatment of malignant pleural mesothelioma: a systematic review and economic evaluation.
By Dundar Y, Bagust A, Dickson R, Dodd S, Green J, Haycox A, *et al*.

No. 2
A systematic review and economic model of the clinical effectiveness and cost-effectiveness of docetaxel in combination with prednisone or prednisolone for the treatment of hormone-refractory metastatic prostate cancer.
By Collins R, Fenwick E, Trowman R, Perard R, Norman G, Light K, *et al*.

No. 3
A systematic review of rapid diagnostic tests for the detection of tuberculosis infection.
By Dinnes J, Deeks J, Kunst H, Gibson A, Cummins E, Waugh N, *et al*.

No. 4
The clinical effectiveness and cost-effectiveness of strontium ranelate for the prevention of osteoporotic fragility fractures in postmenopausal women.
By Stevenson M, Davis S, Lloyd-Jones M, Beverley C.

No. 5
A systematic review of quantitative and qualitative research on the role and effectiveness of written information available to patients about individual medicines.
By Raynor DK, Blenkinsopp A, Knapp P, Grime J, Nicolson DJ, Pollock K, *et al*.

No. 6
Oral naltrexone as a treatment for relapse prevention in formerly opioid-dependent drug users: a systematic review and economic evaluation.
By Adi Y, Juarez-Garcia A, Wang D, Jowett S, Frew E, Day E, *et al*.

No. 7
Glucocorticoid-induced osteoporosis: a systematic review and cost–utility analysis.
By Kanis JA, Stevenson M, McCloskey EV, Davis S, Lloyd-Jones M.

No. 8
Epidemiological, social, diagnostic and economic evaluation of population screening for genital chlamydial infection.
By Low N, McCarthy A, Macleod J, Salisbury C, Campbell R, Roberts TE, *et al*.

No. 9
Methadone and buprenorphine for the management of opioid dependence: a systematic review and economic evaluation.
By Connock M, Juarez-Garcia A, Jowett S, Frew E, Liu Z, Taylor RJ, *et al*.

No. 10
Exercise Evaluation Randomised Trial (EXERT): a randomised trial comparing GP referral for leisure centre-based exercise, community-based walking and advice only.
By Isaacs AJ, Critchley JA, See Tai S, Buckingham K, Westley D, Harridge SDR, *et al*.

No. 11
Interferon alfa (pegylated and non-pegylated) and ribavirin for the treatment of mild chronic hepatitis C: a systematic review and economic evaluation.
By Shepherd J, Jones J, Hartwell D, Davidson P, Price A, Waugh N.

No. 12
Systematic review and economic evaluation of bevacizumab and cetuximab for the treatment of metastatic colorectal cancer.
By Tappenden P, Jones R, Paisley S, Carroll C.

No. 13
A systematic review and economic evaluation of epoetin alfa, epoetin beta and darbepoetin alfa in anaemia associated with cancer, especially that attributable to cancer treatment.
By Wilson J, Yao GL, Raftery J, Bohlius J, Brunskill S, Sandercock J, *et al*.

No. 14
A systematic review and economic evaluation of statins for the prevention of coronary events.
By Ward S, Lloyd Jones M, Pandor A, Holmes M, Ara R, Ryan A, *et al*.

No. 15
A systematic review of the effectiveness and cost-effectiveness of different models of community-based respite care for frail older people and their carers.
By Mason A, Weatherly H, Spilsbury K, Arksey H, Golder S, Adamson J, *et al*.

No. 16
Additional therapy for young children with spastic cerebral palsy: a randomised controlled trial.
By Weindling AM, Cunningham CC, Glenn SM, Edwards RT, Reeves DJ.

No. 17
Screening for type 2 diabetes: literature review and economic modelling.
By Waugh N, Scotland G, McNamee P, Gillett M, Brennan A, Goyder E, *et al*.

No. 18
The effectiveness and cost-effectiveness of cinacalcet for secondary hyperparathyroidism in end-stage renal disease patients on dialysis: a systematic review and economic evaluation.
By Garside R, Pitt M, Anderson R, Mealing S, Roome C, Snaith A, *et al*.

No. 19
The clinical effectiveness and cost-effectiveness of gemcitabine for metastatic breast cancer: a systematic review and economic evaluation.
By Takeda AL, Jones J, Loveman E, Tan SC, Clegg AJ.

No. 20
A systematic review of duplex ultrasound, magnetic resonance angiography and computed tomography angiography for the diagnosis and assessment of symptomatic, lower limb peripheral arterial disease.
By Collins R, Cranny G, Burch J, Aguiar-Ibáñez R, Craig D, Wright K, *et al*.

No. 21
The clinical effectiveness and cost-effectiveness of treatments for children with idiopathic steroid-resistant nephrotic syndrome: a systematic review.
By Colquitt JL, Kirby J, Green C, Cooper K, Trompeter RS.

No. 22
A systematic review of the routine monitoring of growth in children of primary school age to identify growth-related conditions.
By Fayter D, Nixon J, Hartley S, Rithalia A, Butler G, Rudolf M, *et al*.

No. 23
Systematic review of the effectiveness of preventing and treating *Staphylococcus aureus* carriage in reducing peritoneal catheter-related infections.
By McCormack K, Rabindranath K, Kilonzo M, Vale L, Fraser C, McIntyre L, *et al*.

No. 24
The clinical effectiveness and cost of repetitive transcranial magnetic stimulation versus electroconvulsive therapy in severe depression: a multicentre pragmatic randomised controlled trial and economic analysis.
By McLoughlin DM, Mogg A, Eranti S, Pluck G, Purvis R, Edwards D, *et al*.

No. 25
A randomised controlled trial and economic evaluation of direct versus indirect and individual versus group modes of speech and language therapy for children with primary language impairment.
By Boyle J, McCartney E, Forbes J, O'Hare A.

No. 26
Hormonal therapies for early breast cancer: systematic review and economic evaluation.
By Hind D, Ward S, De Nigris E, Simpson E, Carroll C, Wyld L.

No. 27
Cardioprotection against the toxic effects of anthracyclines given to children with cancer: a systematic review.
By Bryant J, Picot J, Levitt G, Sullivan I, Baxter L, Clegg A.

No. 28
Adalimumab, etanercept and infliximab for the treatment of ankylosing spondylitis: a systematic review and economic evaluation.
By McLeod C, Bagust A, Boland A, Dagenais P, Dickson R, Dundar Y, *et al*.

No. 29
Prenatal screening and treatment strategies to prevent group B streptococcal and other bacterial infections in early infancy: cost-effectiveness and expected value of information analyses.
By Colbourn T, Asseburg C, Bojke L, Philips Z, Claxton K, Ades AE, *et al*.

No. 30
Clinical effectiveness and cost-effectiveness of bone morphogenetic proteins in the non-healing of fractures and spinal fusion: a systematic review.
By Garrison KR, Donell S, Ryder J, Shemilt I, Mugford M, Harvey I, *et al*.

No. 31
A randomised controlled trial of postoperative radiotherapy following breast-conserving surgery in a minimum-risk older population. The PRIME trial.
By Prescott RJ, Kunkler IH, Williams LJ, King CC, Jack W, van der Pol M, *et al*.

No. 32
Current practice, accuracy, effectiveness and cost-effectiveness of the school entry hearing screen.
By Bamford J, Fortnum H, Bristow K, Smith J, Vamvakas G, Davies L, *et al*.

No. 33
The clinical effectiveness and cost-effectiveness of inhaled insulin in diabetes mellitus: a systematic review and economic evaluation.
By Black C, Cummins E, Royle P, Philip S, Waugh N.

No. 34
Surveillance of cirrhosis for hepatocellular carcinoma: systematic review and economic analysis.
By Thompson Coon J, Rogers G, Hewson P, Wright D, Anderson R, Cramp M, *et al*.

No. 35
The Birmingham Rehabilitation Uptake Maximisation Study (BRUM). Home-based compared with hospital-based cardiac rehabilitation in a multi-ethnic population: cost-effectiveness and patient adherence.
By Jolly K, Taylor R, Lip GYH, Greenfield S, Raftery J, Mant J, *et al*.

No. 36
A systematic review of the clinical, public health and cost-effectiveness of rapid diagnostic tests for the detection and identification of bacterial intestinal pathogens in faeces and food.
By Abubakar I, Irvine L, Aldus CF, Wyatt GM, Fordham R, Schelenz S, *et al*.

No. 37
A randomised controlled trial examining the longer-term outcomes of standard versus new antiepileptic drugs. The SANAD trial.
By Marson AG, Appleton R, Baker GA, Chadwick DW, Doughty J, Eaton B, *et al*.

No. 38
Clinical effectiveness and cost-effectiveness of different models of managing long-term oral anticoagulation therapy: a systematic review and economic modelling.
By Connock M, Stevens C, Fry-Smith A, Jowett S, Fitzmaurice D, Moore D, *et al*.

No. 39
A systematic review and economic model of the clinical effectiveness and cost-effectiveness of interventions for preventing relapse in people with bipolar disorder.
By Soares-Weiser K, Bravo Vergel Y, Beynon S, Dunn G, Barbieri M, Duffy S, *et al*.

No. 40
Taxanes for the adjuvant treatment of early breast cancer: systematic review and economic evaluation.
By Ward S, Simpson E, Davis S, Hind D, Rees A, Wilkinson A.

No. 41
The clinical effectiveness and cost-effectiveness of screening for open angle glaucoma: a systematic review and economic evaluation.
By Burr JM, Mowatt G, Hernández R, Siddiqui MAR, Cook J, Lourenco T, *et al*.

No. 42
Acceptability, benefit and costs of early screening for hearing disability: a study of potential screening tests and models.
By Davis A, Smith P, Ferguson M, Stephens D, Gianopoulos I.

No. 43
Contamination in trials of educational interventions.
By Keogh-Brown MR, Bachmann MO, Shepstone L, Hewitt C, Howe A, Ramsay CR, *et al*.

No. 44
Overview of the clinical effectiveness of positron emission tomography imaging in selected cancers.
By Facey K, Bradbury I, Laking G, Payne E.

No. 45
The effectiveness and cost-effectiveness of carmustine implants and temozolomide for the treatment of newly diagnosed high-grade glioma: a systematic review and economic evaluation.
By Garside R, Pitt M, Anderson R, Rogers G, Dyer M, Mealing S, *et al*.

No. 46
Drug-eluting stents: a systematic review and economic evaluation.
By Hill RA, Boland A, Dickson R, Dündar Y, Haycox A, McLeod C, *et al*.

No. 47
The clinical effectiveness and cost-effectiveness of cardiac resynchronisation (biventricular pacing) for heart failure: systematic review and economic model.
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Recruitment to randomised trials: strategies for trial enrolment and participation study. The STEPS study.
By Campbell MK, Snowdon C, Francis D, Elbourne D, McDonald AM, Knight R, *et al*.

No. 49
Cost-effectiveness of functional cardiac testing in the diagnosis and management of coronary artery disease: a randomised controlled trial. The CECaT trial.
By Sharples L, Hughes V, Crean A, Dyer M, Buxton M, Goldsmith K, *et al*.

No. 50
Evaluation of diagnostic tests when there is no gold standard. A review of methods.
By Rutjes AWS, Reitsma JB, Coomarasamy A, Khan KS, Bossuyt PMM.

No. 51
Systematic reviews of the clinical effectiveness and cost-effectiveness of proton pump inhibitors in acute upper gastrointestinal bleeding.
By Leontiadis GI, Sreedharan A, Dorward S, Barton P, Delaney B, Howden CW, *et al*.

No. 52
A review and critique of modelling in prioritising and designing screening programmes.
By Karnon J, Goyder E, Tappenden P, McPhie S, Towers I, Brazier J, *et al*.

No. 53
An assessment of the impact of the NHS Health Technology Assessment Programme.
By Hanney S, Buxton M, Green C, Coulson D, Raftery J.

Volume 12, 2008

No. 1
A systematic review and economic model of switching from non-glycopeptide to glycopeptide antibiotic prophylaxis for surgery.
By Cranny G, Elliott R, Weatherly H, Chambers D, Hawkins N, Myers L, *et al*.

No. 2
'Cut down to quit' with nicotine replacement therapies in smoking cessation: a systematic review of effectiveness and economic analysis.
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By Thornton J, Ashcroft D, O'Neill T, Elliott R, Adams J, Roberts C, *et al*.

No. 4
Does befriending by trained lay workers improve psychological well-being and quality of life for carers of people with dementia, and at what cost? A randomised controlled trial.
By Charlesworth G, Shepstone L, Wilson E, Thalanany M, Mugford M, Poland F.

No. 5
A multi-centre retrospective cohort study comparing the efficacy, safety and cost-effectiveness of hysterectomy and uterine artery embolisation for the treatment of symptomatic uterine fibroids. The HOPEFUL study.
By Hirst A, Dutton S, Wu O, Briggs A, Edwards C, Waldenmaier L, *et al*.

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Methods of prediction and prevention of pre-eclampsia: systematic reviews of accuracy and effectiveness literature with economic modelling.
By Meads CA, Cnossen JS, Meher S, Juarez-Garcia A, ter Riet G, Duley L, *et al*.

No. 7
The use of economic evaluations in NHS decision-making: a review and empirical investigation.
By Williams I, McIver S, Moore D, Bryan S.

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Stapled haemorrhoidectomy (haemorrhoidopexy) for the treatment of haemorrhoids: a systematic review and economic evaluation.
By Burch J, Epstein D, Baba-Akbari A, Weatherly H, Fox D, Golder S, *et al*.

No. 9
The clinical effectiveness of diabetes education models for Type 2 diabetes: a systematic review.
By Loveman E, Frampton GK, Clegg AJ.

No. 10
Payment to healthcare professionals for patient recruitment to trials: systematic review and qualitative study.
By Raftery J, Bryant J, Powell J, Kerr C, Hawker S.

No. 11
Cyclooxygenase-2 selective non-steroidal anti-inflammatory drugs (etodolac, meloxicam, celecoxib, rofecoxib, etoricoxib, valdecoxib and lumiracoxib) for osteoarthritis and rheumatoid arthritis: a systematic review and economic evaluation.
By Chen Y-F, Jobanputra P, Barton P, Bryan S, Fry-Smith A, Harris G, *et al*.

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The clinical effectiveness and cost-effectiveness of central venous catheters treated with anti-infective agents in preventing bloodstream infections: a systematic review and economic evaluation.
By Hockenhull JC, Dwan K, Boland A, Smith G, Bagust A, Dündar Y, *et al*.

No. 13
Stepped treatment of older adults on laxatives. The STOOL trial.
By Mihaylov S, Stark C, McColl E, Steen N, Vanoli A, Rubin G, *et al*.

No. 14
A randomised controlled trial of cognitive behaviour therapy in adolescents with major depression treated by selective serotonin reuptake inhibitors. The ADAPT trial.
By Goodyer IM, Dubicka B, Wilkinson P, Kelvin R, Roberts C, Byford S, *et al*.

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The use of irinotecan, oxaliplatin and raltitrexed for the treatment of advanced colorectal cancer: systematic review and economic evaluation.
By Hind D, Tappenden P, Tumur I, Eggington E, Sutcliffe P, Ryan A.

No. 16
Ranibizumab and pegaptanib for the treatment of age-related macular degeneration: a systematic review and economic evaluation.
By Colquitt JL, Jones J, Tan SC, Takeda A, Clegg AJ, Price A.

No. 17
Systematic review of the clinical effectiveness and cost-effectiveness of 64-slice or higher computed tomography angiography as an alternative to invasive coronary angiography in the investigation of coronary artery disease.
By Mowatt G, Cummins E, Waugh N, Walker S, Cook J, Jia X, *et al*.

No. 18
Structural neuroimaging in psychosis: a systematic review and economic evaluation.
By Albon E, Tsourapas A, Frew E, Davenport C, Oyebode F, Bayliss S, *et al*.

No. 19
Systematic review and economic analysis of the comparative effectiveness of different inhaled corticosteroids and their usage with long-acting beta$_2$ agonists for the treatment of chronic asthma in adults and children aged 12 years and over.
By Shepherd J, Rogers G, Anderson R, Main C, Thompson-Coon J, Hartwell D, *et al*.

No. 20
Systematic review and economic analysis of the comparative effectiveness of different inhaled corticosteroids and their usage with long-acting beta$_2$ agonists for the treatment of chronic asthma in children under the age of 12 years.
By Main C, Shepherd J, Anderson R, Rogers G, Thompson-Coon J, Liu Z, *et al*.

No. 21
Ezetimibe for the treatment of hypercholesterolaemia: a systematic review and economic evaluation.
By Ara R, Tumur I, Pandor A, Duenas A, Williams R, Wilkinson A, *et al*.

No. 22
Topical or oral ibuprofen for chronic knee pain in older people. The TOIB study.
By Underwood M, Ashby D, Carnes D, Castelnuovo E, Cross P, Harding G, *et al*.

No. 23
A prospective randomised comparison of minor surgery in primary and secondary care. The MiSTIC trial.
By George S, Pockney P, Primrose J, Smith H, Little P, Kinley H, *et al*.

No. 24
A review and critical appraisal of measures of therapist–patient interactions in mental health settings.
By Cahill J, Barkham M, Hardy G, Gilbody S, Richards D, Bower P, *et al*.

No. 25
The clinical effectiveness and cost-effectiveness of screening programmes for amblyopia and strabismus in children up to the age of 4–5 years: a systematic review and economic evaluation.
By Carlton J, Karnon J, Czoski-Murray C, Smith KJ, Marr J.

No. 26
A systematic review of the clinical effectiveness and cost-effectiveness and economic modelling of minimal incision total hip replacement approaches in the management of arthritic disease of the hip.
By de Verteuil R, Imamura M, Zhu S, Glazener C, Fraser C, Munro N, *et al*.

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We look forward to hearing from you.

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