Mesh versus non-mesh for inguinal and femoral hernia repair (Protocol)

Lockhart K, Teo E, Teo S, Dhillon M, van Driel ML

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[Intervention Protocol]

Mesh versus non-mesh for inguinal and femoral hernia repair

Kathleen Lockhart[1], Edward Teo[2], Shawn Teo[3], Manvinder Dhillon[4], Mieke L van Driel[5]

[1]Townsville Hospital, Douglas, Australia. [2]Gold Coast Hospital & Health Service, Gold Coast, Australia. [3]Faculty of Medicine, Nursing and Health Sciences, Monash University, Clayton, Australia. [4]Department of Surgery, Ipswich General Hospital, Queensland Health, Ipswich, Australia. [5]Discipline of General Practice, School of Medicine, The University of Queensland, Brisbane, Australia

Contact address: Edward Teo, Gold Coast Hospital & Health Service, 1 Hospital Boulevard, Southport, Gold Coast, Queensland, 4215, Australia. eteo@outlook.com. edward.teo@health.qld.gov.au.

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ABSTRACT

This is the protocol for a review and there is no abstract. The objectives are as follows:

To evaluate the outcomes of inguinal and femoral hernia repair techniques in adults, specifically comparing closure with mesh versus without mesh.

BACKGROUND

Description of the condition

A hernia is defined as a protrusion of an organ or part of an organ through the body wall that normally contains it (Brooks 2014a). Abdominal wall hernias are common, with a prevalence in the general population of 4% for those aged over 45 years (Jenkins 2008). Inguinal and femoral hernias are known collectively as groin hernias (Brooks 2014a). Of all groin hernias, 96% are inguinal and 4% are femoral (Rutkow 1993). Men are eight times more likely to develop a groin hernia than women and 20 times more likely to require a groin hernia repair (Brooks 2014a).

Groin hernias may present as a heaviness or discomfort in the groin region, or a visible or palpable bulge. Discomfort is usually most pronounced when intra-abdominal pressure is increased, for example with heavy lifting, straining or prolonged standing. Risk factors for groin hernias include history of hernia or prior hernia repair, older age, male sex, chronic cough, chronic constipation, abdominal wall injury, smoking and family history of hernia (Brooks 2014a). The current literature seems to support the view that obesity may be a protective factor for groin hernias (Liem 1997; Rosemar 2008; Ruhl 2007).

Inguinal hernias are the most common type of hernia in both genders, accounting for 75% of all abdominal wall hernias, with a lifetime risk of 27% in men and 3% in women (Jenkins 2008). Inguinal hernias are classified as congenital or acquired (Brooks 2014a). Congenital inguinal hernias are caused by a failure of the processus vaginalis (invagination of the parietal peritoneum that precedes the migration and descent of the testes in males) to close. The portion of the processus vaginalis within the inguinal canal is called the 'canal of Nuck' in females and usually obliterates by the eighth foetal month of life (Brooks 2014a). In contrast, acquired hernias are due to the weakening or disruption of the fibromuscular tissues of the abdominal wall, allowing the protrusion of intra-abdominal contents through the acquired defect (Brooks 2014a). This may be facilitated by inherent connective tissue abnormalities, chronic abdominal wall injury (including any chronic in-

creased intra-abdominal pressure) and possibly adverse effects of drugs such as glucocorticoids (thinning of skin and weakening of soft tissues) or smoking (Brooks 2014a; Cannon 1981; Sorenson 2002). Acquired hernias can present acutely and may require emergency surgical intervention.

Inguinal hernias are further classified as indirect or direct. Indirect inguinal hernias protrude through the internal inguinal ring, which is the site where the spermatic cord in males and the round ligament in females exits the abdomen (Brooks 2014a). Direct inguinal hernias protrude medial to the inferior epigastric vessels within Hesselbach's triangle (formed by the inguinal ligament inferiorly, the inferior epigastric vessels laterally and the rectus abdominis muscle medially) (Brooks 2014a). Femoral hernias are located inferior to the inguinal ligament and protrude through the femoral ring, medial to the femoral sheath containing the femoral artery and vein. Femoral hernias are acquired; the femoral ring can widen with age or injury (Brooks 2014a). Femoral hernias represent 20% to 31% of repairs in women compared to only 1% in men (Brooks 2014a).

It is important to differentiate femoral hernias from inguinal hernias given that femoral hernias are more likely to strangulate. As women are more likely to have femoral hernias than men, a relatively high proportion of women who present acutely with a symptomatic acquired hernia will require emergency management compared to their male counterparts. (Dahlstrand 2009; Koch 2005; Rosemar 2010). Classically, femoral hernias present as mildly painful non-reducible groin lumps located inferolateral to the pubic tubercle; inguinal hernias are generally found superolaterally to the pubic tubercle (Whalen 2011). However, femoral hernias tend to move above the inguinal ligament, where they may be mistaken for an inguinal hernia. Differentiation on clinical grounds is notoriously unreliable, and unrelated to the experience of the examining practitioner (Whalen 2011). Ultrasonography, computed tomography or even diagnostic laparoscopy may have a role in further investigation of hernia type or occult hernia (Brooks 2014a; Whalen 2011).

Groin hernias may present as emergencies with complications such as bowel incarceration and obstruction or strangulation (Brooks 2014a). Incarceration refers to the irreducible trapping of hernia contents within the hernia sac. Reduced venous and lymphatic flow leads to swelling of the incarcerated tissue, which can lead to impediment of arterial supply resulting in ischaemia and necrosis of the hernia contents (strangulation). The overall risk of incarceration and strangulation is low, between 0.3% and 3% per year (Brooks 2014a; Fitzgibbons 2006; Gallegos 1991).

Description of the intervention

The definitive treatment of all hernias is surgical repair, regardless of hernia origin or type. Repair of inguinal hernias is one of the most common general surgical procedures performed (McCormack 2003; Rutkow 1993). Urgent emergency surgical repair is indicated for patients who develop complications. If this is undertaken within approximately four to six hours from onset of symptoms, an emergency surgical repair may prevent loss of bowel from prolonged strangulation (Brooks 2014b). However, for uncomplicated hernias, the optimal timing of repair and aspects of repair technique remain controversial. Currently it is recommended that patients with symptomatic hernias should undergo an elective hernia repair. For patients who are asymptomatic but have risk factors for groin hernia incarceration or strangulation, a hernia repair is generally undertaken as soon as is feasible (Brooks 2014b). For male patients with minimal symptoms, with a 'watchful waiting' approach to treatment, the cumulative probability of developing problems such as increasing pain, incarceration or strangulation is 2.8% at three months, 4.5% to 23% at two years and 31% at four years (Fitzgibbons 2006; Gallegos 1991; O'Dwyer 2006).

The aim of hernia repair surgery is not only to fix the current hernia defect, but also to reduce the risk of recurrence. Recurrence rates for primary hernia repair range from 0.5% to 15% depending on the hernia site, type of repair and clinical circumstances (Brooks 2014b).

Groin hernia repairs can involve the use of a mesh (otherwise known as a hernioplasty) or no mesh (that is, herniorrhaphy). The mesh used in hernia repair is typically made from a synthetic polymer, usually polypropylene, which is inert and does not cause abnormal inflammation. The mesh is lightweight and flexible, and designed to avoid impediment of local structures or positional movement. Meshes may be held in place using partially dissolvable sutures and/or a fibrin glue, of which the glue may produce a more effective seal (Brooks 2014b). A mesh repair involves covering the hernial defect by placing the mesh on one of the layers of the abdominal wall either using an open approach or a minimal access laparoscopic technique (McCormack 2003). The approach to repair depends on a number of factors in each individual case, including the type of hernial defect, patient factors and the surgeon's preference. With the open approach, the repair is generally anterior to the hernial defect, whereas laparoscopic repair is approached from a posterior aspect. Prosthetic mesh is being increasingly incorporated into hernia surgery (either open or laparoscopic) as a component of tension-free repair (Brooks 2014b).

Open techniques for inguinal hernia repairs include tension-free mesh repairs such as the Lichtenstein, plug and patch, and Kugel (preperitoneal) repairs, and non-mesh primary tissue approximation repairs such as the Shouldice, Bassini and McVay repairs (Brooks 2014b). In the tension-free mesh repair category, the mesh is placed in front of the transversalis fascia, such as with the Lichtenstein tension-free hernioplasty, or behind the transversalis fascia in the preperitoneal space, for example, the Kugel procedure (Amid 2005). With the tissue approximation repairs, which do not involve mesh placement, the Shouldice technique is generally the preferred suture-based repair, which involves a four-layer reconstruction of the fascia transversalis. Alternatives to the Shouldice technique include the original Bassini method in which

the edges of the defect are simply sewn back together with tension and, less commonly, the McVay method. The McVay method involves reinforcement of the inguinal canal by approximating the transversus abdominis aponeurosis and transversalis fascia to the pectineal ligament, thus restoring the canal floor by bringing together the femoral sheath and the inguinal ligament. It is important to note that the McVay style of repair is also typically used in open femoral hernia repairs, with possible approaches from an infra-inguinal (Lockwood), trans-inguinal (Lotheissen) or supra-inguinal (McEvedy) aspect (Amid 2005).

The two main laparoscopic groin hernia repairs are the totally extraperitoneal (TEP) and transabdominal preperitoneal patch (TAPP) repairs (Bittner 2011), both requiring the use of a mesh. TEP repair is performed by gaining access to the preperitoneal space (that is, the space between the peritoneum and the anterior abdominal wall) using an anterior approach, without ever actually entering the abdomen (Ferzli 1998; McKernan 1993). A TAPP repair, on the other hand, requires the surgeon to enter the peritoneal (abdominal) cavity to access the preperitoneal space. Some of the more significant disadvantages of this approach include potential injury to adjacent organs and, long-term, adhesions resulting in bowel obstruction (Wake 2005; Vader 1997).

Common early complications of hernia repair surgery include wound seroma or haematoma, urinary retention, bladder injury and superficial wound infection. Complications that may occur later following hernia repair surgery include persistent groin pain and post-herniorrhaphy neuralgia, testicular complications, deep wound or mesh infection, recurrent hernia and mesh migration or erosion (Brooks 2014c). The incidence of post-surgical complications is more common following emergent repairs and recurrent hernia repairs (Brooks 2014c).

A Cochrane review published in 2008 showed that whilst laparoscopic repairs were associated with quicker recovery times and less persistent pain, the procedure itself usually takes longer and has higher rates of bladder and vascular injuries. Hernia recurrence post laparoscopic mesh repair was less common compared to open non-mesh repair, with the main indicator of recurrence related to the use of a mesh rather than the approach itself (McCormack 2003).

How the intervention might work

Prior to 1958, abdominal wall hernias were closed with primary suture repair. Tension on the weak fascia was thought to be one of the main contributing factors to repair failure. Then, in 1958, Dr Francis Usher published his 'tension-free' technique using a permanently implanted polypropylene mesh (Read 1999). This led to the Lichtenstein repair some 30 years later, which popularised mesh for hernia repair. The logic that Usher used to explain his use of polypropylene mesh was this: the mesh was a material that could be used to close over the hernial defect and provide ongoing reinforcement to the attenuated fascia of the abdominal wall by encouraging growth of connective tissue (scar tissue) around and through the mesh fibres (Doctor 2006). It was expected that the best meshes would be those made of very strong material and able to induce the most fibrosis. Unfortunately, this fibrotic reaction led to pain and movement restriction and it soon became clear that this needed to be reduced. In order to do this, the surface area, and therefore strength, of the mesh had to be reduced. Calculations of intra-abdominal pressures proved that this would be possible without compromising mesh function. In fact, the tensile strength of a mesh required to withstand the maximum abdominal pressure is only a tenth of that of most meshes (Brown 2010). This realisation led to the concept of light-weight meshes.

Light-weight meshes were first introduced in 1998 (Vypro) and their superiority over the heavy-weight meshes is now widely accepted. These meshes have large pores (normally 3 to 5 mm) and a small surface area. They stimulate a reduced inflammatory reaction and, therefore, have greater elasticity and flexibility (Klinge 2008). They also shrink less and have been shown to cause less pain compared to heavier meshes after Lichtenstein inguinal hernia repairs. Unfortunately, despite these improvements, patients continue to have complications such as recurrence, infection and adhesion formation (Brown 2010). Thus, the search for an ideal mesh continued.

The difficulty of finding a single, 'ideal' mesh is acknowledged by the development of composite meshes. These combine more than one material and are the basis of most new mesh designs. The main advantage of the composite meshes is that they can be used in the intraperitoneal space with minimal adhesion formation. Despite the vast selection of brands available, nearly all these meshes continue to use one of the three basic materials: polypropylene, polyester and expanded polytetraflouroethylene (ePTFE). These are used in combination with each other or with a range of additional materials such as titanium, omega 3, Monocryl, polyvinylidene difluoride (PVDF) and hyaluronate. However, as might be expected, none of these synthetic materials are without disadvantages (O'Dwyer 2005).

The problems encountered with synthetic materials led to the development of bio-materials, which are currently the most physiologically based implants. These consist of an acellular collagen matrix derived from human dermis (Aderm) or porcine small intestine submucosa (Surgisis). The matrix allows soft tissue to infiltrate the mesh which eventually becomes integrated into the body by a process of remodelling. Unfortunately, this process also appears to lead to a rapid reduction in their mechanical strength, and concerns regarding this have restricted their use to infected environments (where one would normally use an absorbable synthetic material such as Vicryl) (Brown 2010).

Why it is important to do this review

Currently, about one million meshes are used per year world-wide in hernia repairs (Klinge 2002). In 2002, the EU Hernia Trialists

Collaboration analysed 58 randomised controlled trials and found that the use of mesh was superior to other techniques; in particular, the meta-analyses noted fewer recurrences and less postoperative pain with mesh repair compared to all other techniques (EU Hernia Trialists 2002). Despite the favourable results of mesh repair and its adoption as common practice in developed countries, it has yet to be integrated as standard practice by all surgeons (Nixon 2009). Non-mesh repairs are still commonly performed worldwide, particularly in developing countries; for example, in African countries, when surgical treatment is provided (65% to 75% as an emergency procedure rather than elective), fewer than 5% of hernias are repaired using implanted mesh (Yang 2011). This is likely to be related to the increased costs involved in mesh (and also laparoscopic) repair which can be unaffordable in countries where the typical per capita government health expenditure (USD 28 in Ghana, USD 7 in Uganda) is usually less than the price of a single-use package of commercial mesh (USD 40 to 100) (Yang 2011). The biological meshes are available at an even higher cost (Klinge 2008). Research into low-cost mesh alternatives (such as mosquito-net mesh) and innovative construction of standard commercial meshes are being undertaken and show promise (Yang 2011).

An updated meta-analysis of the current literature is needed regarding the use of mesh in inguinal and femoral hernia repairs. In clinical practice, laparoscopy is increasingly used as the operative approach of choice. To address this, this review will provide a comprehensive analysis of trials exploring the use of mesh in the context of all operative approaches. The previous Cochrane review considering mesh versus non-mesh repairs specified only open repair as an inclusion criterion, and did not include the increasingly favoured laparoscopic approach.

OBJECTIVES

To evaluate the outcomes of inguinal and femoral hernia repair techniques in adults, specifically comparing closure with mesh versus without mesh.

METHODS

Criteria for considering studies for this review

Types of studies

All individual parallel and cluster randomised controlled trials (RCTs) investigating mesh techniques for open or laparoscopic repair of inguinal or femoral hernias are eligible for inclusion.

Types of participants

All persons with a clinically diagnosed inguinal or femoral hernia, or both, where surgical management is indicated.

Types of interventions

Any of the following mainstream techniques for surgical repair of an inguinal or femoral hernia are accepted:

- Concerning inguinal hernias:
  - Mesh repairs:
    - ◇ Open; including Lichtenstein approach
    - ◇ Laparoscopic; including transabdominal preperitoneal (TAPP) and totally extraperitoneal (TEP) approaches
    - ◇ Any type of commercially marketed non-absorbable mesh or absorbable biomesh may be used; including 'plug-and-patch' kits (that is, absorbable plugs/tacks with (non-)absorbable patch/mesh)
  - Suture repairs:
    - ◇ Tension; including Bassini, McVay and Shouldice approaches
    - ◇ Tension-free; including Desarda and Guarnieri approaches
    - ◇ Any type of commercially marketed non-absorbable or absorbable sutures may be used
- Concerning femoral hernias:
  - Mesh repairs:
    - ◇ Open mesh/mesh plug repair
    - ◇ Laparoscopic; including TAPP or TEP approaches
    - ◇ Any type of commercially marketed non-absorbable mesh or absorbable biomesh may be used; including 'plug-and-patch' kits (that is, absorbable plugs/tacks with (non-)absorbable patch/mesh)
  - Suture repairs:
    - ◇ Open McVay suture repair; including Lockwood's infra-inguinal, Lotheissen's trans-inguinal and McEvedy's high approaches
    - ◇ Any type of commercially marketed non-absorbable or absorbable sutures may be used

Types of outcome measures

Primary outcomes

1. Recurrence of the same hernia (i.e. excludes formation of a hernia at a new site not previously repaired or reinforced) due to:

i) Failure of operation (with recurrence within 3 months of surgery, unless otherwise specified)

ii) Weakening of the abdominal wall (with recurrence occurring after 12 months of surgery, unless otherwise specified)

2. Surgical complications, including but not limited to:

i) Acute (within 30 days of surgery) major complications: neurovascular or visceral injury, wound dehiscence and deep wound (and mesh) infections

ii) Acute (within 30 days of surgery) minor complications: haematoma or seroma formation, and superficial wound infections

iii) Chronic (present at one year postoperatively and for at least three months in duration) complications: chronic pain, paraesthesia or numbness (measurable using standardised pain and numbness scores, for example, Visual Analogue Scales, which can be reassessed at 3, 6, 9 and 12 months).

Secondary outcomes

1. Duration of surgical operation (measurable in minutes)
2. Duration of postoperative hospital stay (measurable in days)
3. Time required to return to full activities of daily living including work and exercise (measurable in days)
4. Number of operations where 'opposite' method had to be initiated (that is, conversion from laparoscopic to open approach)
5. Mortality (that is, number of associated deaths within 30 days of the operation during the study trial period)
6. Cost of surgery and hospital admission

Search methods for identification of studies

Electronic searches

We will search the Cochrane Colorectal Cancer Group Specialized Register, Cochrane Central Register of Controlled Trials (CENTRAL) latest issue (Appendix 1), MEDLINE (1950 to current date) (Appendix 2), EMBASE (1974 to current date) (Appendix 3) and Web of Science (1985 to current date) (Appendix 4). We will impose no publication or language restrictions.

Searching other resources

We will search relevant clinical trials registers such as the World Health Organization (WHO) International Clinical Trials Registry Platform (ICTRP) (http://www.who.int/ictrp/en/) and ClinicalTrials.gov (http://clinicaltrials.gov/) for completed and ongoing trials. We will also search reference lists of included trials and review articles, search books related to surgical hernia repairs, search abstracts from general surgical conferences concerning hernias and mesh repair, and send written enquiries to the authors of major relevant studies and experts in the field. We will also contact pharmaceutical companies to obtain access to any unpublished trial data, should there be any.

Data collection and analysis

Selection of studies

Three review authors (KL, ET, ST) will assess titles and abstracts retrieved from the search to determine their relevance concerning the objectives of this review. We will manage disagreements through discussion, a deciding arbiter (MD) or both. We will enter all search results into Review Manager 5.3 (RevMan 2014).

Data extraction and management

Two review authors (KL, ET) will design a data extraction sheet for study reports, which will be pilot tested using sample studies and revised by the other authors (MD, MVD). Onto this report, two authors (KL, ST) will independently extract and record key features of each study including details of the:

- Authors
- Date and place of publication
- Study design
- Inclusion and exclusion criteria
- Setting
- Summary of study participant characteristics
- Summary of intervention and control conditions
- Number of participants in each arm (including dropouts)
- Adverse events
- Outcome measurement and assessment time points
- Risk of bias (as per the domains specified in Assessment of risk of bias in included studies)
- Any relevant additional comments reported by the study authors

We will manage disagreements through discussion, a deciding arbiter (MVD) or both. We will enter and present the data for each included study into a table in Review Manager 5.3 (RevMan 2014).

Assessment of risk of bias in included studies

Two review authors (KL, ST) will independently analyse each study in conjunction with The Cochrane Collaboration's tool for assessing 'Risk of bias' (Higgins 2011). This approach uses a domain-based evaluation that aims to address main potential areas of bias in studies, where a grade (that is, either low, high or unclear) is assigned for each of the following domains:

- Random sequence generation (low risk if true random sequence generation was described)
- Allocation concealment (low risk if sealed, opaque, numbered envelopes or central allocation after registration)
- Blinding of participants and assessors (low risk if both the participant and the assessor were blinded to either intervention or treatment arms)

- Incomplete or selective outcome data reporting (low risk if > 80% of those randomly assigned were assessed)
- Any other potential sources of bias (such as, study stopped early because of a data-dependent process, notable baseline imbalance, study funding from a profit-based organisation, surgeon competence or experience).

A high risk of bias indicates that the study design has not met the criteria for a low risk classification as noted above for each of the respective domains. Similarly, an unclear risk of bias denotes that the study has not declared sufficient information regarding their study design to make a judgement. We will manage any disagreements through discussion, a deciding arbiter (MVD) or both. We will present our assessment of risk of bias for the included studies in the 'Risk of bias' summary tables and graphs as generated through input into Review Manager 5.3 (RevMan 2014).

Measures of treatment effect

1. We will present dichotomous (binary) data as a measure of risk and relative risk by using an odds ratio (OR) with 95% confidence intervals (CIs). Where possible, we will calculate the absolute risk reduction (ARR) and number needed to treat to benefit (NNTB) or number needed to treat to harm (NNTH) for comparison against other treatments or non-treatment.
2. We will present continuous data as a mean difference (MD) if the same scale is used. Alternatively, a standardised mean difference (SMD) will be calculated (that is, an average of the combined standard deviations) in the event that each study uses a different scale. In this case, we will also assess the impact of using the highest verses the lowest of the available standard deviations (SD) on the overall estimate of effect. If SDs are not reported we will estimate the SD based on similar studies and use this in the meta-analysis (Higgins 2011).
3. We will present data reported as rates as a rate ratio. We will use rates to express outcomes over time. This may be expressed as a rate ratio, which may demonstrate outcomes more clearly than a risk ratio as it accounts for the likelihood that some participants may experience multiple events (Higgins 2011).

Unit of analysis issues

We envisage that the unit of analysis in our review will be the participant. Nonetheless:

1. if the unit of analysis is not the same as the unit of randomisation, such as in cluster-randomised trials, we plan to adjust for clustering by using the guidance given in the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2011);
2. if there are multiple measurements for the same participant (e.g. multiple hernias in the same person), we plan to analyse the data as in a cluster-randomised trial.

Dealing with missing data

We intend to contact the trial authors of the original studies when further data or information is required. We will perform analyses based on intention-to-treat (ITT) principles, whereby the missing data for randomised participants will be assumed to be treatment failures in this review. This approach of ITT analysis (that is, assuming drop-outs as failures) may underestimate the effect of the intervention, therefore we may perform both ITT and on-treatment (that is, non-ITT) analyses to explore the impact of missing data on the overall outcome (Higgins 2011). Furthermore, for continuous data we will assess the impact of missing data on the overall estimate of effect by imputing missing data in the following ways: best case scenario where the missing data are considered 2 SD greater in the intervention arm than in the control arm and worst case scenario where the missing data are considered 2 SD less than in the control arm.

Assessment of heterogeneity

We will assess the included studies for heterogeneity through three successive steps to determine if they should be pooled with the rest of the included studies or considered separately:

1. Two review authors will independently analyse the included studies for their 'face-value' similarities; that is, for the extent of clinical of diversity (participants, interventions and outcomes), and for methodological diversity (study design and risk of bias).
2. We then intend to assess the included studies for statistical heterogeneity using the Chi^2 test with a P value of less than 0.10 being statistically significant.
3. We then intend to calculate the I^2 statistic as instructed in the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2011); where 0% to 40% is likely to indicate minimal heterogeneity, 30% to 60% may represent moderate heterogeneity, 60% to 90% may represent substantial heterogeneity, and 90% to 100% may represent considerably significant heterogeneity. The importance of the observed value of I^2 does depend on the magnitude and direction of the treatment effects, and strength of evidence for heterogeneity (that is, the P value from the Chi^2 test or the confidence interval for I^2).

Assessment of reporting biases

If a sufficient number of studies have been pooled (that is, greater than 10, we plan to use a funnel plot to inspect visually the risk of publication bias, whereby more pronounced asymmetry of the funnel plot may be indicative of a substantial overestimation of the intervention effect (Higgins 2011).

Data synthesis

We will synthesise the data using one of these two methods:

1. We will use the fixed-effect model in the absence of statistical heterogeneity according to the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2011), where the analysis will produce an estimate of the true effect.

2. We will use the random-effects model in the event of statistical heterogeneity for pooling the study data using the Mantel-Haenszel method according to the *Cochrane Handbook for Systematic Review of Interventions* (Higgins 2011), where the analysis produces an average effect. In the event that there is an insufficient number of studies to produce an average effect in a random-effects model, a fixed-effect model will be used.

3. Where cluster RCTs are included, we will use the generic inverse variance method (Higgins 2011).

If studies are clinically heterogeneous, we will not pool them in meta-analysis.

Subgroup analysis and investigation of heterogeneity

If sufficient data are available, we intend to explore further the treatment effect in specific subgroups, including:

- inguinal versus femoral hernia;
- direct versus indirect inguinal hernia;
- male versus female participants;
- elective versus emergency surgery;
- different types of mesh; for example, biological versus composite synthetics.

Sensitivity analysis

If sufficient data are available, we intend to perform sensitivity analyses:

1. In order to determine the impact of risk of bias on the overall effect estimate, we will add high risk of bias studies to low risk of bias studies and compare the results.

2. In order to determine the impact of heterogeneity on the overall estimate of effect, we will remove studies that contribute to heterogeneity from the analyses and compare the results.

We intend to use two different methods of pooling to test sensitivity by pooling all studies together and then removing studies from the meta-analysis one by one, and noting if there has been any significant change in the overall results; simultaneously, we will also compare the use of a fixed-effect versus random-effects model for the pooling analysis as we exclude each study one by one.

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* *Indicates the major publication for the study*

APPENDICES

Appendix 1. CENTRAL search strategy

#1 MeSH descriptor: [Hernia, Inguinal] explode all trees
#2 MeSH descriptor: [Hernia, Femoral] explode all trees
#3 ((Inguina* or femoral or groin*) and herni*):ti,ab,kw
#4 (#1 or #2 or #3)
#5 MeSH descriptor: [Laparoscopy] explode all trees
#6 MeSH descriptor: [Herniorrhaphy] explode all trees
#7 MeSH descriptor: [Sutures] explode all trees
#8 ((laparascop* or open or hernia*) and (repair or surg* or intervent* or operat* or approach* or technique*)):ti,ab,kw
#9 (herniorrhaph* or hernioplast* or sutur* or tension* or Lichtenstein* or transabdominal preperitoneal or TAPP or totally extraperitoneal or TEP or Bassini* or McVay* or Shouldice* or Desarda* or Guarnieri* or Lockwood* or Lotheissen* or McEvedy*):ti,ab,kw
#10 (#5 or #6 or #7 or #8 or #9)
#11 MeSH descriptor: [Surgical Mesh] explode all trees
#12 (mesh* or plug*):ti,ab,kw
#13 (#11 or #12)
#14 (#4 and #10 and #13)

Appendix 2. MEDLINE (Ovid) search strategy

1. exp Hernia, Inguinal/
2. exp Hernia, Femoral/
3. ((Inguina* or femoral or groin*) and herni*).mp.
4. 1 or 2 or 3
5. exp Laparoscopy/
6. exp Herniorrhaphy/
7. exp Sutures/
8. ((laparascop* or open or hernia*) and (repair or surg* or intervent* or operat* or approach* or technique*)).mp.
9. (herniorrhaph* or hernioplast* or sutur* or tension* or Lichtenstein* or transabdominal preperitoneal or TAPP or totally extraperitoneal or TEP or Bassini* or McVay* or Shouldice* or Desarda* or Guarnieri* or Lockwood* or Lotheissen* or McEvedy*).mp.
10. 5 or 6 or 7 or 8 or 9
11. exp Surgical Mesh/
12. (mesh* or plug*).mp.
13. 11 or 12
14. 4 and 10 and 13
15. randomized controlled trial.pt.
16. controlled clinical trial.pt.

17. randomized.ab.
18. placebo.ab.
19. clinical trial.sh.
20. randomly.ab.
21. trial.ti.
22. 15 or 16 or 17 or 18 or 19 or 20 or 21
23. humans.sh.
24. 22 and 23
25. 14 and 24

Appendix 3. EMBASE (Ovid) search strategy

1. exp inguinal hernia/
2. exp femoral hernia/
3. ((Inguina* or femoral or groin*) and herni*).mp.
4. 1 or 2 or 3
5. exp laparoscopy/
6. exp herniorrhaphy/
7. exp suture/
8. ((laparascop* or open or hernia*) and (repair or surg* or intervent* or operat* or approach* or technique*)).mp.
9. (herniorrhaph* or hernioplast* or sutur* or tension* or Lichtenstein* or transabdominal preperitoneal or TAPP or totally extraperitoneal or TEP or Bassini* or McVay* or Shouldice* or Desarda* or Guarnieri* or Lockwood* or Lotheissen* or McEvedy*).mp.
10. 5 or 6 or 7 or 8 or 9
11. exp surgical mesh/
12. (mesh* or plug*).mp
13. 11 or 12
14. 4 and 10 and 13
15. CROSSOVER PROCEDURE.sh.
16. DOUBLE-BLIND PROCEDURE.sh.
17. SINGLE-BLIND PROCEDURE.sh.
18. (crossover* or cross over*).ti,ab.
19. placebo*.ti,ab.
20. (doubl* adj blind*).ti,ab.
21. allocat*.ti,ab.
22. trial.ti.
23. RANDOMIZED CONTROLLED TRIAL.sh.
24. random*.ti,ab.
25. 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24
26. 14 and 25

Appendix 4. Science Citation Index-Expanded/Conference Proceedings Citation Index-Science

#1 TI=(((Inguina* or femoral or groin*) and herni*))
#2 TOPIC: (((laparascop* or open or hernia*) and (repair or surg* or intervent* or operat* or approach* or technique*)))
#3 TOPIC: ((herniorrhaph* or hernioplast* or sutur* or tension* or Lichtenstein* or transabdominal preperitoneal or TAPP or totally extraperitoneal or TEP or Bassini* or McVay* or Shouldice* or Desarda* or Guarnieri* or Lockwood* or Lotheissen* or McEvedy*))
#4 (#3 OR #2)
#5 TI=((mesh* or plug*))
#6 (#5 AND #4 AND #1)
#7 TOPIC: (((controlled trial or controlled clinical trial or placebo or clinical trial or random* or trial or cct or rct)))
#8 (#7 AND #6)

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DECLARATIONS OF INTEREST

None of the authors have any conflicts of interest to declare.

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