Meta-analysis of randomized controlled trials comparing laparoscopic with open mesh repair of recurrent inguinal hernia

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Background: Although there is plentiful evidence regarding the use of laparoscopic surgery for primary inguinal hernia, there is a paucity of literature concerning its role after recurrence. There has been no quantitative review of the evidence, despite suggestions that pooled analysis of existing data is required.

Methods: Medline, Embase, trial registries, conference proceedings and reference lists were searched for controlled trials of laparoscopic versus conventional open surgery for mesh repair of recurrent hernia. The primary outcomes were recurrence and chronic pain. Secondary outcomes were operating time, visual analogue pain score, superficial wound infection, haematoma or seroma formation, time to return to normal activities and serious complications requiring operation. Pooled odds ratios were calculated for categorical outcomes and weighted mean differences for continuous outcomes.

Results: Four trials were included in the analysis. There was no effect on recurrence or chronic pain. Laparoscopic surgery was associated with significantly less postoperative pain, a quicker return to normal activities and fewer wound infections, at the cost of a longer operating time. There was no difference in haematoma formation or the need for additional operations.

Conclusion: Careful patient selection and surgeons’ experience are important in the selection of technique for recurrent inguinal hernia repair.

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Introduction

Hernia repair is one of the commonest procedures performed by general surgeons; indeed, it has been stated that 'the history of hernia repair is the history of surgery'. Inguinal hernias affect 0.14 per cent of the population and account for 70,000 operations per year in the UK. The advent of laparoscopy has revolutionized abdominal surgery and a large body of evidence has been amassed to compare laparoscopic and open techniques in the repair of primary inguinal hernias. Advantages of laparoscopic procedures may include a reduction in postoperative pain and hospital stay, and the ability to undertake a simultaneous repair of symptomatic incipient contralateral herniation. However, open repair can be performed under local anaesthesia and is preferred by many surgeons.

The repair of recurrent inguinal hernia is a more complex undertaking, accounting for up to 15 per cent of all hernia surgery. Although there is plentiful evidence in primary disease, few controlled studies have compared outcome of laparoscopic surgery with that of open tension-free mesh repair for recurrent inguinal hernia. There has hitherto been no meta-analysis of results, despite suggestions that a pooled analysis of these individually small trials is required to eliminate any type II error.

Methods

An electronic search was performed using the Embase and Medline databases from 1966 to 2009. The search terms ‘hernia’, ‘recurrent’, ‘laparoscopic’, ‘TAPP’, ‘TEP’, ‘Lichtenstein’ and MeSH headings ‘Laparoscopy’ (MeSH), ‘Hernia, Inguinal’ (MeSH) were used in combination with the Boolean operators AND or OR. Two authors independently performed electronic searches in July 2009. The electronic search was supplemented by a handsearch of published abstracts from meetings of the Surgical Research Society, the Society of Academic and Research
Surgery, the Association of Surgeons of Great Britain and Ireland, the European Hernia Society, the Asia Pacific Hernia Society and the American Hernia Society from 1980 to 2009. The reference lists of articles obtained were also searched to identify further relevant citations. Finally, the search included the Current Controlled Trials Register (http://www.controlled-trials.com) and the Cochrane Database of Controlled Trials.

Abstracts of the citations identified by the search were then scrutinized by two of the authors (A.K. and S.R.M.) to determine eligibility for inclusion in the meta-analysis. Studies were included if they were controlled trials in which patients underwent either laparoscopic or tension-free open mesh repair of recurrent inguinal hernia. Previous studies have shown there to be no significant difference in outcomes between giant prosthesis for reinforcement of the visceral sac (GPRVS) and Lichtenstein or transabdominal preperitoneal (TAPP) and totally extraperitoneal (TEP) operations when performed for recurrent or bilateral hernias. These techniques were therefore pooled into composite ‘tension-free open mesh repair’ and ‘tension-free laparoscopic mesh repair’ groups for analysis.

The primary outcome measures for the meta-analysis were postoperative hernia recurrence and the development of chronic pain. Chronic pain was defined as ‘severe chronic pain’ after at least 1 year. Secondary outcome measures were operating time, mean linear pain score on a visual analogue scale (VAS) during the first 7 days after surgery, superficial wound infection, haematoma or seroma formation, time to return to normal activities, and the incidence of complications requiring further surgery. This final composite outcome measure was defined as the need for additional operations during or after the hernia repair to treat complications. Superficial wound infections were defined as those treated without further surgery and were identified by clinical examination without microbiological confirmation. Haematoma or seroma formation was identified by clinical examination alone before discharge from hospital, without the requirement for radiological confirmation. The time to return to normal activity was defined as the time taken for patients to return to work after surgery; all patients were encouraged to return to work as soon as possible, irrespective of their job or the operative technique employed.

Statistical analysis
Data from eligible trials were entered into a computerized spreadsheet for analysis. The quality of each trial was assessed using the Jadad scoring system. Statistical analysis was performed using StatsDirect 2.5.7 (StatsDirect, Altrincham, UK). Weighted mean difference was calculated for the effect size of laparoscopic surgery on continuous variables such as operating time, postoperative pain VAS and time to return to normal activity. Pooled odds ratios were calculated for the effect of laparoscopic surgery on discrete variables such as postoperative wound infection, haematoma or seroma, recurrence and development of chronic pain.

All pooled outcome measures were determined using random-effects models as described by DerSimonian and Laird. Heterogeneity among the trials was assessed by means of the $I^2$ inconsistency test and Cochran’s Q statistic, a null hypothesis test in which $P < 0.050$ is taken to indicate the presence of significant heterogeneity. The Egger test was used to assess the funnel plot for significant asymmetry, indicating possible publication or other biases.

Results

The initial search identified 728 publications (Fig. 1). After screening, six prospective trials were identified. One study compared laparoscopic and open surgery in the repair of a composite group of bilateral and recurrent inguinal hernias. It was not possible to obtain data for the recurrent hernia group in isolation by contacting the study authors and so this trial was excluded from pooled meta-analysis. One study did not randomize trial participants between operative techniques. Sensitivity analysis by removing this trial revealed its significant effect on pooled operating times (Fig. 2). Therefore, this trial was also excluded from the final meta-analysis. One study randomized two cohorts separately to TAPP or TEP laparoscopic surgery, and both were pooled separately for analysis. Surgical techniques in the ‘tension-free open mesh repair’ group included both GPRVS and Lichtenstein operations. The ‘tension-free laparoscopic mesh repair’ group included both TAPP and TEP operations (Table 1).

Primary outcome measures

Recurrence
All four trials reported hernia recurrence after repair of recurrent inguinal hernia and there was no significant difference between laparoscopic and open groups (pooled odds ratio 0.84 (95 per cent confidence interval (c.i.) 0.33 to 2.17); $P = 0.724$) (Fig. 3). There was no significant statistical heterogeneity (Cochran’s $Q = 6.27$, $P = 0.180$; $I^2 = 0.36$ (95 per cent c.i. 0.00 to 0.76)) or bias (Egger test $= -0.51$, $P = 0.701$).

Chronic pain
There was no significant effect of laparoscopic surgery on development of chronic pain (more than 1 year after surgery).
Fig. 1 QUOROM diagram for review. RCT, randomized controlled trial

Table 1 Characteristics of trials included in final meta-analysis

<table>
<thead>
<tr>
<th>Study</th>
<th>No. of patients</th>
<th>Study design</th>
<th>Jadad score</th>
<th>Pain scoring system</th>
<th>Intraoperative anaesthesia</th>
<th>Postoperative anaesthesia</th>
<th>Operative technique</th>
<th>Mean(s.d.) length of follow-up*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beets et al.8 1999</td>
<td>79</td>
<td>RCT</td>
<td>2</td>
<td>VAS and VRS</td>
<td>General</td>
<td>Paracetamol 1 g TDS (as needed)</td>
<td>Open: GPRVS 37</td>
<td>34 (6–50) months†</td>
</tr>
<tr>
<td>Dedemadi et al.5 2006</td>
<td>82</td>
<td>RCT</td>
<td>2</td>
<td>Pain score at rest</td>
<td>General</td>
<td>Paracetamol</td>
<td>Open: Lichtenstein 32</td>
<td>5 years</td>
</tr>
<tr>
<td>Eklund et al.9 2007</td>
<td>147</td>
<td>Multicentre RCT</td>
<td>3</td>
<td>VAS</td>
<td>General 117</td>
<td>Paracetamol 325 mg + dextropropoxyphene 32.5 mg</td>
<td>Open: Lichtenstein 74</td>
<td>1087(588) days</td>
</tr>
<tr>
<td>Kouhia et al.10 2009</td>
<td>96</td>
<td>RCT</td>
<td>2</td>
<td>—</td>
<td>Spinal 46</td>
<td>Opioid + other unspecified analgesic</td>
<td>Open: Lichtenstein 47</td>
<td>5 years</td>
</tr>
</tbody>
</table>

*Values are mean(s.d.) unless indicated otherwise; †mean (range). RCT, randomized controlled trial; VAS, visual analogue scale; VRS, verbal rating scale; TDS, three times daily; GPRVS, giant prosthesis for reinforcement of the visceral sac; Lap, laparoscopic; TAPP, transabdominal preperitoneal; TEP, totally extraperitoneal.
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- Beets et al.8
- Feliu et al.14
- Dedemadi et al.5 – TAPP
- Dedemadi et al.5 – TEP
- Eklund et al.9
- Kouhia et al.10

Pooled effect size

a Including Feliu et al.14 trial

b Excluding Feliu et al.14 trial

Fig. 2 Sensitivity analysis illustrating the influential effect of the non-randomized trial by Feliu and colleagues.14 a Initial forest plot of weighted mean difference in operating times between laparoscopic and open surgery before this trial was removed. b Forest plot showing final analysis of weighted mean difference in operating times between laparoscopic and open tension-free mesh repair of recurrent inguinal hernia incorporating only randomized controlled trials. Weighted mean differences are shown with 95 per cent confidence intervals.

surgery), which was reported by three trials8–10 (pooled odds ratio 0·91 (95 per cent c.i. 0·14 to 5·88); P = 0·921) (Fig. 4). There was no significant statistical heterogeneity (Cochran’s Q = 4·52, P = 0·104; I² = 0·56 (95 per cent c.i. 0·00 to 0·86)). Too few trials provided data to allow calculation of statistical bias.

Secondary outcome measures

Postoperative pain scores

Two trials contained data regarding postoperative pain scores measured on a VAS in the first 7 days after surgery8,9. Laparoscopic surgery was associated with a significant reduction in pain VAS (weighted mean difference −0·58 (95 per cent c.i. −0·84 to −0·31); P < 0·001) (Fig. 5). There was no evidence of significant heterogeneity (Cochran’s Q = 0·52, P = 0·471). There were too few data to allow calculation of the I² value for heterogeneity or to apply the Egger test to evaluate statistical bias.

Superficial wound infection

All four trials reported superficial wound infection treated by antibiotics5,8–10. Laparoscopic surgery was associated with significantly fewer superficial wound infections than open surgery in pooled analysis (pooled odds ratio 0·29 (95 per cent c.i. 0·08 to 0·96); P = 0·043) (Fig. 6). There was no statistical evidence of heterogeneity (Cochran Q = 0·96, P = 0·916; I² = 0·00 (95 per cent c.i. 0·00 to 0·64)) or bias (Egger test = −0·14, P = 0·936).

Operating time

All included trials reported length of operation5,8–10. Laparoscopic surgery took significantly longer than the open procedure (weighted mean difference 0·68 (95 per cent c.i. 0·23 to 1·13) min; P = 0·003) (Fig. 2b). However, there was evidence of significant statistical heterogeneity (Cochran’s Q = 20·07, P < 0·001; I² = 0·80 (95 per cent c.i. 0·37 to 0·90)) and significant
Combined (random)

![Forest plot](image)

**Fig. 4** Forest plot for pooled odds ratio of the development of chronic pain after laparoscopic or open tension-free mesh repair of recurrent inguinal hernia. Odds ratios are shown with 95 per cent confidence intervals.

<table>
<thead>
<tr>
<th>Odds ratio</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.80</td>
<td>(0.09, 109.10)</td>
</tr>
<tr>
<td>5.21</td>
<td>(0.19, infinity)</td>
</tr>
<tr>
<td>0.26</td>
<td>(0.06, 0.94)</td>
</tr>
<tr>
<td>0.91</td>
<td>(0.14, 5.88)</td>
</tr>
</tbody>
</table>

**Return to daily activity**

Return to normal working activity was reported by all four trials. Laparoscopic surgery significantly shortened the time taken to return to working activities (weighted mean difference $-0.82$ (95 per cent c.i. $-1.27$ to $-0.36$) days; $P < 0.001$) (Fig. 7). However, this outcome measure was associated with significant statistical heterogeneity (Cochran’s $Q = 20.00$, $P < 0.001$; $I^2 = 0.80$ (95 per cent c.i. 0.37 to 0.90)). There was no evidence of significant statistical bias (Egger test $= 5.88$, $P = 0.443$).

**Wound seroma or haematoma**

All four trials reported the development of postoperative seroma or haematoma. There was no significant effect of laparoscopic or open surgery on seroma or haematoma formation (pooled odds ratio $0.65$ (95 per cent c.i. $0.22$ to $1.92$); $P = 0.440$) (Fig. 8). Although there was no statistical evidence of bias (Egger test $= -8.53$, $P = 0.225$), this outcome measure was associated with significant statistical heterogeneity (Cochran’s $Q = 18.38$, $P = 0.001$; $I^2 = 0.78$ (95 per cent c.i. $0.27$ to $0.89$)).

**Complications requiring further surgery**

Three trials reported intraperitoneal complications requiring additional surgery. These comprised reoperation to repair a peritoneal tear in the open group and bleeding from the epigastric artery requiring additional intraoperative or postoperative operations in both groups. There were no injuries to major vascular structures or to an intraperitoneal viscus. There was no significant difference in complications requiring additional surgery between the groups (pooled odds ratio $1.48$ (95 per cent c.i. $0.36$ to $6.10$); $P = 0.585$) (Fig. 9). There was no significant statistical heterogeneity (Cochran’s $Q = 1.65$, $P = 0.438$; $I^2 = 0.00$ (95 per cent c.i. $0.00$ to $0.73$)) and there were insufficient data to carry out the Egger test for bias.

**Discussion**

This meta-analysis demonstrated that laparoscopic tension-free mesh repair of recurrent inguinal hernia did not offer a significant benefit over open tension-free mesh repair in the major outcome measures of preventing future recurrence and chronic pain. Laparoscopic surgery offered benefits in secondary outcome measures by reducing short-term postoperative pain, shortening the time to return to work.
Recurrence affects about 9 percent of repairs of recurrent inguinal hernia and was the first major outcome measure of this meta-analysis. It has been suggested previously that laparoscopic tension-free mesh repair of recurrent inguinal hernia leads to lower rates of recurrence of around 2 percent if performed by experienced surgeons. However, the present meta-analysis of randomized controlled trials demonstrated no significant difference between laparoscopic and open techniques in the rate of recurrence. The reported follow-up was sufficient for detection of recurrence in all analysed trials (Table I), all employed intention-to-treat methodology and the analysis of this important outcome measure may be considered robust in the absence of statistical evidence of bias or heterogeneity. Patient-related risk factors including changes in anatomy after index hernia repair, or surgeon-related factors including the greater likelihood of technical error, increase the likelihood of recurrence independently of the operative work after operation and reducing the incidence of superficial wound infections, but there was a significantly longer operating time in the laparoscopic group.
technique employed for the repair of recurrent inguinal hernia.

Chronic pain is a major cause of morbidity, affecting up to 54 per cent of patients after hernia repair. It is a particular concern after repair of recurrent inguinal hernia. A laparoscopic approach to recurrent hernia repair is favoured by some surgeons as it avoids open dissection through scar tissue, with unfamiliar anatomy and higher theoretical potential for injury to unidentified nerves, lymphatics and blood vessels. However, this theoretical advantage did not translate into a significant difference in the major outcome measure of chronic pain or a significant difference in the secondary outcome measure of haematoma or seroma formation. This may be partly attributable to patient-related risk factors common to both operative techniques, such as young age and high body mass index. The importance of preoperative risk factors for the development of chronic pain may be reflected in the insignificant heterogeneity observed across trials for this primary outcome measure. However, there were too few data to allow calculation of statistical bias, so a degree of caution is required in interpreting results for this outcome measure.

The secondary findings of reduced postoperative pain, fewer superficial wound infections and earlier return to work in the laparoscopic group are not surprising. These findings mirror those noted in repair of primary inguinal hernia and have been replicated in many surgical specialties embracing laparoscopic techniques. A frequently reported disadvantage of laparoscopic surgery is the risk of serious complications requiring additional operations. Major injuries to the bladder, bowel and aorta have all been described during laparoscopic hernia repair. However, in the present meta-analysis there was no significant difference in the incidence of complications requiring operative management during or after recurrent inguinal hernia repair. Furthermore, no major intraperitoneal injury was reported in any of the studied trials.

Laparoscopic surgery was associated with a significant increase in operating time. A sensitivity analysis to ascertain the effect of a non-randomized trial on operating time demonstrated that inclusion of this trial exerted a significant independent effect on pooled operating time analysis, masking the significant difference between laparoscopic and open groups. The final pooled analysis, incorporating only patients subjected to randomized selection, demonstrated significantly longer operating times in the laparoscopic group. This underlined the hazards of selection bias in trial design, as well as the benefits of patient selection for laparoscopic surgery.

Statistical heterogeneity in operating times may reflect the methodological heterogeneity of the trials analysed. In addition to the variety of operations performed within composite laparoscopic and open groups, variation in the seniority of operating surgeons is known to affect outcome in laparoscopic hernia surgery. None of the trials reported single-operator series and so interoperator variability is likely to have contributed to statistical heterogeneity in this outcome measure, a factor that would not compromise the statistical validity of the analysis.

The National Institute for Health and Clinical Excellence (NICE) has produced guidance on this topic. It currently advocates the use of laparoscopic repair for inguinal hernias that are either recurrent or bilateral. Furthermore, NICE places significant emphasis on the surgeon’s experience in laparoscopic repair and stipulates that this is a key factor if laparoscopy is to be considered the preferred technique for recurrent hernia. There was no consensus on a preferred method of laparoscopic repair (TAPP or TEP), and no trials specify a minimum degree of laparoscopic experience to eliminate the learning curve. In addition to emphasizing the importance of operator experience, the guidelines of the European Hernia Society state that the technique used in the index hernia repair should be taken into account when choosing the technique for repair of recurrence. Further research should address the importance of the technique used during index herniorrhaphy and its implications for the choice of technique for recurrent hernia repair.

The potential advantage of a laparoscopic approach after bilateral recurrence compared with unilateral recurrence requires quantification and further study. Furthermore, the Kugel–Ugahary open approach confers a theoretical advantage of providing a better view of the avascular preperitoneal space and level 1 evidence is required to quantify its potential role in the management of recurrent inguinal hernia.

Although laparoscopic repair of primary hernia is more expensive to healthcare providers than open surgery, reduced differences in operating time and more marked reduction in convalescence are seen for bilateral hernias, rendering laparoscopic surgery cost effective in this context. The findings of this meta-analysis imply that these economic conclusions may also apply to recurrent hernia surgery.

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References