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Dislocation of hip arthroplasty in patients with femoral neck fractures

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Abstract

Treatment of displaced fractures of the femoral neck with a hemiarthroplasty (HA) or a total hip arthroplasty (THA) today constitutes standard procedures with a good and predictable outcome with regard to the need for revision surgery, hip function and the health-related quality of life (HRQoL). However, dislocation of the prosthesis remains a substantial clinical problem in this patient group and the dislocation rate is considerably higher than what can be expected following a THA in patients with osteoarthritis. There are several reported risk factors for prosthetic dislocations of which the influence of the surgical approach in patients with femoral neck fractures is still controversial. Moreover, little is known about the effect of the dislocation on the patients HRQoL. In order to prevent dislocation of the hip arthroplasty information on the direction of the dislocation is important for accurate implant positioning and for optimising the postoperative regimens. However, specific studies regarding this topic are missing for patients with fractures of the femoral neck.

In *Study I,* a prospective cohort study on 739 hips treated with HA due to a femoral neck fracture, factors influencing the risk of prosthetic dislocation were analysed. In a 2–10 year follow-up the posterolateral approach was associated with a significantly increased risk for dislocation of the prosthesis compared to the anterolateral approach. The patients' age, gender, the indication for surgery, the surgeon's experience or the type of HA did not affect the dislocation rate.

In *Study II,* another prospective cohort study with a 1–11 year follow-up of 713 hips treated with THA due to a femoral neck fracture, factors influencing the risk of prosthetic dislocation were analysed. Compared to the anterolateral approach, the posterolateral approach was associated with a significantly increased risk for dislocation of the prosthesis. The patients' age, gender, the indication for surgery, the surgeon's experience or the size of the femoral head did not affect the dislocation rate.

In *Study III,* a multicentre prospective cohort study on 319 patients treated with a primary HA or THA due to a femoral neck fracture, dislocation of the prosthesis had a significant negative effect on the HRQoL during the first year after the surgery. A recurrent dislocation of the arthroplasty seems to result in a persistent deterioration in the HRQoL, while patients with a single dislocation appear to experience only a temporary deterioration.

In *Study IV* a study on 74 patients with a primary dislocation of an HA or a THA within one year after surgery due to a femoral neck fracture, the surgical approach significantly influenced the direction of dislocation in patients treated with HA, while no such correlation was found after THA. This suggests that the surgical approach is only one of several factors affecting the direction of dislocation after THA. Our results imply that the position of the acetabular component might be one important factor.

The major conclusions of this thesis are that a prosthesis dislocation has a negative influence on the health-related quality of life and, in order to reduce the overall dislocation rate after both HA and THA in patients with femoral neck fractures, an anterolateral surgical approach should be used instead of a posterolateral one.

List of Papers

This thesis is based on the following papers, which are indicated in the text by their Roman numerals (*Studies I-IV*):

I.   Dislocation of hemiarthroplasty after femoral neck fracture. Better outcome after the anterolateral approach in a prospective cohort study on 739 consecutive hips. *Enocson A, Tidermark J, Törnkvist H, Lapidus L J. Acta Orthopaedica 2008; 79: 211-217.*

II.   Dislocation of total hip replacement in patients with fractures of the femoral neck. A prospective cohort study of 713 consecutive hips. *Enocson A, Hedbeck C-J, Tidermark J, Pettersson H, Ponzer S, Lapidus L J. Acta Orthopaedica 2009; 80: 184-189.*

III.   Quality of life after dislocation of hip arthroplasty: a prospective cohort study on 319 patients with femoral neck fractures with a one-year follow-up. *Enocson A, Pettersson H, Ponzer S, Törnkvist H, Dalén N, Tidermark J. Quality of Life Research 2009; 18: 1177-1184.*

IV.   The influence of the surgical approach on the direction of hip arthroplasty dislocation. A study on patients with femoral neck fractures. *Enocson A, Lapidus G, Törnkvist H, Tidermark J, Lapidus L J. Submitted.*

List of Abbreviations

AL	Anterolateral surgical approach
ASA	American Society of Anesthesiologists
CI	Confidence interval
EQ-5D	EuroQol-5 dimensions
HA	Hemiarthroplasty
HIF	Hammarby Idrottsförening
HR	Hazard ratio
HRQoL	Health-related quality of life
IF	Internal fixation
OA	Osteoarthritis
OR	Odds ratio
PL	Posterolateral surgical approach
RA	Rheumatoid arthritis
THA	Total hip arthroplasty
THR	Total hip replacement
RCT	Randomised controlled trial
SPSS	Statistical Package for the Social Sciences

Introduction

The global incidence of hip fractures is rising. The total numbers worldwide have been estimated to reach 6.3 million in the year of 2050 (Cooper et al. 1992). Osteoporosis is the major underlying factor and the elderly female population is mostly affected. The cumulated risk for an 80-year-old female in Sweden is 20%, and nearly 50% for a 90-year-old (Zetterberg et al. 1984). Although most of the patients are elderly, the hip fracture population is not homogeneous. The population ranges from middle-aged actively working patients with high functional demands, to very old bedridden patients with severe cognitive dysfunction, low functional demands and short lifetime-expectancy. The treatment of hip fractures therefore needs to be optimised in relation to the individual patients' functional demands, lifetime expectancy and risk profile. This is especially important in elderly patients with displaced femoral neck fractures, a patient group for whom there are several treatment options.

Treatment of femoral neck fractures

Approximately 50% of the hip fractures involve the femoral neck, and of those about 75% are displaced (Garden III and IV) (Garden 1961). The femoral neck fracture has been called "the unsolved fracture" and the treatment of displaced femoral neck fractures is a challenge. Acute surgery is uncontroversial, but the optimal surgical method is still under debate. The main different treatment choices are: internal fixation (IF), hemiarthroplasty (HA) and total hip arthroplasty (THA). HAs are only used in patients with hip fractures, whereas THAs can be used in patients with degenerative joint disease, i.e. osteoarthritis (OA), as well as in fracture patients. There are two types of HAs, unipolar and bipolar. The unipolar HA has a large femoral head articulating with the acetabulum while the bipolar HA has a second articulating joint included within the prosthesis and thereby theoretically reducing the wear of the acetabular cartilage. Historically, in Scandinavia, closed reduction of the fracture and IF has been the method of choice for displaced femoral neck fractures. However, since after IF fracture healing complications are reported to occur in up to 50% of the patients, and subsequent reoperations in up to 35% (Lu-Yao et al. 1994, Tidermark et al. 2003b, Blomfeldt et al. 2005), IF is recommended today in Sweden only for treatment of patients not medically fit for an arthroplasty, and of young patients with a long lifetime-expectancy and thereby a high risk of requiring revision arthroplasty (Thorngren 2002).

Several decades have passed since the first modern THA (Charnley) in Sweden was inserted at Stockholm Söder Hospital in 1967. Today, the treatment of displaced fractures of the femoral neck with an HA or a THA constitutes standard procedures with a good and predictable outcome with regard to the need for revision surgery, to hip function and to the health-related quality of life (HRQoL) (Tidermark et al. 2003b, Keating et al. 2006, Blomfeldt et al. 2007, Frihagen et al. 2008). HA is a common surgical procedure in the most elderly patients with low functional demands, and THA is the preferred method for the active lucid elderly patient and both procedures can be employed either as primary operations for displaced fractures or as

secondary operations after failed IF. However, although arthroplasty as a treatment for displaced femoral neck fractures is today uncontroversial, there are complications associated with this surgical procedure. Unlike patients operated due to OA, mechanical loosening of the prosthesis so as to necessitate revision surgery is uncommon in the fracture population (Swedish Hip Arthroplasty Register 2007), mainly due to the limited life expectancy in this elderly population. Instead, prosthesis dislocation is the most common, and infection the second most common reason for revision surgery in patients with femoral neck fractures treated with HA in Sweden (Swedish Hip Arthroplasty Register 2007).

Hip arthroplasty dislocation

Dislocation of a hip arthroplasty is defined by the loss of contact between the femoral head and the acetabulum (HA) or the acetabular component (THA) that requires intervention to relocate the joint (Padgett and Warashina 2004) (Figure 1).

Figure 1
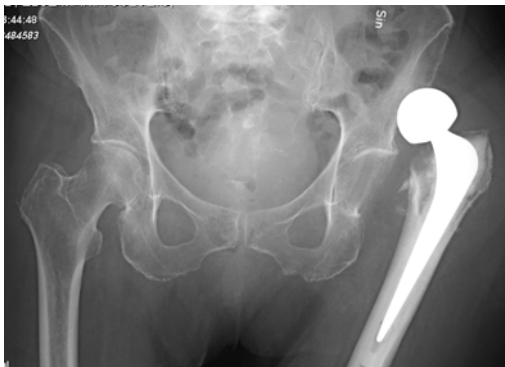
Dislocation of an HA   Dislocation of a THA

Moreover, inter-prosthetic dissociation may be an added problem for the reduction procedure in certain bipolar HAs necessitating open reduction (Varley and Parker 2004). However, most modern bipolar surgical systems have a stable construct to prevent dissociation between the inner and the outer head.

The risk for dislocation of the prosthesis remains a substantial problem and the dislocation rate is considerably higher in patients treated with a THA after a femoral neck fracture than what can be expected after a THA in patients with OA or rheumatoid arthritis (RA) (Woo and Morrey 1982, Berry et al. 2004, Meek et al. 2006). Among patients with femoral neck fractures dislocation is reported to range between 2% and 16% for HA (Pajarinen et al. 2003, Varley and Parker 2004) and between 2% and 22% for THA (Lu-Yao et al. 1994, Johansson et al. 2000, Tidermark et al. 2003b). Moreover, the percentage of patients with at least one recurrent dislocation after the first closed reduction is high: up to 60% (Yuan and Shih 1999, Kotwal et al. 2009), and revision surgery due to instability is reported to occur in 35–50% of the patients

suffering from a dislocated hip prosthesis (Woo and Morrey 1982, Li et al. 1999, Kotwal et al. 2009), a procedure far from always being successful (Woo and Morrey 1982, Kotwal et al. 2009). Furthermore, a dislocation results in additional hospital costs (Sanchez-Sotelo et al. 2006) and may also increase the mortality rate (Blewitt and Mortimore 1992).

Dislocations can be categorised as early or late based upon the timing after the hip arthroplasty. Although there is no established definition, a dislocation that occurs within the first weeks or months after the primary operation is usually defined as early. Primary early dislocations are usually treated successfully with closed reduction. The exception is early dislocations due to marked malpositioning of one or two of the prosthetic components so as to necessitate revision surgery. Generally, early dislocations have a better prognosis than to late dislocations. The latter usually have a multifactorial aetiology including polyethylene wear of the acetabular component and/or soft tissue laxity, and therefore more often require surgical intervention (von Knoch et al. 2002).

Risk factors for prosthetic dislocations

Risk factors for prosthetic dislocations can be divided into patient risk factors and surgical risk factors. Potential patient risk factors include: preoperative diagnosis, age, gender, obesity, cognitive dysfunction and drug abuse. Potential surgical risk factors include: component positioning, size of the femoral head, the skill of the surgeon and the surgical approach.

Patient risk factors

As previously mentioned, patients operated with THA due to a femoral neck fracture run an increased risk of prosthetic dislocations when compared to patients in whom the indication for surgery is OA or RA. Moreover, advanced age is reported to be a risk factor for dislocation (Berry et al. 2004, Meek et al. 2006) possibly due to difficulties for these patients in complying with range-of-motion limitations, poor vision and poor coordination (Woolson and Rahimtoola 1999). Also female gender has been advocated as being a risk factor, although the exact cause of this is not known (Woo and Morrey 1982, Berry et al. 2004). Furthermore, Sadr Azodi et al. (2008) found an association between a high body mass index (BMI) and an increased risk for dislocation, and Paterno et al. (1997) reported a higher incidence in patients with a history of alcohol abuse. However, all of the above mentioned studies focus on patients with degenerative joint disease. Studies including patients with femoral neck fractures within this field of research are sparse. Since there are fundamental differences between these two patient categories in preoperative hip function, age and co-morbidities we believe that they should be analysed separately. Male gender has recently been reported to be a risk factor for revision due to dislocations in patients with femoral neck fractures (Leonardsson et al. 2009).

Cognitive dysfunction appears to be a substantial risk factor for dislocation both in patients with degenerative joint disease (Woolson and Rahimtoola 1999) and with femoral neck fractures (Johansson et al. 2000). Johansson et al. (2000) reported a 32% dislocation rate in patients with mental impairment treated with a THA through a posterior approach compared to 12% in those who were assessed to be mentally intact.

Furthermore, among fracture patients there has been reported an increased risk for dislocations after a secondary THA compared to a primary one (Woo and Morrey 1982, McKinley and Robinson 2002).

Surgical risk factors

Malpositioning of the prosthetic components is a well-known risk factor for dislocations in patients with degenerative joint disease (Lewinnek et al. 1978, Ali Khan et al. 1981, Dorr and Wan 1998, Biedermann et al. 2005). The acetabular component is usually recommended to be inserted with an inclination angle of 30° to 50° and an anteversion angle of 5° to 25° (Lewinnek et al. 1978). The positioning of the femoral component is also a risk factor, although less critical than that of the acetabular component, and the most common cause of dislocation is malpositioning of the acetabular component (McCollum and Gray 1990, Daly and Morrey 1992, Morrey 1997). Identifying a malpositioned component is not always easy. Plain radiographs provide limited information about the orientation of the components. A more detailed analysis of the position of the acetabular component and the femoral stem anteversion requires assessment with CT (Mian et al. 1992, Pierchon et al. 1994, Olivecrona et al. 2004).

The prosthetic head size is also related to the risk of dislocation as the arc of motion required to dislocate a prosthetic head is directly related to the diameter of the head (Kluess et al. 2007). Consequently, larger prosthetic heads have been shown to decrease the risk of dislocation (Bystrom et al. 2003, Berry et al. 2005) as well as the risk of recurrent dislocations (Hedlundh et al. 1996a).

Inexperienced surgeons (Hedlundh et al. 1996b) and those with low annual surgical volume (Hedlundh et al. 1996b, Katz et al. 2001) appear to have a higher incidence of dislocation.

Again, none of the above studies address patients with femoral neck fractures specifically. As discussed before, there is good reason to analyse these two patient categories separately. Among all the risk factors for prosthetic dislocation, the influence of the surgical approach is the most controversial and it is, next to accurate positioning of the prosthetic components, the most important one that can be influenced by the surgeon.

Surgical approaches for hip arthroplasty

Posterior approach

Austin Moore, Colombia, South Carolina, USA, was an innovator not only because he developed the classical Moore prosthesis (Moore 1952), but also because he proposed that displaced fractures of the femoral neck should best be treated with primary arthroplasty. In the 1950s he developed a posterior approach called "the southern exposure" for insertion of a hip hemiarthroplasty (Moore 1957). The patient was placed in a lateral position, and a curved skin incision was made behind the greater trochanter. The fascia lata was incised, the fibres of gluteus maximus were divided and the sciatic nerve was exposed and protected. The insertions of the short external rotators were divided, the posterior joint capsule exposed and a posterior capsulectomy was performed. The hip could then be dislocated by flexion, adduction and

internal rotation. After insertion of the prosthesis, the wound was closed with "a few deep sutures", before the skin was finally sutured. The entire procedure could be completed in 20–30 minutes according to the author.

Anterior approach

In 1982 Kevin Hardinge, Lancashire, UK, published an article describing a surgical approach for THA which he called "the direct lateral approach" (Hardinge 1982). The patient was placed in a supine position. A straight skin incision was made and the gluteal fascia and iliotibial band was divided along the midlateral line of the trochanter. The anterior part of the gluteus medius tendon was incised using diathermy. Proximally the incision was curved around the greater trochanter splitting the muscle fibres without cutting them, and distally the incision passed down through the vastus lateralis. The whole complex was then moved anteriorly, using dissection by diathermy, until the anterior capsule of the hip joint was accessible. An anterior capsulectomy was performed and the femoral head could be dislocated by flexion, adduction and external rotation. After insertion of the prosthesis, the tendinous complex was resutured to its origin.

A few years later, in 1985, Wolfgang Gammer, Ludvika, Sweden, published "a modified lateroanterior approach" for insertion of THA (Gammer 1985). This approach was similar to the Hardinge approach, but the patient was placed in a lateral, instead of a supine position and the anterior part of gluteus medius in continuation with the anterior part of the vastus lateralis was released by decorticating with an osteotome from the insertion on the greater trochanter.

The distribution between the anterior and posterior approaches in Sweden during 2008 for patients operated with THA due to OA was 46% and 54%, respectively. The corresponding figures for patients with femoral neck fractures were 56% for anterior and 44% for posterior approaches. Among patients undergoing a HA in 2008, 51% were operated with an anterior approach and 49% with a posterior approach (personal communication, Göran Garellick and Cecilia Rogmark, Swedish Hip Arthroplasty Register).

Quality of life

Assessments of the health related quality of life (HRQoL) are being used more and more frequently as an outcome in modern orthopaedic studies. The term "quality of life" is defined as the individual's perception of his or her position in life in the context of the culture and value systems in which he or she lives and in relation to their goals, expectations, standards and concerns (WHO-QoL Group, 1993). This definition includes physical health, psychological health and socioeconomic well-being. HRQoL focuses more on the impact of a perceived state of health, as a result of an injury or illness, on the ability to live a fulfilling life.

Even though dislocation is a relatively common and serious complication, there are no previous reports on the effect of the dislocation on the patient-reported HRQoL for patients treated with an arthroplasty due to a femoral neck fracture.

Several instrument for assessing HRQoL have been developed, and EuroQol (EQ-5D) (Brooks 1996) is one of the most frequently used ones.

Direction of prosthesis dislocation

In order to be able to prevent dislocation of the hip arthroplasty, information on the direction of the dislocation is important for accurate implant positioning and for optimising the postoperative regimens. In routine health care it is often assumed that patients operated on using an anterior surgical approach are more likely to dislocate anteriorly, and *vice versa* for a posterior approach. Although information concerning this issue is valuable and has implications for selecting an accurate implant position and for optimising the postoperative rehabilitation regimens, there are few studies on this specific issue. In a paper from 1982, Woo and Morrey (1982) reported that 77% of patients who had undergone a THA utilising a posterior approach and postoperatively sustained a dislocation presented with a posterior dislocation of the prosthesis, while patients operated upon with an anterior approach had an equal distribution between anterior and posterior dislocations, 46% each. The results for the anterolateral approach have been confirmed by Biedermann et al. (2005) and those for the posterolateral approach by Pierchon et al. (1994). However, the majority of the patients in these studies were operated due to degenerative joint disease, and data regarding this issue is lacking for patients treated with HA or THA for a femoral neck fracture.

Aims of the Studies

Study 1

To analyse factors influencing the stability of an HA with special reference to the surgical approach, within the context of a large prospective cohort trial including consecutive patients with a femoral neck fracture.

Study 2

To analyse factors influencing the stability of a THA with special reference to the surgical approach within the context of a large prospective cohort trial including consecutive patients with a femoral neck fracture.

Study 3

To investigate how a dislocation of a hip arthroplasty influences the HRQoL of patients treated for femoral neck fractures.

Study 4

To analyse the influence of the surgical approach on the direction of prosthesis dislocation among patients suffering from dislocations of an HA or a THA after a femoral neck fracture.

Patients and Methods

Ethics

All studies were conducted in conformity with the Helsinki Declaration and each protocol was approved by the local ethics committee. In *Study III* all patients gave their informed consent to participate.

Age and gender

The mean age in *Study I* was 84 years with 80 % of the patients being females. In *Study II* the mean age was 77 years also with 80 % being females. In *Study III* the mean age was 82 years with 81 % being females, and in *Study IV* the mean age was 79 years with 85 % of the patients being females.

Study I

All patients operated on in our department since 1996 have been prospectively registered in a clinical audit database in which all major complications during the first 6 weeks after surgery have been recorded and validated. Via the audit we identified 739 consecutive HAs performed in 720 patients between 1996 and 2003. The indication for the HA procedure was a non-pathological displaced femoral neck fracture (Garden III and IV) in 457 patients (primary HA) and revision surgery after a failed IF of a femoral neck fracture in 282 patients (secondary HA). An anterolateral (AL) surgical approach was used on 431 hips and a posterolateral (PL) approach on 308 hips. A posterior repair was performed on 176 of these 308 hips. A 6-week prospective follow-up was performed within the context of our clinical audit. The patients were asked to report if any complication had occurred after surgery and, if so, where it had been diagnosed and treated. Furthermore, to identify all patients with a dislocation of their HA later than after 6 weeks, the patient records for these patients were searched from the date of surgery until December 31, 2005, or if the patient had deceased earlier, until the date of death. Finally, by using the Swedish personal identification number we searched the National Board of Health and Welfare's national registry to find any patients treated for dislocation of their HA at any other Swedish hospital. No such case was found. The follow-up time, including deceased patients during follow-up, was a median of 2.3 (0–10) years.

Study II

Via the same audit we identified 713 consecutive THAs performed in 698 patients between 1996 and 2005. The patients were operated with a primary THA (n=311) for a non-pathological displaced femoral neck fracture (Garden III and IV) or a secondary THA (n=402)

due to a fracture healing complication (non-union or avascular necrosis) after IF of a femoral neck fracture. An AL approach was used on 463 hips and a PL on 250 hips. A posterior repair was performed in 110 of the 250 PL approaches. A 6-week prospective follow-up was performed within the context of our clinical audit, as in *Study I*. Furthermore, all individual patient records were searched until December 31, 2006, or death, to find information about any dislocations and associated reoperations. Finally, as in *Study I*, a search was performed in the National Board of Health and Welfare's national registry to find patients who had been treated elsewhere in Sweden for a dislocation. One such case was found. The follow-up time including those deceased during follow-up was a median of 4.3 (0–11) years.

Study III

Between 1 January and 31 December 2003, all consecutive patients with an acute hip fracture admitted to any of the four university hospitals in Stockholm County (Danderyds Hospital, Karolinska University Hospital Solna, Karolinska University Hospital Huddinge and Stockholm Söder Hospital) were included in a prospective cohort study. A total number of 2213 patients with a hip fracture were admitted to the participating hospitals and, from that cohort, 319 consecutive patients without diagnosed dementia and/or severe cognitive dysfunction, and with a non-pathological displaced fracture of the femoral neck (Garden III and IV) and treated with a primary HA (n=217) or THA (n=102) were included in the present study (Figure 2). The patients were interviewed about their HRQoL according to the EQ-5D during the last week before the fracture occurred as baseline (preinjury recall). At the 4- and 12-month follow-ups the patients were again interviewed about their perceived HRQoL according to the EQ-5D and the EQ-5D $_{index}$ scores were calculated. Furthermore, the occurrence and date of any possible dislocation and associated reoperation were recorded.

Study IV

We included 74 operated patients who had had a primary hip arthroplasty (n=40) for a displaced femoral neck fracture (Garden III and IV) or a secondary arthroplasty (n=34) due to a fracture healing complication after internal fixation of a femoral neck fracture. The patients were recruited from *Study I* (25 HA patients) and from *Study II* (26 THA patients). Finally, another 23 patients who suffered a primary dislocation from 2004 (HA, n=17) or 2006 (THA, n=6) until November 2008, were identified in the database of our unit and included. All included patients were operated on at our department between January 1996 and September 2008 and had had a primary dislocation of their HA (n=42) or THA (n=32) within one year after surgery and had available radiographs allowing interpretation. An AL surgical approach was used in 42 patients and a PL in 32. The lateral radiograph from the time of the primary dislocation was analysed and the head of the dislocated prosthesis was classified as positioned anterior, posterior or superior to the acetabulum (HA) or the acetabular component (THA). Angles of inclination and anteversion of the acetabular component were measured in patients with THA on the anteroposterior and the lateral radiographs, respectively.

Figure 2

Flow chart of the patients in *Studies I-IV*
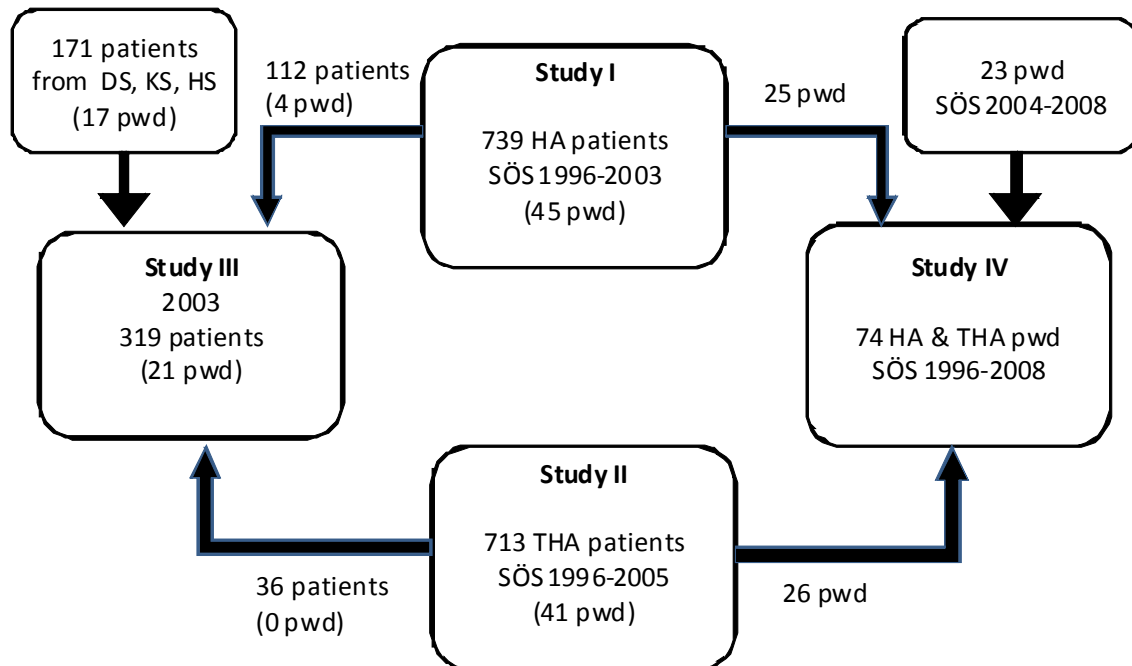
SÖS = Stockholm Söder Hospital, DS = Danderyds Hospital, KS = Karolinska University Hospital Solna, HS = Karolinska University Hospital Huddinge, pwd = patients with dislocations

Fracture classification

The fracture classification used for femoral neck fractures was the Garden classification (Garden 1961). This classification is based on the anteroposterior radiographic view. Undisplaced fractures are Garden type I (valgus impacted fracture) and type II (undisplaced fracture). Displaced fractures are type III (partially displaced fracture) and type IV (fully displaced fracture). The undisplaced type I and II fractures both have the same good prognosis after IF (Tidermark 2003), in contrast to the displaced fractures type III and IV, both of which have the same poor prognosis after IF (Lu-Yao et al. 1994, Tidermark 2003).

ASA classification

The ASA (American Society of Anesthesiologists) classification (Owens et al. 1978) which was used in *Study III* to assess physical health prior to surgery has been shown to effectively predict mortality in hip fracture patients (Söderqvist et al. 2009). The assessment was made by the attending anaesthetist prior to surgery. ASA 1 indicates a completely healthy person; ASA 2, a

person with a mild systemic disease; ASA 3, a person with severe systemic disease that is incapacitating; ASA 4, a person with an incapacitating disease that is a constant threat to life; ASA 5, a moribund patient who is not expected to live 24 hours with or without surgery. There were no patients with an ASA 5 classification in the study. For the purpose of the analysis, the ASA results were further dichotomised into ASA 1–2, 3–4.

EQ-5D

In *Study III* the HRQoL was assessed using the EuroQol (EQ-5D) (Brooks 1996). The EQ-5D has five dimensions: mobility, self-care, usual activities, pain/discomfort and anxiety/depression. Each dimension is divided into three degrees of severity: no problem, some problems, and major problems. Dolan et al. (1996) used the time trade-off (TTO) method to rate these different states of health in a large UK population (UK EQ-5D Index Tariff). We used the preference scores generated from this population when calculating the scores (EQ-5D $_{index}$ score) for our study population. A value of 0 indicated the worst possible state and a value of 1 the best possible.

The EQ-5D is brief and easy to use in elderly patients (Brazier et al. 1996) and has been validated in hip-fracture patients (Coast et al. 1998) and displayed good responsiveness (Tidermark et al. 2003a, Tidermark and Bergström 2007), i.e. a good ability to capture clinically important changes. Moreover, it also allows combining of different dimensions of health to form an overall index, the EQ-5D $_{index}$ score, as required for health care evaluations (Borgström et al. 2006) and for constructing quality-adjusted life years (QALYs), a measure frequently used in cost-effectiveness analyses.

Radiological analysis

In *Study IV* the radiological analysis was performed by an independent radiologist who was blinded to the surgical approach. The lateral radiograph from the time of the primary dislocation was analysed and the position of the head of the dislocated prosthesis was classified as anterior, posterior or superior in relation to the acetabulum (HA) or the acetabular component (THA) (Figures 3 & 4). This position was assumed to be the route and direction of the dislocation of the prosthesis (Woo and Morrey 1982, Cobb et al. 1996). In patients operated with a THA the angles of inclination and anteversion of the acetabular component were measured on the anteroposterior and the lateral radiographs, respectively, using the method described by Woo and Morrey (1982).
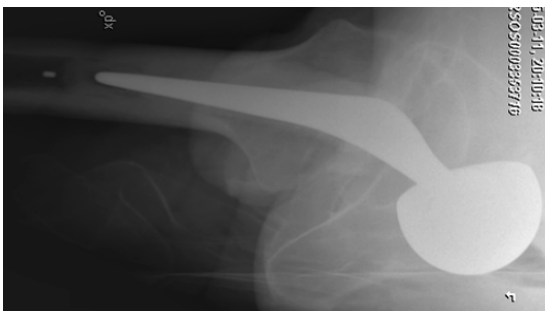
Figure 3
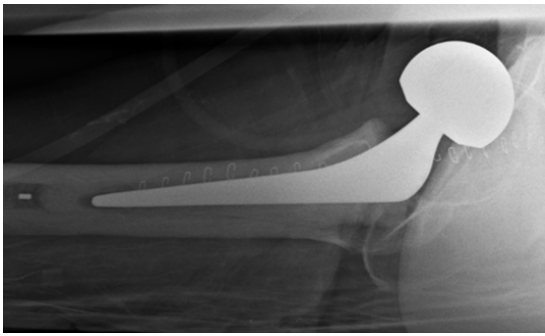
Anterior dislocation of an HA

Anterior dislocation of a THA

Figure 4

Posterior dislocation of an HA

Posterior dislocation of a THA

Surgical procedures

Surgical approach

In *Studies I, II* and *IV* patients operated through various surgical approaches were compared. We have used the terminology anterolateral (AL) surgical approach for a Hardinge (Hardinge 1982) approach performed with the patient in a lateral position, and posterolateral (PL) surgical approach for a classical Moore (Moore 1957) approach. In *Studies I* and *II* patients operated through a PL approach were further divided into those in whom a posterior repaired was performed or not. A posterior repair was defined as a repair of the short external rotators, with or without a simultaneous repair of the posterior capsule.

Postoperatively the patients were mobilised bearing full weight, with the aid of crutches if needed. The patients were given instructions on how to avoid dislocation of the prosthesis and to abandon the crutches when they feel safe.

A very important fact was that at each point in time, the selection of the surgical approach was determined by the individual surgeon's preference.

Arthroplasties

Types of prosthesis and brands of prosthesis used in *Studies I–IV* are given in Figure 5 and Table 1.

Figure 5
Radiographs of the prostheses used in the studies
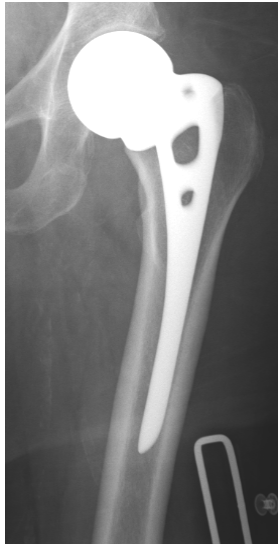
Uncemented unipolar HA   Cemented unipolar HA   Cemented bipolar HA

Cemented THA   Uncemented THA

Table 1

Prostheses used in the studies

Prosthesis type	Study I n=739	Study II n=713	Study III[1] n=319	Study IV n=74
UHA	389	0	80	11
CUniHA	127	0	39	10
CBiHA	223	0	98	21
CTHA	0	707	101	31
UTHA	0	5	1	0
HTHA	0	1	0	1

UHA = Uncemented unipolar HA (Austin-Moore), CUniHA = Cemented unipolar HA (Exeter Unipolar), CBiHA = Cemented bipolar HA (Exeter Bipolar), CTHA = Cemented THA, UTHA = Uncemented THA, HTHA = Hybrid THA (uncemented femoral and cemented acetabular components). THA femoral components used: cemented Exeter, cemented Charnley, uncemented BiMetric, uncemented Corail. THA acetabular components used: cemented Exeter, cemented Charnley, uncemented Trilogy, uncemented Romanus

[1] Information regarding the brand of the prosthesis is lacking

Statistical Methods

In *Studies I* and *II* the Mann-Whitney U-test was used for scale variables in independent groups. Nominal variables were tested by the Chi-square or Fisher's exact test. All tests were two-sided. In *Study I* multivariable logistic regression analyses were performed in order to evaluate factors associated with prosthetic dislocation. The associations are presented as odds ratios (ORs) with 95% confidence intervals (CIs). In *Study II* we used multivariable Cox regression to evaluate factors associated with prosthetic dislocation after the operation. The associations are presented as hazard ratios (HRs) with 95% CIs.

In *Study III* we used a multivariable mixed-effects model approach. The variance-covariance for the model was assumed to be block diagonal but unstructured within a block defined by subjects. We used the restricted maximum likelihood as our model estimation method and Akaikes Information Criteria (AIC) to compare the overall model fit between the model with an intercept and the unstructured variance-covariance and the model where the independent factors were included. We present the estimated fixed effects and their 95% CIs and their significance. To further analyse factors of importance for HRQoL at the 12-month follow-up, we used the Chi-square test to compare the distribution of the number of dislocations according to the EQ-5D dimensions.

In *Study IV* scale variables were tested using one-way ANOVA and a post hoc analysis was performed when comparing groups using a t-test with a Bonferroni correction adjusted for three groups. The normality assumption within each group was tested with the Shapiro-Wilks test and the homogeneity of the variances was tested with the Levene's test. Nominal variables were tested two-sided with the Fisher´s exact test.

In all studies the results were considered significant at p <0.05. The statistical software used was SPSS for Windows.

Results

Study I

Dislocation of the HA occurred in 45 of 739 (6%) hips. The anterolateral (AL) approach was associated with a lower risk of dislocation (3.0%) compared to the posterolateral (PL) approach with posterior repair (8.5%), or without posterior repair (13%) (p<0.001). The univariable logistic regression analyses indicate a significantly increased risk for dislocations in hips operated upon using the PL approach with or without posterior repair and a decreased risk in cemented Unipolar HAs. The multivariable logistic regression analysis showed that the PL approach was the only factor associated with a significantly increased risk for dislocation, OR 3.9 (CI 1.6–10) for the PL approach with posterior repair and OR 6.9 (CI 2.6–19) for the PL approach without posterior repair. The age, sex, indication for surgery, the surgeon's experience and type of HA did not significantly affect the dislocation rate (Table 2).

The first dislocation occurred early (within 6 weeks) in 39 patients and late in 6 patients. In 42 of 45 patients an attempted closed reduction was performed after the first dislocation. In the remaining 3 patients, all with severe dementia, the uncemented Austin-Moore prosthesis was removed without an attempt at reduction. The primary closed reduction was successful in 32 of 42 hips. Of the remaining 10 hips, 7 uncemented Austin-Moore HAs were extracted in patients with severe dementia, some non-ambulant, due to instability or irreducibility. Two hips displayed incongruence of the joint on the post-reduction radiograph due to acetabular impingement (soft tissue and cement, respectively) and both were reduced openly. None of these patients had any further dislocation. Finally, 1 hip displayed severe instability during the reduction procedure which was considered to be caused by a shallow acetabular socket. This arthroplasty was converted to a THA. Consequently, 34 of 45 hips remained with the prosthesis *in situ* after the primary dislocation, including the 2 openly reduced ones (see above). Of these, 14 had recurrent dislocations. There were no dissociations of the cemented bipolar HAs during the study period.

Information regarding cognitive function and/or dementia based on the physician's subjective assessment was available for 598 patients. Based on these data there was no selection based on cognitive function to any of the surgical approaches. Among patients operated on using the AL approach 93 of 419 (22%) were assessed as having some degree of cognitive dysfunction or dementia compared with 43 of 179 (24%) operated upon using the PL approach (p=0.7). As expected the dislocation rate was higher among patients with cognitive dysfunction and/or dementia compared to those without, 14 of 136 (10%) and 19 of 462 (4%), respectively (p=0.009). Owing to the fact that the data were incomplete and based on a subjective assessment, we did not include cognitive function as a variable in the regression analyses.

There were no differences regarding general complications, i.e. cardiovascular, thromboembolic, cerebrovascular, pneumonia or death within the first 6 weeks when comparing patients operated on via the AL or PL approach.

Table 2

Logistic regression to evaluate factors associated with prosthetic dislocation for HA patients (n=739)

Explanatory	Univariable		Multivariable	
	OR (95%CI)	p-value	OR (95%CI)	p-value
Age				
< 85 years	1 (reference)		1 (reference)	
≥ 85 years	0.6 (0.3-1.2)	0.1	0.6 (0.3-1.1)	0.1
Gender				
Male	1 (reference)		1 (reference)	
Female	1.7 (0.7-4.0)	0.3	1.5 (0.6-3.7)	0.4
Indication				
Primary	1 (reference)		1 (reference)	
Secondary	1.6 (0.9-2.9)	0.1	1.0 (0.5-2.0)	0.9
Surgeon's experience				
Registrar	1 (reference)		1 (reference)	
Post-registrar	1.0 (0.4-2.2)	0.9	1.3 (0.6-3.0)	0.5
Type of HA				
Uncemented unipolar	1 (reference)		1 (reference)	
Cemented unipolar	0.2 (0.5-0.8)	0.03	0.6 (0.1-3.1)	0.6
Cemented bipolar	0.8 (0.4-1.6)	0.6	2.1 (0.9-4.9)	0.1
Surgical approach				
AL	1 (reference)		1 (reference)	
PL with posterior repair[1]	3.0 (1.4-6.4)	0.005	3.9 (1.6-9.8)	0.003
PL without posterior repair	4.9 (2.3-10)	<0.001	6.9 (2.6-19)	<0.001

HA = hemiarthroplasty, AL = anterolateral, PL = posterolateral, OR = odds ratio
[1] = 3 missing values regarding information on posterior repair

Study II

Dislocation of the THA occurred in 41 of the 713 hips, giving an overall dislocation rate of 6%. The AL surgical approach was associated with a lower risk of dislocation (1.9%) than the PL approach with posterior repair (12%), or without posterior repair (14%) (p<0.001). The univariable analysis indicated a significantly increased risk for dislocations in hips operated upon using the PL approach with or without posterior repair and for hips with the 22-mm femoral head. However, the multivariable Cox regression analysis showed that the PL approach was the only factor associated with a significantly increased risk of dislocation with HR 5.5 (2.1–14) for the PL approach with posterior repair and HR 5.7 (2.0–16) for the PL approach without posterior repair. The patient's age, sex, the indication for surgery, the experience of the surgeon, and the femoral head size did not influence the dislocation rate (Table 3).

The first dislocation occurred early (within 6 weeks) in 24 of 41 patients. Closed reduction was successful in 39 of 41 patients with a primary dislocation. One of the remaining 2 patients (PL approach) was reoperated upon using a socket wall augmentation device and had no further dislocations. The other patient (AL approach) underwent open reduction, got a deep infection, and had the prosthesis extracted. Twenty-five of the 39 patients who were initially successfully treated with closed reduction had recurrent dislocations: 6 of the 8 patients operated upon using the AL approach and 19 of the 31 patients treated using the PL approach (p=0.7). Revision surgery due to instability was performed in 11 of the 41 patients, (including the 2 patients treated with a primary open procedure) during the study period: 3 of 9 patients operated upon using the AL approach, and 8 of 32 patients treated using the PL approach (p=0.7).

There was no selection of patients with dementia to any of the surgical approaches. Among patients operated on using the AL approach 18 of 463 (4%) had diagnosed dementia compared with 6 of 250 (2%) operated on using the PL approach (p=0.4).

When comparing patients operated on using the AL or PL approach there were no differences regarding nerve injuries, deep infections or mortality within the first year after surgery. Other general complications within the first 6 weeks such as pneumonia and cardiovascular, thromboembolic and cerebrovascular events were also equally distributed between the two groups.

Table 3

Cox regression to evaluate factors associated with prosthetic dislocation in THA patients (n=713)

| Explanatory	Univariable		Multivariable	
	HR (95%CI)	p-value	HR (95%CI)	p-value
Age				
< 78 years	1 (reference)		1 (reference)	
≥ 78 years	0.8 (0.4-1.4)	0.4	0.8 (0.4-1.5)	0.4
Gender				
Male	1 (reference)		1 (reference)	
Female	1.2 (0.5-2.6)	0.7	1.2 (0.5-2.7)	0.7
Indication				
Primary	1 (reference)		1 (reference)	
Secondary	1.5 (0.8-2.8)	0.2	0.8 (0.4-1.6)	0.5
Surgeon's experience				
Registrar	1 (reference)		1 (reference)	
Post-registrar	1.4 (0.4-4.5)	0.6	0.9 (0.3-2.8)	0.8
Femoral head size				
22 mm	1 (reference)		1 (reference)	
28 mm	0.3 (0.1-0.5)	<0.001	0.7 (0.3-1.5)	0.4
Surgical approach				
AL	1 (reference)		1 (reference)	
PL with posterior repair	6.1 (2.6-14)	<0.001	5.5 (2.1-14)	<0.001
PL without posterior repair	6.8 (3.1-15)	<0.001	5.7 (2.0-16)	0.001

THA = total hip arthroplasty, AL = anterolateral, PL = posterolateral, HR = hazard ratio

Study III

A dislocation of the arthroplasty occurred in 21 of the 319 patients (7%), 8 of whom had a single dislocation and 13 recurrent dislocations. Eighteen of the patients had their first dislocation within 6 weeks after prosthesis surgery. At 4 months after surgery all patients with a single dislocation (n=8) had had their one and only dislocation and all remaining patients with recurrent ($\geq$ 2) dislocations (n=13) had had their first and second dislocation. After the 4-month follow-up there were 3 additional dislocations in 2 of the patients with recurrent dislocations (Figure 6).

Figure 6
The time and order of dislocations (n=50) for all patients (n=21)
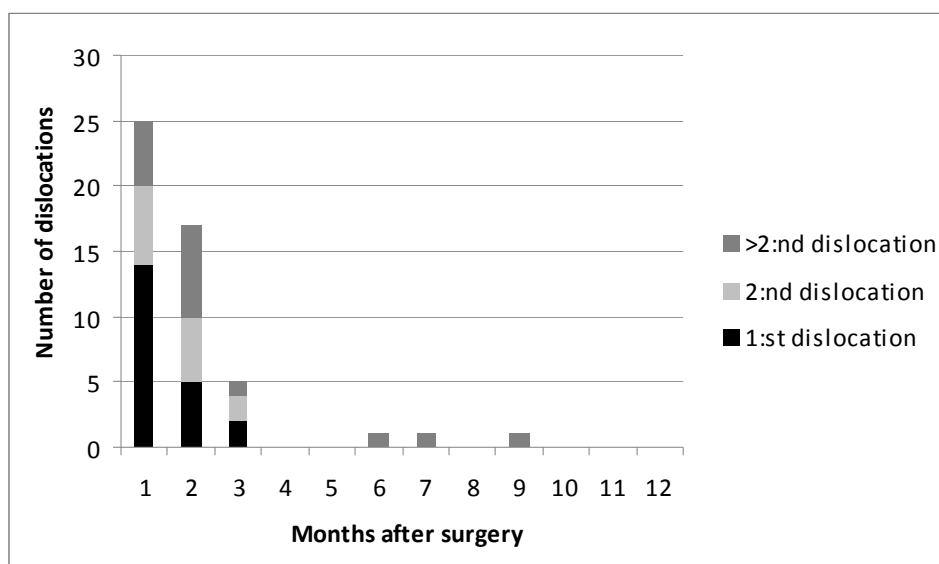
Dislocation, type of prosthesis, time and ASA were all significantly related to HRQoL in the unadjusted mixed-effects model regression analysis (Table 4). However, when performing the adjusted analysis, only the number of dislocations, type of prosthesis and time after surgery were significantly related to HRQoL. Neither age, gender, nor ASA class had any significant influence on the EQ-5D $_{index}$ score.

Table 4

Mixed-effects model regression analysis of factors of importance for HRQoL (EQ-5D $_{index}$ score) (n=319)

		Unadjusted estimate, Parameter (95% CI)	p-value	Adjusted estimate* Parameter (95% CI)	p-value
No. of dislocations			0.013		0.003
	0	Ref		Ref	
	1	-0.09 (-0.26, 0.08)	0.317	-0.11 (-0.27, 0.06)	0.204
	≥2	-0.19 (-0.32, -0.06)	0.005	-0.21 (-0.34, -0.08)	0.001
Prosthesis			0.004		0.004
	THA	Ref		Ref	
	Cemented HA	-0.07 (-0.13, -0.01)	0.019	-0.08 (-0.14, -0.02)	0.012
	Uncemented HA	-0.11 (-0.18, -0.04)	0.001	-0.12 (-0.20, -0.05)	0.001
Time			0.000		0.000
	Pre	Ref		Ref	
	4 months	-0.12 (-0.16, -0.08)	0.000	-0.12 (-0.16, -0.08)	0.000
	12 months	-0.14 (-0.18, -0.09)	0.000	-0.14 (-0.19, -0.09)	0.000
ASA	**1-2**	Ref		Ref	
	3-4	-0.05 (-0.11, 0.00)	0.042	-0.04 (-0.09, 0.02)	0.168
Gender	**Female**	Ref		Ref	
	Male	-0.04 (-0.11, 0.03)	0.238	-0.03 (-0.09, 0.04)	0.395
Age (continuous)		-0.0003 (-0.004, 0.003)	0.888	0.002 (-0.001, 0.006)	0.190

*Adjusted for all the factors in Table 3: EQ-5D $_{index}$ score, dislocation, prosthesis type, time, ASA, gender and age using mixed-model regression

Before the fracture there were no differences in the mean EQ-5D $_{index}$ score between the groups (0 vs 1, p=0.38; 0 vs ≥ 2, p=0.23; 1 vs ≥ 2, p=0.93). The mean (SD) EQ-5D $_{index}$ score for all patients before the fracture and for those still alive at 4 and 12 months is displayed in Table 5 and Figure 7. At 4 months the mean EQ-5D $_{index}$ score was lower for patients with recurrent dislocations than for those with no dislocation (p=0.001). Although there was a tendency towards a worse outcome for patients with a single dislocation, this was not statistically significant (p=0.08). At 12 months the mean EQ-5D $_{index}$ score for patients with recurrent dislocations was still significantly lower than for patients with no dislocation (p=0.001), while the EQ-5D $_{index}$ score for patients with a single dislocation had returned to a level similar to that in patients with no dislocation.

Figure 7

Mean EQ-5D $_{index}$ score for patients with no (0), one (1) and recurrent (≥ 2) dislocations before surgery (0 months) and at 4 and 12 months after surgery, respectively
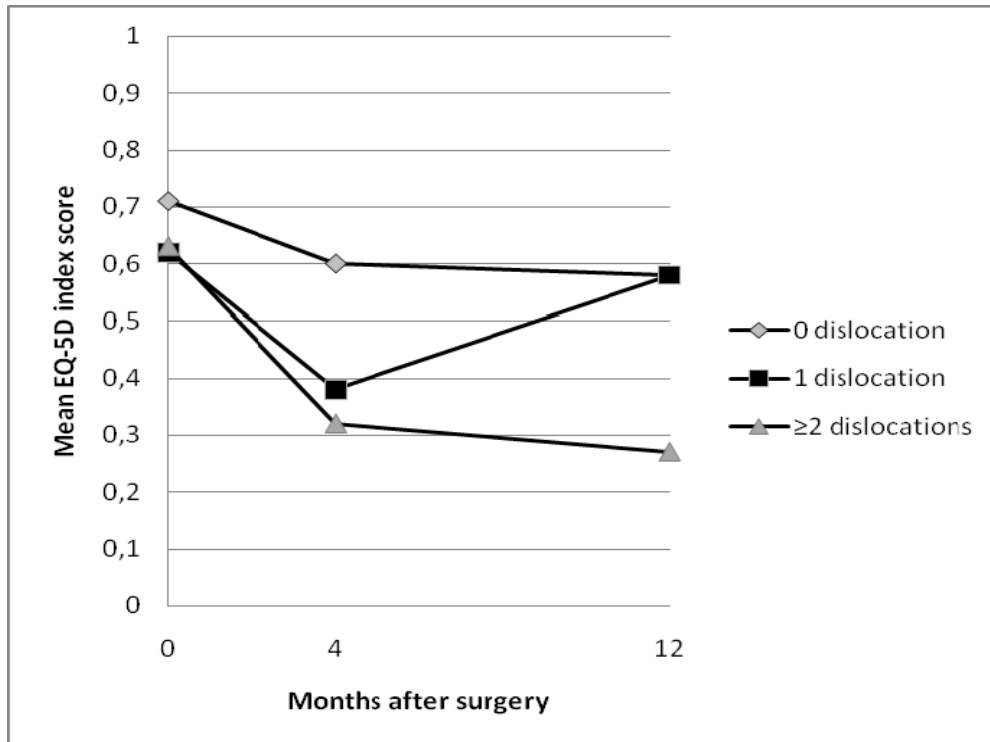

Table 5

The EQ-5D $_{index}$ score (mean; SD) for all patients before the fracture (n=319) and for all patients still alive at 4 (n=299) and 12 months (n=280) in relation to the occurrence of a dislocation, i.e no dislocation, one dislocation or recurrent dislocations

	0 dislocation	1 dislocation	≥ 2 dislocations
Prefracture	0.71 (0.28)	0.62 (0.28)	0.63 (0.27)
Missing	19/298	0/8	1/13
At 4 months	0.60 (0.30)	0.38 (0.23)	0.32 (0.20)
Missing	33/280	1/6	4/13
At 12 months	0.58 (0.33)	0.58 (0.27)	0.27 (0.28)
Missing	26/262	1/6	0/12

Missing = the proportion of missing EQ-5D $_{index}$ score values

Moreover, patients with uncemented and cemented HAs displayed lower scores than patients with a THA, and the HRQoL for the entire cohort was higher before the fracture than 4 and 12 months after surgery.

The differences in the EQ-5D $_{index}$ score at 12 months between patients without any dislocations and those with recurrent dislocations were due to differences in the EQ-5D dimensions self-care (p=0.01), usual activities (p=0.01) and anxiety/depression (p=0.02), while there were no significant differences in mobility (p=0.20) and pain/discomfort (p=0.42).

Study IV

The mean time from surgery to the primary dislocation was 32 days.

The direction of dislocation in relation to the surgical approach for the HA group is shown in Figure 8. In the HA/AL group the dislocations were categorised as anterior in 19 patients (68%), posterior in 7 (25%) and superior in 2 (7%). No patient in the HA/PL group had an anterior dislocation, 13 patients (93%) had a posterior dislocation and one patient (7%) had a superior dislocation. This difference in the direction of the dislocation between the HA/AL and the HA/PL groups was significant (p<0.001).

The direction of dislocation in relation to the surgical approach for the THA group is shown in Figure 9. In the THA/AL group the dislocations were categorised as anterior in 4 patients (29%), posterior in 5 (36%) and superior in 5 (36%). In the THA/PL group 5 patients (28%) had an anterior dislocation, 10 (56%) a posterior dislocation and 3 (17%) a superior dislocation. There was no significant (p=0.388) difference between the THA/AL group and THA/PL group regarding the direction of the dislocation.

Figure 8
The direction of dislocation in relation to the surgical approach in the HA group (n=42)
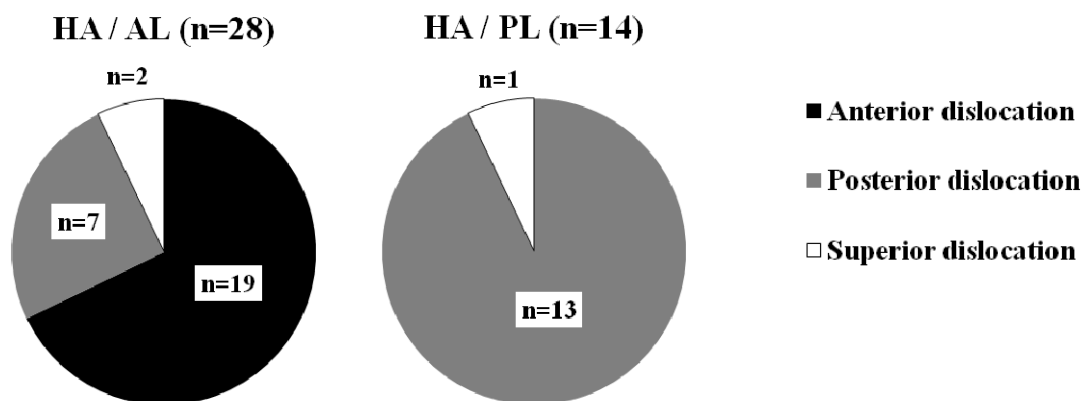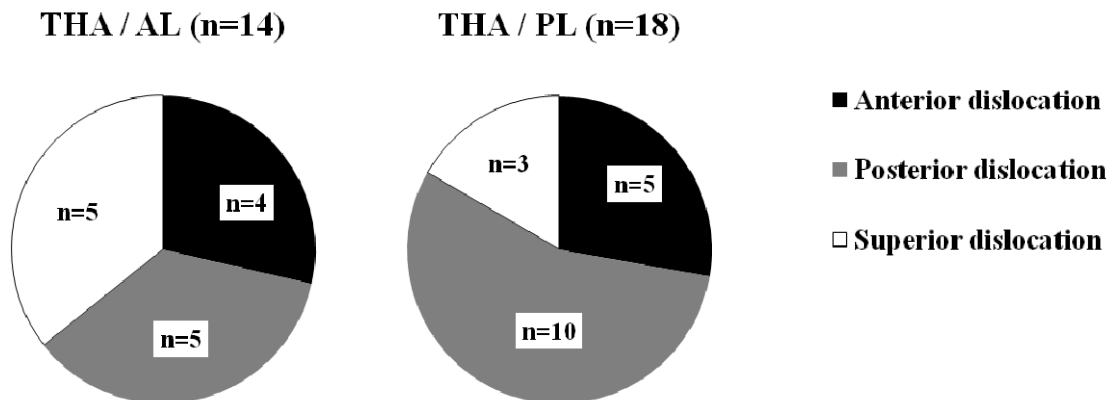

HA = hemiarthroplasty, AL = anterolateral surgical approach, PL = posterolateral surgical approach
p<0.001 between HA/AL and HA/PL

Figure 9
The direction of dislocation in relation to the surgical approach in the THA group (n=32)

THA / AL (n=14)   THA / PL (n=18)

■ Anterior dislocation

■ Posterior dislocation

□ Superior dislocation

THA = total hip arthroplasty, AL = anterolateral surgical approach, PL = posterolateral surgical approach
p=0.388 between THA/AL and THA/PL

The inclination and anteversion angles of the acetabular component in relation to the direction of dislocation in patients with a THA are displayed in Table 6. The mean angle of inclination was 48° in patients with an anterior dislocation, 39° in patients with a posterior dislocation and 44° in patients with a superior dislocation. Only the difference between the anterior and posterior dislocation groups was significant (p=0.045). The mean angle of anteversion was 24° in patients with an anterior dislocation and 13° in patients with posterior and superior dislocations, respectively. The differences between the anterior and posterior and between the anterior and superior dislocation groups were significant (p=0.027 and p=0.048, respectively).

Table 6
The inclination and anteversion of the acetabular component in relation to the direction of dislocation in patients with THA (n=32)

	Anterior (n=9)	Posterior (n=15)	Superior (n=8)	
	Mean (SD; range)			p-value
Inclination[1]	48° (2.2; 45-52)	39° (9.6; 27-61)[3]	44° (7.8; 35-60)	0.037
Anteversion[2]	24° (9.8; 13-45)	13° (9.6; -5-31)	13° (7.8; 2-24)	0.012

[1] p-values between groups after Bonferroni correction were: Anterior versus Posterior 0.045, Anterior versus Superior 0.777 and Posterior versus Superior 0.546
[2] p-values between groups after Bonferroni correction were: Anterior versus Posterior 0.027, Anterior versus Superior 0.048 and Posterior versus Superior 1.0
[3] One missing value

General Discussion

The overall aim of this thesis was to study dislocations of hip arthroplasties in patients with femoral neck fractures. In *Studies I* and *II*, the aims were to analyse factors influencing the stability of HAs and THAs with special reference to the surgical approach. In *Study III* we assessed how a dislocation of the hip arthroplasty influenced the patients' HRQoL. Finally, in *Study IV* the aim was to investigate the influence of the surgical approach on the direction of prosthetic dislocation. All our studies include only patients treated for a fracture of the femoral neck. In the literature, there are very few studies on dislocation of hip arthroplasty in this particular group of patients. The majority of the studies focus on patients with degenerative joint disease. Patients with femoral neck fracture not only run a substantial increased risk of dislocations, but they are also generally older and have more frequent co-morbidities compared to patients with a degenerative joint disease. Therefore, there are good reasons to conduct studies including only fracture patients.

The influence of the surgical approach on the stability of a hip arthroplasty

Anterolateral versus posterolateral approach

The results in both *Studies I* and *II* strongly indicate that a posterolateral surgical approach, as compared to an anterolateral one, carries a significantly increased risk for dislocation of the prosthesis in patients with fractures of the femoral neck treated with an HA or a THA.

In *Study I*, the risk for dislocation was profoundly increased after a posterolateral approach, both with posterior repair (8.5%) and without posterior repair (13%), compared to the anterolateral approach (3.0%), while other factors such as age, gender, indication for surgery, the surgeon's experience and type of HA did not appear to affect the dislocation rate. The results for the THA patients in *Study II* are similar, but there was an even more evident increased risk following a posterolateral approach, both with posterior repair (12%) and without posterior repair (14%), compared to the anterolateral approach (1.9%). The patient's age, gender, the indication for surgery, the experience of the surgeon, and the femoral head size did not influence the dislocation rate for THAs.

The optimal surgical approach for HA and THA is still controversial. A recent Cochrane Review (Parker and Pervez 2002) presented only one RCT comparing various surgical approaches in patients with femoral neck fractures (Sikorski and Barrington 1981). The authors studied 114 patients with a femoral neck fracture treated with a cemented Thompson HA prosthesis. Owing to the quality of information obtained from this single trial, the Cochrane reviewers were not able to draw any conclusion regarding the optimal surgical approach with regards to dislocations. We have not found any RCT comparing various surgical approaches for THA in fracture patients.

Our finding of an increased dislocation rate for HA after the posterolateral approach is in accord with those of previously conducted non-randomised trials. In a systematic review of the literature, Varley and Parker (2004) reported an increased dislocation rate using the

posterior approach, as compared to the anterior one, 5.1% versus 2.4%. In a prospective study on 531 patients, Keene and Parker (1993) reported an increased dislocation rate using the posterolateral approach in comparison with the anterolateral one. Finally, in a retrospective study, Pajarinen et al. (2003) reported a dislocation rate of 16% using the posterior approach as compared to 7% using the anterior approach in 338 patients treated with a Thomson HA.

For THA and the anterolateral approach, our dislocation rate of 2% is equivalent to previous results for THA using the anterolateral approach in two RCTs from our institution. Tidermark et al. (2003b) reported a 2% dislocation rate after THA in an RCT comparing IF and THA, and Blomfeldt et al. (2007) did not find any dislocation in either of the arthroplasty groups in an RCT comparing bipolar HA and THA. These results are on a par with the 1% dislocation rate reported for all arthroplasties in the multicentre RCT by Keating et al. (2006), comparing IF, bipolar HA, and THA. A higher dislocation rate (8%) was reported by Baker et al. (2006) in an RCT comparing IF with THA also using the anterolateral approach.

Our results for the posterolateral approach in *Study II* with 12% and 14% dislocations in patients after THA using the posterolateral approach with, and without posterior repair, are of the same magnitude as reported for the THA groups in RCTs utilising the posterolateral approach. In an RCT comparing IF and THA, Johansson et al. (2000) reported a 22% dislocation rate after THA. Skinner et al. (1989) reported a 13% dislocation rate for THA in an RCT comparing IF, unipolar HA, and THA. In a 13-year follow-up of the same patient population, the dislocation rate in the THA group had increased to 20% (Ravikumar and Marsh 2000). This cumulative long-term risk of dislocation has been highlighted in two other recent studies, although containing only a small number of patients with femoral neck fractures (Berry et al. 2004, von Knoch et al. 2002).

The incidence of dislocation as related to surgical approaches is difficult to assess within the context of a conventional randomised study. Therefore, a large prospective cohort trial such as the present ones, including consecutive patients and in which the selection of the surgical approach at each point in time was determined by the individual surgeon's preference, is a good approach only surpassed in quality by a trial using randomisation by surgeon. We have therefore good reason to assume that our conclusions regarding the studied risk factors for dislocation are valid for these patient cohorts.

The strengths of *Studies I* and *II* are the large number of consecutively entered patients, a homogeneous group of patients, the relatively long follow-up period, and the validation of dislocation data via the Swedish National Board of Health and Welfare's nationwide registry.

One important reason why dislocations are so frequent after the posterolateral approach in elderly patients with femoral neck fractures may be that a posterior dislocation in the hip results from a flexion/internal rotation, a much more common position in the daily life of an elderly patient compared to extension/external rotation, the position which may result in an anterior dislocation. We did not find any case of inter-prosthetic dissociation of bipolar HAs necessitating open reduction indicating that modern bipolar surgical systems have a more stable construct to prevent dissociation between the inner and the outer head.

We did find a lower rate of dislocations in THA patients (1.9%) compared to HA patients (3.0%) when using an anterolateral approach. This is most probably due to a selection of patients with more severe cognitive dysfunction and other co-morbidities in the HA group.

Posterolateral approach with or without posterior repair

Our results in *Study I* indicate that a posterior repair may reduce the dislocation rate after an HA using the posterolateral approach, although not to the same extent as when using an anterolateral approach, and the difference did not reach statistical significance. In a retrospective review including HA patients Ko et al. (2001) compared the dislocation rate for 1483 patients operated on via the posterior approach without posterior repair between 1986 and 1997, with 205 patients operated with posterior repair between 1998 and 1999. A posterior approach with reattachment of the capsule and the external rotators was claimed to reduce the dislocation rate from 1.9% to zero. However, in the former group 19% of the patients were excluded due to incomplete records and inadequate follow-up and in the latter group the posterior repair procedure was performed or supervised by two of the authors with special interest in hip arthroplasty surgery. These circumstances may reduce the generalisability of the results of the study, a notion that is supported by the remarkably low dislocation rate compared to previous studies (Pajarinen et al. 2003, Varley and Parker 2004).

In *Study II* we could not demonstrate any positive effect of posterior repair in THA patients operated with a posterolateral approach. This is in contrast to the results of a recent meta-analysis by Kwon et al. (2006) comprising 4115 patients from 5 studies, in which the dislocation rate for THA was 0.5% for patients with a posterior repair, and 5% for those without. However, only two of the included studies reported on the preoperative diagnosis and in those only a minority of the patients were operated due to fractures of the femoral neck (5%) or sequelae after femoral neck fractures (15%). The conclusion that a posterior repair greatly reduces the risk for dislocations is therefore probably most valid for patients with degenerative joint disease.

One weakness of *Studies I* and *II* is that the information concerning the posterior repair is from a review of the medical charts for each separate patient and there could be patients in whom a repair had been performed without being recorded.

Selection of surgical approach

There may be other reasons for selecting the surgical approach than the risk of a dislocation. A posterior approach has been suggested to be easy to perform using less extensive tissue dissection which may result in a shorter operating time and less blood loss and is also considered to be associated with less gait problems. The advocated advantages of an anterior approach, apart from a decreased risk for dislocations, are a decreased risk of injury to the sciatic nerve and a better exposure of the acetabulum. In a recent Cochrane review (Jolles and Bogoch 2006) of patients treated with THA due to OA, the authors were not able to find any differences in Trendelenburg gait, injury to specific nerves (including the sciatic nerve), post operative pain or the Harris Hip Score one year after surgery. Keene and Parker (1993) reported in a study on HA patients an increased rate of thrombosis after a posterior approach and longer operating times, increased blood loss and more infections after the anterior approach. Sikorski and Barrington (1981) reported more general medical complications and an increased mortality in patients operated with an HA via a posterior approach compared to an anterior one. We could not demonstrate any differences in mortality or other complications except dislocations when

comparing patients operated on using anterolateral or posterolateral approaches in *Studies I* and *II*.

When discussing the selection of surgical approach it is often stated that the most important factor in order to avoid dislocations is that the surgeon uses the approach with which he or she is most familiar. Sköldenberg et al. (meeting abstract Swedish Orthopaedic Association annual meeting 2009) recently presented data on dislocations for patients treated with HA or THA due to a femoral neck fracture from an institution were the majority of the surgeons used the posterolateral approach but were recommended to change to the anterolateral approach. The dislocation rate during the time period when most surgeons used the posterolateral approach was 7.6% which decreased to 1.2% during the period when the majority of the surgeons had changed to the anterolateral approach. It should be noted that all dislocations during the second time period were in patients in whom the surgeon chose to continue to use the posterolateral approach. Furthermore, it should also be noted that the learning curve for the anterolateral approach was included in the second time period for several of the surgeons. The results of this study suggest that, for this patient group, it is safe and rewarding to change from the posterolateral to the anterolateral approach in order to reduce the rate of dislocations.

Other factors influencing the stability of an arthroplasty

Age and gender

We could not demonstrate any influence of age or gender on the risk of dislocation in our patients treated with HA or THA due to a femoral neck fracture. This is in contrast to previous studies focusing mainly on OA patients in which advanced age (Berry et al. 2004, Meek et al. 2006) and female gender (Woo and Morrey 1982, Berry et al. 2004) are mentioned as risk factors for prosthetic dislocations. Difficulties in complying with range-of-motion limitations, poor vision and poor coordination are suggested to be causes of the increased risk associated with advanced age (Woolson and Rahimtoola 1999), whereas the possible mechanism behind an increased risk for females is unclear.

Primary versus secondary arthroplasty

We did not find any difference in the rate of dislocations when comparing primary and secondary HAs or THAs. This finding is in contrast to a previous report from a non-randomised study by Roberts and Parker (2002) in which they reported 0.8% and 4% dislocations among patients operated with a primary or secondary Austin-Moore HA prosthesis respectively. In a prospective case-control study, McKinley and Robinson (2002) reported an increased number of dislocations after a secondary THA (20%) compared to a primary one (8%), all being performed via a posterior approach. A similar finding was reported by Woo and Morrey (1982), 12% after a secondary THA and 9% after a primary one.

There are no obvious reasons why a secondary arthroplasty should have an increased dislocation rate. On the one hand, the surgical procedure during a secondary operation is often more technically demanding. In addition, these patients have often suffered a long period of

time with pain and disability prior to the secondary operation resulting in poor muscle function. But on the other hand, this operation is usually an elective procedure with an optimised patient. Moreover, the stiff joint capsule developed during the often long time to failure of the internal fixation may also decrease the risk of instability, comparable to that of patients with a degenerative joint disease.

Size of the femoral head

A larger femoral head size has been suggested to reduce the risk of dislocation. This has been reported in clinical studies (Amstutz et al. 2004, Berry et al. 2005, Hedlundh et al. 1996a) as well as in experimental ones (Kluess et al. 2007), while some studies have not demonstrated this positive effect (Woo and Morrey 1982). We could not demonstrate any effect of the size of the femoral head on the risk for dislocations in THA patients in *Study II*. Although our univariable regression analysis suggested a lower dislocation risk for the 28-mm head than for the 22-mm head, this could not be confirmed in the multivariable analysis. This finding could be explained by the fact that the majority of the patients operated with a 22-mm femoral head were operated using a posterolateral approach. We have not found any previous studies including only fracture patients addressing this issue.

Experience of the surgeon

It has been reported that inexperienced surgeons are associated with an increased incidence of dislocations compared to more experienced ones when performing THA (Hedlundh et al. 1996b). Surprisingly, the experience of the surgeons did not significantly affect the risk of dislocation in any of our studies. This may be partly explained by the fact that the registrars at our department are routinely assisted by a senior orthopaedic surgeon when performing an HA or a THA procedure.

Cognitive function

A limitation of *Studies I* and *II* is the lack of a preoperative assessment of cognitive function based on a validated instrument. Cognitive dysfunction appears to be a significant risk factor for dislocation in hip fracture patients treated with a primary THA (Johansson et al. 2000), but its influence on the dislocation rate after a primary HA has not been properly evaluated. In *Study I*, as expected the dislocation rate was higher among patients with cognitive dysfunction or dementia compared to those without, but there was no selection based on cognitive function to any of the surgical approaches. In *Study II* 3% of patients had diagnosed dementia, but there was no selection bias with regard to dementia to any of the approaches. We have for a long time avoided performing THA in patients with severe cognitive dysfunction/dementia. However, performing a THA may be necessary in single patients with severe cognitive dysfunction/dementia, e.g. in patients with severe pain due to avascular necrosis or a present OA.

Recurrence of dislocations and need for revision surgery

The number of patients suffering from recurrent dislocations was high; in *Study I* 44%, in *Study II* 64% and in *Study III* 62%. These incidences are in line with two previous studies reporting high incidences of recurrent dislocations (both 60%) in patient cohorts mainly including patients with OA (Yuan and Shih 1999, Kotwal et al. 2009). Keene and Parker (1993) reported 47%, and Pajarinen et al. (2003) reported 50% recurrent dislocations in HA patients.

In *Study II* revision surgery due to instability of the THA was performed in 27% of the patients during the study period, which was slightly lower than the 35% reported by Woo and Morrey (1982) in a study with a similar follow-up time. These high figures underline the fact that instability is a severe complication often necessitating major revision surgery in order to regain stability, a procedure that is far from always being successful. Woo and Morrey (1982) reported that the instability persisted in one third of the hips revised due to recurrent dislocations.

Quality of life

In *Study III*, a dislocation, especially if recurrent, had a significant negative effect on the quality of life during the first year after the hip arthroplasty in patients treated with HA or THA after a femoral neck fracture. To the best of our knowledge, the impact of a prosthetic dislocation on the HRQoL has not been evaluated previously in a prospective cohort study on patients with femoral neck fractures treated with a primary arthroplasty.

In a retrospective study Kotwal et al. (2009) used the EQ-5D and Oxford Hip Score (OHS) (Dawson et al. 1996) to analyse the influence of prosthetic dislocations on HRQoL in 69 patients operated with THAs due to various diagnosis. They found no difference in EQ-5D 1.5–7.3 years after surgery between patients with dislocations and a control group, but reported that both patients with single and recurrent dislocations presented a worse outcome in OHS compared to the control patients. Furthermore, Forsythe et al. (2007) reported in a retrospective case-control study on patients with THAs that they did not find any significant difference in HRQoL assessed with WOMAC (Bellamy et al. 1988) and SF-12 (Ware et al. 1996) approximately 1.5 years after the index operation in 32 patients who had had 1–3 dislocations during the first postoperative year compared to the control group.

However, due to the retrospectively design of both these studies, the HRQoL was not assessed at any previous point in time. Moreover, although not stated in the paper by Forsythe et al., considering the mean age of the patients in that study, i.e. 69–70 years, their subjects were probably mainly elective patients with a diagnosis of degenerative joint disease, as were the patients in the study by Kotwal et al. Patients operated upon for degenerative joint disease are generally younger and have less co-morbidity than fracture patients and therefore the influence of a dislocation on the quality of life may differ between these patient categories.

The limited decline in the EQ-5D $_{index}$ score reported by our patients with no dislocation was of the same magnitude as has previously been reported for patients with femoral neck fractures treated with primary THA or HA not experiencing a dislocation (Tidermark et al. 2003b, Blomfeldt et al. 2007). The substantial deterioration in HRQoL reported at 4 months in patients

with a single dislocation and at both follow-ups for those who suffered from recurrent dislocations is comparable to what has been reported for patients with displaced femoral neck fractures with a fracture-healing complication after internal fixation (Tidermark et al. 2002), indicating that a dislocation has a profound effect on the patients' perceived quality of life.

Our further analysis of the EQ-5D dimensions indicates that the difference between patients with recurrent dislocations and those without dislocations at one year was mainly due to perceived difficulties in self-care, usual activities and increased problems with anxiety/depression, while the patients did not report more pronounced problems concerning mobility and pain/discomfort. These findings imply that an unstable hip arthroplasty usually functions well between the dislocation occasions, but the patients do not rely on the operated hip and constantly fear an additional dislocation and therefore experience difficulties in performing certain daily activities.

A limitation of *Study III* is that the prefracture EQ-5D $_{index}$ score is based on how our patients rated their HRQoL the week before the fracture, i.e. a retrospective rating. The patients' ability to correctly recall their health status prior to the hip fracture may be questioned. However, since a prospective collection of HRQoL baseline data for a specific injury population is impossible, the alternative methods often used are preinjury recall, as in this and other trauma studies (MacKenzie et al. 1993, Tidermark et al. 2003b, Blomfeldt et al. 2007). The assessment by our patients regarding their EQ-5D $_{index}$ score the week before the fracture was comparable or slightly lower than those of similar age groups in the Swedish reference population (Burstrom et al. 2001), indicating that they did not overestimate their preinjury HRQoL. Another limitation is the missing values for the EQ-5D $_{index}$ score at the different follow-ups, but since the missing data were similarly distributed among the three groups (0, 1 or ≥ 2 dislocations), we believe that the data were missing in a random fashion. Therefore, the mixed-effect model that uses all available data on each patient should not bias our results and influence our conclusions.

The major strength of this study is its multicentre design, allowing the inclusion of a large number of consecutive patients with fractures of the femoral neck treated with a primary arthroplasty from a well-defined population during a defined period of time.

Direction of prosthesis dislocation

Our finding in *Study IV* that the direction of dislocation of an HA in patients with a femoral neck fracture is highly dependent on the surgical approach has not been reported previously. In the absence of an acetabular component, the direction of dislocation is influenced by the position of the femoral component and/or the surgical approach. The position of the femoral stem may differ slightly between the different approaches but, on the other hand, the condition for an optimal implant position is an important characteristic of the surgical approach. Therefore, the surgical approach is likely to be the most important factor deciding the direction of dislocation and it is reasonable to assume that the femoral head is prone to dislocate in a direction in which the soft tissues have been weakened by surgery in HA patients.

Furthermore, we found no significant difference in the direction of dislocation between patients operated on with THA via the anterolateral or posterolateral approach. The interpretation of these results is, however, difficult as 25% of the THA patients had a superior dislocation. The superior dislocations are most likely a result of an anterior or a posterior dislocation in which the abductor muscles have pulled the dislocated femur in a cranial direction, leaving the femoral head in a position superior to the socket.

The method we used to assess the direction of dislocation, i.e. from radiographs, may be criticised although the same method has been used in previous studies (Woo and Morrey 1982, Cobb et al. 1996). As our analysis is based only on primary and early (within one year after surgery) dislocations, it is however unlikely that a prosthesis would dislocate anteriorly and then move all the way around the acetabulum (HA) or the acetabular component (THA) to end up in a posterior position, or *vice verse*, at the time when the radiograph is taken. It is therefore reasonable to assume that the position of the dislocated prosthesis represents the route for the dislocation. The exception is a superior dislocation as discussed above. An alternative method for assessing the direction of dislocation could be to test the stability and the direction of the dislocation of the prosthesis at the time of the reduction manoeuvre. However, this may be difficult to perform in routine health care since many of the reductions are performed by junior surgeons outside office hours who may be reluctant to redislocate the hip after a successful reduction.

Position of implants

The association between the position of the acetabular component and the risk for dislocation has been discussed in several studies. The socket is usually recommended to be inserted with an inclination angle of 30° to 50° and an anteversion angle of 5° to 25° (Lewinnek et al. 1978, Ali Khan et al. 1981, Dorr and Wan 1998, Biedermann et al. 2005). In our study the angle of anteversion was greater for patients with anterior dislocations than for those with posterior dislocations. This is in line with the results of Biederman et al. (2005) who reported an increased relative risk/OR for anterior dislocation as anteversion of the acetabular component increased and *vice versa* for posterior dislocations. However, other authors have not been able to demonstrate any correlation between socket anteversion and the risk for dislocations (Pierchon et al. 1994, Pollard et al. 1995, Paterno et al. 1997). The influence of the angle of inclination on the direction of the dislocation is even more unclear. Our results, as well as those of others do not support the view that this is a factor of major importance as long as the inclination is within recommended limits (Pierchon et al. 1994, Pollard et al. 1995, Paterno et al. 1997, Biedermann et al. 2005).

Our method for assessing the position of the acetabular component has limitations even though it has been used by several previous authors (Woo and Morrey 1982, Daly and Morrey 1992, Pollard et al. 1995, Cobb et al. 1996, Paterno et al. 1997, Zwartele et al. 2004). In particular, measuring the anteversion of the socket may be difficult as no true reference line is available in the pelvis. However, the method gives a fair estimate of the position of the socket and gross malpositioning can be appreciated. Another weakness of this study is the lack of assessments of the femoral stem anteversion. However, the orientation of the femoral

component is assumed to be less critical than that of the acetabular component and the most common cause of dislocation is malpositioning of the acetabular component (McCollum and Gray 1990, Daly and Morrey 1992, Morrey 1997). A more detailed analysis of the position of the acetabular component and the femoral stem anteversion requires assessment by CT (Mian et al. 1992, Pierchon et al. 1994, Olivecrona et al. 2004). In summary, the weaknesses of our study, as stated above, should not jeopardise the validity of our main conclusions.

One strength of *Study IV* is that the patient cohort was well defined with regard to the pre-operative diagnosis, a similar follow-up time and the fact that they were all treated at one hospital during a defined period of time where the selection of the surgical approach at each point was determined by the individual surgeon's preference. Another strength is that the radiological analysis was performed by an independent radiologist who was blinded to the surgical approach.

Clinical implications

When performing a hip arthroplasty on patients with femoral neck fractures using an anterolateral approach, the risk for dislocation is only 2–3%, which is on a par with the dislocation rate following THA in OA patients. According to the Swedish Hip Arthroplasty Register there were about 1400 patients operated with a THA, and about 4500 operated with an HA due to a hip fracture in Sweden during 2008. According to the same register, 49% of these HAs and 44% of the THAs were performed using a posterior approach. Theoretically, applying the results from *Study I* (HA; 3.0% dislocations with AL and mean 10.4% with PL±posterior repair) and *Study II* (THA; 1.9% dislocations with AL and mean 12.8% with PL±posterior repair) to these figures, a changeover to using the anterolateral approach in all patients would reduce the number of patients suffering a dislocation by approximately 200–250 patients a year in Sweden. This would spare these patients a substantial decrease in HRQoL caused by the dislocations and also spare 35–50% of them from having to undergo revision surgery due to recurrent dislocations.

We suggest that the anterolateral approach should be used as the standard surgical approach for primary and secondary hip arthroplasties in patients with femoral neck fractures, and we have good reasons to assume that the shift from the posterolateral to the anterolateral approach can be performed safely.

Conclusions

Study I

In patients treated with HA due to a femoral neck fracture the posterolateral approach, as compared to the anterolateral one, was associated with a significantly increased risk for dislocation of the prosthesis. A posterior repair appears to reduce the dislocation rate although not to the same low level as in patients operated on using the anterolateral approach. The patients' age, gender, the indication for surgery, the surgeon's experience and the type of HA did not affect the dislocation rate.

Study II

In patients operated upon using a THA after a fracture of the femoral neck the posterolateral surgical approach, as compared to an anterolateral one, carries a significantly increased risk of prosthetic dislocation. This was so regardless of whether a posterior repair was performed or not. The patients' age, gender, the indication for surgery, the surgeon's experience and the size of the femoral head did not affect the dislocation rate.

Study III

In patients treated with a primary hip arthroplasty due to a fracture of the femoral neck, dislocation of the prosthesis had a significant negative effect on the HRQoL during the first year after the surgery. A recurrent dislocation of the arthroplasty appears to result in a persistent deterioration in the HRQoL, while patients with a single dislocation appear to experience only a temporary deterioration. A further analysis of the EQ-5D dimensions indicates that the difference is mainly due to perceived difficulties in self-care, usual activities and increased problems with anxiety/depression in patients with recurrent dislocations.

Study IV

In patients with a primary dislocation of an HA or a THA within one year after prosthesis surgery due to a femoral neck fracture, the surgical approach significantly influenced the direction of prosthesis dislocation in patients treated with HA, while no such correlation was found after THA. This suggests that the surgical approach is only one of several factors affecting the direction of dislocation after THA. Our results imply that the position of the acetabular component might be one important factor.

Overall conclusion

A dislocation of the prosthesis is a common and serious complication after arthroplasty in patients with a fracture of the femoral neck. Besides previously reported negative effects on reoperation rates, hospital costs and mortality, a dislocation, especially if recurrent, has a significant negative effect on the quality of life. An important factor in reducing the overall dislocation rate after both HA and THA in these patients is the use of an anterolateral surgical approach instead of a posterolateral one.

Implications for future research

- A number of studies have suggested that a posterior repair during a posterolateral approach might reduce the risk of dislocations. There is no study addressing the issue of "anterior repair", which could include a surgical technique in which the capsule is preserved and reattached when performing an anterolateral approach. However, based on the low incidences of dislocations even in fracture patients when employing an anterolateral approach, a power analysis indicates that such an RCT would need to include approximately 1500 patients.

- In *Study I*, we observed a trend towards more dislocations among bipolar as compared to unipolar cemented HAs. Furthermore, an increased risk for "revision of all causes" was reported by the Swedish Hip Arthroplasty Register 2007 when comparing bipolar HAs with unipolar HAs. There is no obvious explanation for this, but it is obvious that it has to be ruled out since most of the HAs implanted in Sweden have a bipolar design.

Abstract in Swedish

Operation med en höftprotes av felställda frakturer genom lårbenshalsen är idag en rutinbehandling med goda resultat avseende höftfunktion och hälsorelaterad livskvalitet. Vanligt är att äldre patienter med denna typ av fraktur opereras med en halvprotes (HA) medan yngre patienter opereras med en total höftprotes (THA). En relativt vanlig och fruktad komplikation är dock att protesen vrids ur led (luxerar). En luxation innebär kraftig smärta och att patienten måste läggas in akut på sjukhus och sövas för att man skall kunna vrida tillbaka protesen till rätt läge. Risken för en luxation är betydligt högre för patienter som opererats med höftprotes på grund av en fraktur jämfört med de som opererats på grund av artros. Flera riskfaktorer har betydelse för luxationsrisken, och av dessa är den kirurgiska snittföringen den mest kontroversiella. Vidare är effekten av luxationer på patienternas livskvalitet ofullständigt känd. Kunskapen om åt vilket håll/riktning lårbensprotesen luxerar ur ledskålen är viktig för att kunna positionera protesdelar optimalt under en operation, samt för att kunna utforma optimala postoperativa rehabiliteringsprogram i syfte att minska antalet luxationer.

I S*tudie I* analyserades riskfaktorer för luxationer i en prospektiv kohortstudie med 739 höfter opererad med HA på grund av en fraktur genom lårbenshalsen. Den bakre snittföringen var jämfört med den främre associerad med en ökad risk för protesluxation. Patientens ålder, kön, indikationen för kirurgi, kirurgens erfarenhet eller typen av HA hade ingen betydelse för luxationsrisken.

I *Studie II* analyserades riskfaktorer för luxationer i en prospektiv kohortstudie med 713 höfter opererad med THA på grund av en fraktur genom lårbenshalsen. Den bakre snittföringen var jämfört med den främre associerad med en ökad risk för protesluxation även i denna studie. Patientens ålder, kön, indikationen för kirurgi, kirurgens erfarenhet eller storleken på proteshuvudet hade ingen betydelse för luxationsrisken.

I *Studie III,* en prospektiv multicenter studie följdes 319 patienter under 1 år efter att ha opererats med en HA eller en THA på grund av en fraktur genom lårbenshalsen. Patienter som drabbades av en luxation uppvisade lägre hälsorelaterad livskvalitet jämfört med de som inte drabbades. De patienter som luxerade upprepade gånger uppvisade en oförändrad betydande nedsättning av sin livskvalitet, till skillnad från de patienter som drabbades av endast en luxation vilka återhämtade sin livskvalitet.

I *Studie IV* studerades betydelsen av den kirurgiska snittföringen för riktningen av en protesluxation hos 74 patienter med en luxation av en HA eller en THA inom 1 år efter operation på grund av en fraktur genom lårbenshalsen. Snittföringen hade betydelse för luxationsriktningen hos patienter som opererats med HA, men ej hos THA patienterna. Detta antyder att snittföringen endast är en av flera faktorer av betydelse för luxationsriktningen hos THA patienter, och att positioneringen av protesens ledskål kan vara en ytterligare faktor av betydelse.

De viktigaste konklusionerna av denna avhandling är att luxationer påverkar hälsorelaterad livskvalitet negativt, samt att ett främre snitt bör användas vid proteskirurgi hos patienter med en fraktur genom lårbenshalsen för att minska risken för luxationer

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* Mwalimu is a Swahili word meaning "the teacher". It is the finest title of honour in Tanzania, and it refers to Julius Nyerere who was originally a countryside teacher before he led the country through a peaceful independence process. He became the country´s first president and in time a beloved symbol for good leadership and education. He was, and is, always referred to as Mwalimu.

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