

Review

Meta-analysis of laparoscopic groin hernia repair with or without mesh fixation



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ABSTRACT

Objectives: To evaluate comparative outcomes of laparoscopic repair of groin hernia with and without mesh fixation.

Methods: MEDLINE; EMBASE; CINAHL; CENTRAL; the World Health Organization International Clinical Trials Registry; ClinicalTrials.gov; ISRCTN Register, and bibliographic reference lists were systematically checked. Combination of free text and controlled vocabulary search adapted were applied to thesaurus headings, search operators and limits in each of the above databases. Post-operative pain, procedure time, conversion rate, length of hospital stay, time taken to normal activities, overall complications, seroma formation, cost and recurrence were the outcome parameters. Combined overall effect sizes were calculated using fixed-effect or random-effects models. The work has been reported in line with PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) and AMSTAR (Assessing the methodological quality of systematic reviews) Guidelines. This protocol was registered at the International Prospective Register of Systematic Reviews (registration number: CRD42019139564).

Results: We identified 13 randomized controlled trials reporting a total of 1731 patients (2021 groin hernia) evaluating outcomes of laparoscopic hernia repair with mesh fixation using stapler or tacker (n = 853 patients, 999 hernia) and without mesh fixation (n = 878 patients, 1022 hernia). Mesh Fixation was associated with significantly higher post-operative pain assessed by visual analogue scale (VAS) (MD: 0.59; 95% CI, 0.05–1.13, P = 0.03) and longer procedure time (MD: 2.00; 95% CI, 0.98–3.02, P = 0.0001), compared to no fixation technique. However, there was no significant difference in length of hospital stay (MD: 0.09; 95% CI, -0.05–0.23, P = 0.19), time to normal activities, (MD: 0.12; 95% CI, -0.37–0.61, P = 0.69), overall complications (OR: 1.05; 95% CI, 0.77–1.43, P = 0.76), seroma formation (OR: 0.63; 95% CI, 0.39–1.00, P = 0.05) and recurrence rate (RD: 0.00; 95% CI, -0.01–0.01, P = 0.84) between two groups.

Conclusions: Avoiding mesh fixation with a stapler or tacker during laparoscopic groin hernia repair may reduce postoperative pain and procedure time. Future studies are encouraged to evaluate cost effectiveness of each approach.

1. Introduction

Inguinal hernia repair is one of the most frequently performed general surgical procedures [1]. Laparoscopic groin hernia repair has been shown to be an efficient alternative for open surgery with promising outcomes related to postoperative pain, earlier return to work and normal activities, and an improved quality of life in the

postoperative period [2–4]. However, it has a longer learning curve and higher costs [5,6].

Laparoscopic groin hernia repair can be carried out via two approaches: Total extraperitoneal (TEP) repair or transabdominal preperitoneal (TAPP) repair. TEP repair avoids entering the peritoneal cavity and peritoneal closure, but may be more challenging technically than TAPP repair and has a longer learning curve [7–9].

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Regardless of the type of laparoscopic hernia repair, fixation of mesh, using staples or tacks, is an effort to prevent its migration and consequent recurrence with a potential to increase groin pain. However, a meta-analysis of randomized trials in 2012 found no difference in clinical outcomes, including postoperative pain and recurrence, of laparoscopic hernia repair with or without mesh fixation [10]. Several more randomized trials have been carried out since 2012 making conduction of a new meta-analysis worthwhile.

Aim of this study was to conduct a comprehensive systematic review and meta-analysis of reported outcomes to compare laparoscopic hernia repair with and without mesh fixation.

2. Methods

2.1. Design and study selection

Our eligibility criteria, methods, and evaluated outcomes were highlighted in a review protocol. The current study was reported in line with Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement standards [11] and AMSTAR (Assessing the methodological quality of systematic reviews) Guidelines. This protocol was registered at the International Prospective Register of Systematic Reviews (registration number:CRD42019139564).

All randomized controlled trials (RCTs) evaluating the outcomes of laparoscopic groin hernia repair with and without mesh fixation were included. Participants aged 18 years or older and of any gender who underwent laparoscopic groin hernia repair were considered.

The intervention of interest was laparoscopic groin hernia repair with mesh fixation using any type of stapler or tacker. The primary intervention was compared with laparoscopic groin hernia repair without mesh fixation which was defined as leaving the mesh in the correct anatomical position and closing the hernia defect(s) with no attempt to fix the mesh. Transabdominal preperitoneal (TAPP) repair or total extraperitoneal (TEP) repair of groin hernia, direct or indirect inguinal hernia, pantaloon hernia and femoral hernia as described in Nyhus Classification of groin hernias were considered [12].

Primary outcome measures were defined as the post-operative pain intensity assessed on a 10 mm visual analogue scale (VAS) on the day of surgery and within 24 h following surgery. The pain intensity data described by other means than a 10 mm VAS were standardised to such a scale. Procedure time, conversion to an open procedure, length of hospital stay, time taken to normal activities, overall perioperative (in hospital or 30 day) complications, seroma formation, recurrence, and cost effectiveness were the secondary outcome parameters.

2.2. Literature search strategy

Three authors independently searched the following electronic databases: MEDLINE, EMBASE, CINAHL, and the Cochrane Central Register of Controlled Trials (CENTRAL). The literature search was conducted on 18 December 2018. The search strategy was adapted according to thesaurus headings, search operators and limits in the aforementioned databases (Appendix 1). Furthermore, World Health Organization International Clinical Trials Registry <http://apps.who.int/trialsearch/>, ClinicalTrials.gov <http://clinicaltrials.gov/>, and ISRCTN Register <http://www.isrctn.com/> were searched to identify ongoing and unpublished studies. Moreover, the bibliographic lists of relevant articles and reviews were screened for further potentially eligible trials.

2.3. Selection of studies

The title and abstract of identified articles were evaluated by two independent authors. Subsequently, if relevant, the full-texts of identified articles were retrieved and evaluated against the eligibility criteria of our study. Those studies that met our eligibility criteria were included. Discrepancies in this process were resolved by discussion

between the authors. However, if the disagreement still existed, an independent author was consulted.

2.4. Data extraction and management

An electronic data extraction spreadsheet according to the Cochrane's recommendations for intervention reviews was created. The data extraction spreadsheet was pilot-tested in randomly selected articles and adjusted accordingly. The following information were extracted from the included studies by two independent authors:

- Study-related data (first author, publication year, country of origin of the corresponding author, journal in which the study was published, study design, and study size)
- Baseline demographic and clinical information of the study populations (age, gender, weight or body mass index (BMI), type of the hernia as per Nyhus Classification, and laterality)
- Procedural related data (type of procedure, type of anaesthesia, surgeon expertise, type and size of mesh used, method of fixation if any, use of antibiotic and drain)
- Primary and secondary outcome data

Disagreements during data extraction and management were resolved following consultation with a third independent author.

2.5. Assessment of risk of bias

The methodological quality and risk of bias assessment were carried out by two authors using the Cochrane's tool [13] for RCTs. The Cochrane's tool classifies studies into low, unclear and high risk of bias following evaluating and determining the risk of selection bias, performance bias, detection bias, attrition bias, reporting bias, and other sources of bias. We resolved discrepancies in risk of bias assessment by discussion between the assessing authors. Nevertheless, if no agreement could be reached, a third reviewer was involved as an adjudicator.

2.6. Summary measures and synthesis

For dichotomous outcome variables (overall perioperative complications, seroma, recurrence and conversion to an open procedure), the risk ratio (RR) or risk difference (RD) (when more than three studies had zero events in both mesh fixation and no mesh fixation groups) were calculated as the summary measures. The RR is the risk of an adverse event in the mesh fixation group compared to the no mesh fixation group. The RD is the difference in risk of an adverse event in the mesh fixation group compared to the no mesh fixation group. A RR of less than one would favour the mesh fixation group. For continuous parameters (operative time, postoperative pain, length of hospital stay, time to normal activity), the mean difference (MD) between the two groups was calculated.

The number of hernias was used as the unit of analysis for all outcome parameters of this study except for length of hospital stay and time to normal activity where individual patient was used as unit of analysis. Information with regards to dropouts, withdrawals and any other missing data were recorded. It was planned to contact authors of the included studies where information about outcomes of interest were not reported. The final analysis respected the intention-to-treat concept.

One independent review author entered the extracted data into Review Manager 5.3 software for data synthesis [13]. The entered data were subsequently checked by a second independent review author. Random-effects or fixed-effect modelling were used, as appropriate, for analysis. Only when significant between-study heterogeneity existed, random-effects models were applied. This has previously been defined by Higgins et al. [13]. The results of analysis for each outcome parameter were reported in a forest plot with 95% confidence intervals (CIs).

Heterogeneity among the studies was assessed using the Cochran Q

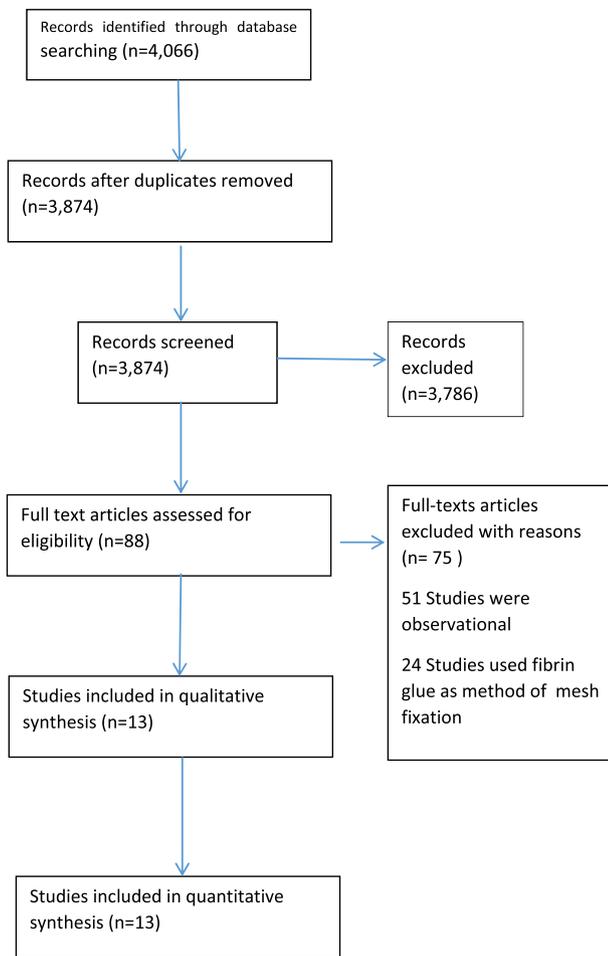


Fig. 1. Study Flow diagram.

test (χ^2). We quantified inconsistency by calculating I^2 and interpreted it using the following guide: 0%–25% might not be important; 25%–75%: may represent moderate heterogeneity; 75%–100% may represent substantial heterogeneity. Moreover, where more than 10 studies were available in analysis of an outcome parameter, funnel plots were constructed in order to assess their symmetry to visually evaluate publication bias.

Sensitivity analyses were conducted to explore potential sources of heterogeneity and assess the robustness of the results. For each outcome parameter, the primary analysis was repeated using random-effects or fixed-effect models. Moreover, for each of the defined dichotomous variable, the pooled Odds ratio (OR), RR, or RD were calculated. Finally, the effect of each study were evaluated on the overall effect size and heterogeneity by repeating the analysis following excluding one study at a time.

3. Results

The literature search through the aforementioned databases identified 4066 articles. After further evaluation of the identified articles, 13 articles [14–26] were deemed appropriate for inclusion (Fig. 1). The included studies consisted of 13 RCT reporting a total of 1731 patients (2021 hernias) of whom 853 (999 hernias) underwent laparoscopic groin hernia repair with mesh fixation and the remaining 878 (1022 hernias) had laparoscopic groin hernia repair without mesh fixation.

Table 1 presents the date of publication and country of origin, journal, and study design of the included studies. Baseline demographic and clinical characteristics of the study populations are presented in Table 2. Patients in the mesh fixation and no mesh fixation groups were

Table 1
Included studies related data.

| Author | Year | Country | Journal | Study design | Blind or not | Method of randomization | Mesh fixation | No mesh fixation |
|-------------|------|----------------|---|------------------|----------------|---------------------------|--------------------|--------------------|
| Ferzli | 1999 | USA | Journal Of American College Of Surgery | Randomized trial | NR | Computer randomization | 50 patient/hernia | 50 patient/hernia |
| Smith | 1999 | UK + Australia | Surgical Endoscopy | Randomized trial | NR | NR | 273 patient/hernia | 263 patient/hernia |
| Moreno-Egea | 2004 | Spain | Archive Of Surgery | Randomized trial | NR | Computer randomization | 85 patient/hernia | 85 patient/hernia |
| Parshad | 2005 | India | Journal Of Society Of Laparoendoscopic Surgeons | Randomized trial | NR | Sealed envelope technique | 25 patient/hernia | 25 patient/hernia |
| Koch | 2006 | USA | Journal Of Society Of Laparoendoscopic Surgeons | Randomized trial | Single blinded | Computer randomization | 20 patients | 20 patient |
| Li | 2007 | China | Chinese Journal Of General Surgery | Randomized trial | NR | Random number tables | 26 hernia | 27 hernia |
| Taylor | 2008 | Australia | Surgical Endoscopy | Randomized trial | Double blinded | Computer/sealed envelope | 30 patient/hernia | 30 patient/hernia |
| Garg | 2011 | India | Surgical Endoscopy | Randomized trial | single blinded | Concealed allocation | 180 patient | 180 patient |
| Ayyaz | 2015 | Ireland | Journal Of Pakistan Medical Association | Randomized trial | Not reported | Lottery: odd versus even | 250 hernia | 250 hernia |
| Claus | 2016 | Brazil | Surgical Endoscopy | Randomized trial | NR | www.randomizer.com | 52 patient | 52 patient |
| Buyukaskik | 2017 | Turkey | Hernia | Randomized trial | NR | Closed envelope | 98 hernia | 96 hernia |
| Redd | 2017 | India | Internal Surgery Journal | Randomized trial | open | NR | 31 patient/hernia | 31 patient/hernia |
| Abd-Raboh | 2018 | Egypt | Journal Of Surgery | Randomized trial | NR | NR | 10 patient/hernia | 50 patient |
| | | | | | | | 50 patient | 68 hernia |
| | | | | | | | 15 | 15 |
| | | | | | | | 31 patient | 27 patient |
| | | | | | | | 35 hernia | 32 hernia |

NR = not reported.

Table 2
Demography and clinical characteristics of the patients.

| Author | Age in years | Male in % | Weight or BMI | Type of hernia as per Nyhus Classification | laterality | History of recurrence |
|-------------|-----------------------------------|------------------|---|---|--|-----------------------|
| Perzli | 55 vs 53 | 100% vs 100% | NR | Type 1 + 2 (indirect): 23 (46%) vs 33 (66%) Type 3 A (direct): 20 (40%) vs 16 (32%) Type 3 B (pantaloon): 7 (14%) vs 1 (2%) Type 3 C (femoral): 1 (2%) vs 0 (0%) Inguinal, details NR | Unilateral: Right 26 (52%) vs 20 (40%) Left 24 (28%) vs 30 (60%) Bilateral: 0 (0%) vs 0 (0%) Unilateral: 249 (91.21%) vs 253 (96.2%) Bilateral: 24 (8.79%) vs 10 (3.8%) | 0 vs 0 |
| Smith | 52.25 ± 20.49 vs 50.75 ± 19.91 | 95.98% vs 97.63% | Weight in Kg 78 (60–110) vs 76 (59–120) | Type 1 + 2 (indirect): 62 (72.94%) vs 53 (62.35%) Type 3 A (direct): 23 (27.06%) vs 32 (37.65%) Type 3 B (pantaloon): 0 (0%) Type 3 C (femoral): 0 (0%) | Unilateral Right 31(36.47%) vs 37 (43.53%) Left 21 (24.71%) vs 22 (25.88%) Bilateral 33 (38.82%) vs 26 (30.59%) Unilateral: 16 (64%) vs 21 (84%) Bilateral: 9 (36%) vs 4 (16%) Unilateral: 14(75.0) vs 13(65.0) Bilateral: 6(25.0) vs 7 (35.0) | NR |
| Moreno-Egea | 53.8 ± 15.6 vs 56.9 ± 16.3 | 78% vs 79% | NR | Incomplete inguinal reducible hernias, Details NR | NR | 16 vs 21 P = 0.18 |
| Parshad | 46.40 ± 15.19 vs 47.16 ± 16.40 | NR | NR | Type 1 + 2 (indirect): 10(39.0) vs 12(44.4) Type 3 A (direct): 13 (50.0) vs 12 (44.4) Type 3 B (pantaloon): 3 (11.0) vs 2 (7.4) Type 3 C (femoral): 0 (0.0) vs 1 (3.7) | NR | NR |
| Koch | 56.3 ± 11.5 vs 54.6 ± 16.1 | 100% vs 100% | BMI 27.0 ± 3.6 vs 27.2 ± 3.1 | Type 1 + 2 (indirect): 53% vs 52% Type 3 A (direct): 24% vs 25% Type 3 B (pantaloon): 9% vs 9% Type 3 C (femoral): 4% vs 4% Inguinal hernias detailed NR | NR | 0 (0%) vs 3 (1.1) |
| Li | 61 ± 15 vs 58 ± 15 | NR | NR | Type 1 + 2 (indirect): 24% vs 25% | NR | NR |
| Taylor | 59.3 vs 59.6 | 92% vs 92% | NR | Type 3 A (direct): 6 (18.7%) vs 6 (19.4) Type 3 B (pantaloon): 0 (0%) vs 0 (0%) Type 3 C (femoral): 0 (0%) vs 0 (0%) Type 1 + 2 (indirect): 2 (20%) vs 14 (28%) Type 3 A (direct): 3 (30%) vs 13 (26%) Type 3 B (pantaloon): 5 (50%) vs 22 (44%) Type 3 C (femoral): 0 (0%) vs 1 (2%) | Unilateral: Unilateral: 67% vs 67% Bilateral: 33% vs 33% | 10% vs 10% |
| Garg | 47.2 ± 12.9 vs 51.9 ± 16.8 | 98.08% vs 94.23% | NR | Type 1 + 2 (indirect): 26 (81.3) vs 25 (80.6) Type 3 A (direct): 6 (18.7%) vs 6 (19.4) Type 3 B (pantaloon): 0 (0%) vs 0 (0%) Type 3 C (femoral): 0 (0%) vs 0 (0%) | Unilateral: 6 (11.5%) vs 8 (15.4%) Bilateral: 46 (88.5%) vs 44 (84.6%) Unilateral: Right 22 (68.8%) vs 21 (67.7%) Left 10 (31.2%) vs 10 (32.3%) Bilateral: 0 (0%) vs 0 (0%) | NR |
| Ayyaz | 44.6 ± 16.3 vs 31.3 ± 12.5 | 87% vs 90.3% | NR | Type 1 + 2 (indirect): 2 (20%) vs 14 (28%) Type 3 A (direct): 3 (30%) vs 13 (26%) Type 3 B (pantaloon): 5 (50%) vs 22 (44%) Type 3 C (femoral): 0 (0%) vs 1 (2%) | NR | NR |
| Claus | 49.0 ± 14.0 vs 51.1 ± 15.7 | 100% vs 88% | NR | Type 1 + 2 (indirect): 26 (37.14) vs 30 (44.12%) Type 3 A (direct): 30 (42.86%) vs 28(41.18%) Type 3 B (pantaloon): 12 (17.1%) vs 8(11.76%) Type 3 C (femoral): 2(2.86%) vs 2(2.94%) Inguinal details NR | Unilateral: Unilateral: 30 (60%) vs 32 (64%) (P = 0.836) Bilateral: 20 (40%) vs 18 (36%) | 1 vs 3 (P = 0.53) |
| Claus | 49.0 ± 14.0 vs 51.1 ± 15.7 | 100% vs 88% | NR | Type 1 + 2 (indirect): 26 (37.14) vs 30 (44.12%) Type 3 A (direct): 30 (42.86%) vs 28(41.18%) Type 3 B (pantaloon): 12 (17.1%) vs 8(11.76%) Type 3 C (femoral): 2(2.86%) vs 2(2.94%) Inguinal details NR | Unilateral: Unilateral: 30 (60%) vs 32 (64%) (P = 0.836) Bilateral: 20 (40%) vs 18 (36%) | 0 vs 0 |
| Buyukasik | 27.3 ± 7.0 vs 31.1 ± 12.8 | 100% vs 100% | BMI 28.1 ± 4.7 vs 28.2 ± 4.1 | Type 1 + 2 (indirect): 31 (88.57%) vs 26 (81.25%) Type 3 A (direct): 3(8.57%) vs 4 (12.5%) Type 3 B (pantaloon): 1(2.86%) vs 2 (6.25%) Type 3 C (femoral): 0 (0%) vs 0 (0%) | NR | NR |
| Redd | NR | NR | NR | Inguinal details NR | NR | NR |
| Abd-Raboh | 35.84 ± 12.67 vs 36.70 ± 11.35 | 96.77% vs 100% | NR | Type 1 + 2 (indirect): 31 (88.57%) vs 26 (81.25%) Type 3 A (direct): 3(8.57%) vs 4 (12.5%) Type 3 B (pantaloon): 1(2.86%) vs 2 (6.25%) Type 3 C (femoral): 0 (0%) vs 0 (0%) | Unilateral: Right 16(51.61%) vs 10 (37.04%) Left 11(35.48%) vs 12 (44.44%) Bilateral: 4 (12.9%) vs 5 (18.52%) | NR NR |

Abbreviations: NR = not reported.

Table 3
Procedural related data.

| Author | procedure | Type of anaesthesia | Number of surgeons/ expertise | Type and size of mesh | Method of fixation | prophylactic antibiotics use | Use of drain |
|-------------|-----------|--|----------------------------------|--|---------------------------|---------------------------------|------------------------|
| Ferzli | TEP | Total local analgesia vs general anaesthesia 2 (2%) vs 98 (98%) | One surgeon | Polypropylene 6 × 6 inch | Endoscopic hernia stapler | yes | NR |
| Smith | TAPP | NR | One surgeon in each center | Polypropylene 15 × 10 cm | EMS Ethicon stapler | NR | NR |
| Moreno-Egea | TEP | General vs spinal Fixation: 72 (84.71%) vs 13 (15.29%) No fixation: 57 (67.06%) vs 28 (32.94%) | Two surgeons | Self-expandable 3 dimension anatomical mesh (Parietex) | stapler | NR | NR |
| Parshad | TEP | NR | NR | Polypropylene 15 x (11–13) cm | stapler | NR | NR |
| Koch | TEP | General | NR | Polypropylene, Ethicon, 15 × 10 cm | tacker | NR | NR |
| Li | TEP | General or spinal | NR | Self-expandable mesh (Parietex) | stapler | NR | NR |
| Taylor | TEP | General | Four surgeons and 3 institutes | Polypropylene mesh 15 × 10 cm | Autosuture Protack | NR | NR |
| Garg | TEP | Spinal | Single surgical team | Polypropylene mesh 15 × 10 cm | Covidien Protack | yes | 6 (11.5%) vs 8 (15.4%) |
| Ayyaz | TEP | General | Single surgical team | Polypropylene 6 × 4 inch | Metallic tackers | yes | NR |
| Claus | TEP | General | Single surgeon | Polypropylene 12–15 cm | Covidien Absorbatack | yes | NR |
| Buyukasik | TEP | General | NR | Polypropylene 10 × 15 cm Ethicon | Covidien Protack | NR | NR |
| Redd | TEP | General | NR | NR | tackers | yes | NR |
| Abd-Raboh | TEP | General | NR | Polypropylene 12 × 15 cm | Non/absorbable tacks | NR | 2 (5.71%) vs 3 (9.37%) |

NR = not reported.

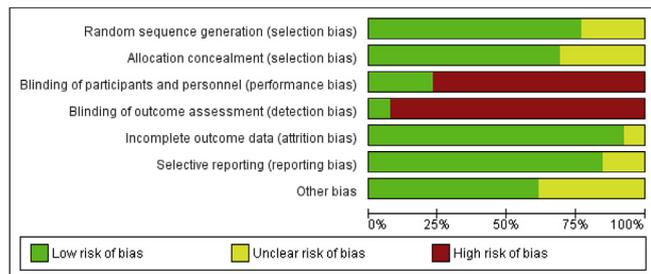
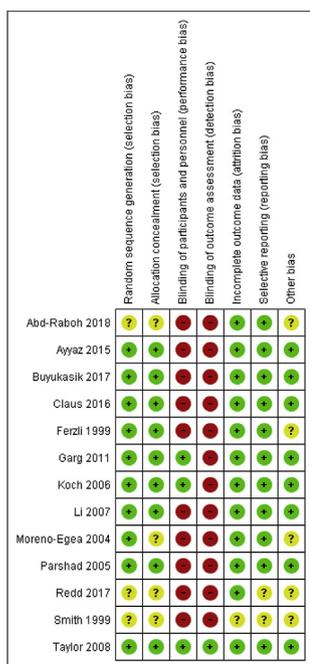


Fig. 2. Risk of bias summary and graph showing authors' judgments about each risk of bias item.

of comparable age and gender in all of the included studies with the male gender to be dominant. The weight or BMI of the included patients were poorly reported by the included studies. The details of types and laterality of the hernias in each study are outlined in Table 2. Furthermore, Table 3 presents the technique adopted by each study in doing the laparoscopic hernia repair, the type of mesh, method of fixation if fixed, number of surgeons involved and their expertise, the type of anaesthesia used, use of prophylactic antibiotics or drains. Twelve studies reported outcomes of TEP repair and one study reported outcomes of TAPP repair. The included studies reported follow-up period ranging from 3 to 60 months. There was no significant difference between the two groups in terms of follow-up period ($P = 0.75$).

3.1. Methodological appraisal

Fig. 2 presents the risk of bias assessment of the included 13 RCTs. There were low risk of attrition and reporting bias in 12 and 11 RCTs, respectively. Selection bias were low in 10 studies and unclear in 3 studies. Performance bias were high in 10 and low in 3 studies. Moreover, detection bias were high in all studies, except the study of Taylor et al. [20].

3.2. Data synthesis

Outcomes are summarised in Figs. 3 and 4. Only two studies evaluated all outcome variables.

Post-operative pain. Nine studies reported post-operative pain as an

outcome. The pooled analysis of 825 hernias demonstrated that the mesh fixation was associated with significantly higher postoperative pain assessed by VAS compared to no fixation technique (MD: 0.59; 95% CI, 0.05–1.13, $P = 0.03$). Between-study heterogeneity was significant ($I^2 = 94%$, 95% CI, 89.7–98.3, $P = 0.00001$).

Procedure time. Seven studies (742 hernias) reported their mean procedure time as an outcome. Our analysis showed that the no mesh fixation technique was associated with a significantly shorter procedure time than the mesh fixation (53.3 min vs 50.04 min MD: 2.00; 95% CI, 0.98–3.02, $P = 0.0001$). Heterogeneity among the studies was low ($I^2 = 22%$, 95% CI 12.3–31.7 $P < 0.0001$).

Seroma. Five studies reported post-operative seroma as an outcome. Post-operative seroma occurred in 32 (7.26%) and 50 (10.7%) patients in the mesh fixation and the no mesh fixation groups, respectively. The pooled analysis of 907 hernias demonstrated that the incidence of post-operative seroma was similar in both groups (RR: 0.66; 95% CI, 0.43–1.00, $P = 0.05$). Low heterogeneity existed among the included studies ($I^2 = 0%$, 95% CI 0-0, $P = 0.89$). Number needed to treat for seroma was 29.

Overall perioperative morbidity. A total of 186 perioperative complications were reported by 11 studies (1476 hernias), 95 (13.05%) in the mesh fixation group and 91 (12.17%) in the no fixation group. No significant difference was found in the complication rate between the two groups (RR: 1.04; 95% CI, 0.80–1.36, $P = 0.76$). There was low heterogeneity among the included studies ($I^2 = 9%$, 95% CI 5.86–12.1, $P = 0.36$). The likelihood of publication bias was low (Fig. 4). Number needed to treat for overall morbidity was –113.

Length of hospital stay. Five studies reported the length of hospital stay as an outcome. The pooled analysis, which included 372 patients, demonstrated that there was no significant difference in length of hospital stay between the two groups (1.79 days vs 1.58 days MD: 0.07; 95% CI, –0.01-0.16, $P = 0.10$). Moderate heterogeneity among the included studies was detected ($I^2 = 46%$, 95% CI 28.5–63.5, $P < 0.11$).

Time to normal activity. Time to normal activity was reported by four studies (790 patients). There was no significant difference in the time taken to normal activity between the two groups (9.05 days vs 8.21 days MD: 0.12; 95% CI, –0.37-0.61, $P = 0.69$). There was moderate heterogeneity among the studies ($I^2 = 52%$, 95% CI 46.2–57.8, $P = 0.10$).

Recurrence. Ten studies (1831 hernias) reported recurrence rate as an outcome. Recurrence rate in the mesh fixation and the no mesh fixation groups were 0.005% and 0.004%, respectively. The pooled analysis did not demonstrate any significant difference in recurrence rate between the two groups (RD: 0.00; 95% CI, –0.01-0.01, $P = 0.84$). Heterogeneity among the included studies was low ($I^2 = 0%$, 95% CI 7.09–18.9, $P = 0.76$). The likelihood of publication bias was low (Fig. 4). Number needed to treat for recurrence was –998.

The available data did not allow us to conduct appropriate analysis on cost or conversion to open procedure.

3.3. Sub-group analysis

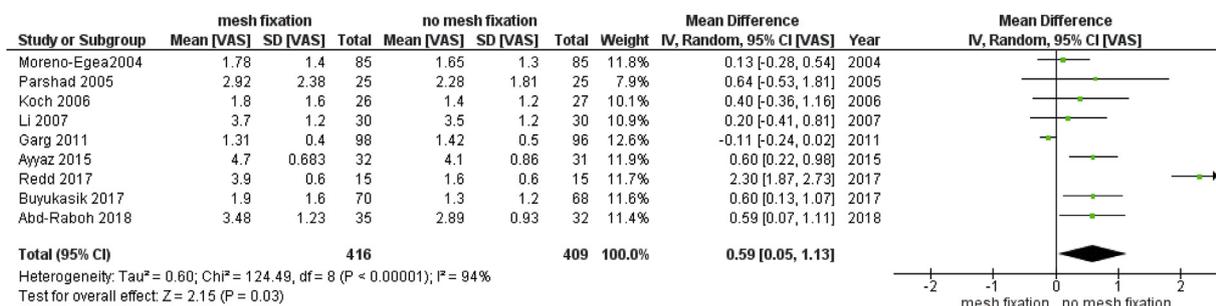
3.3.1. TEP repair

Post-operative pain. Mesh fixation was associated with significantly higher postoperative pain assessed by VAS compared to no fixation technique (MD: 0.59; 95% CI, 0.05–1.13, $P = 0.03$). Between-study heterogeneity was significant ($I^2 = 94%$, $P = 0.00001$).

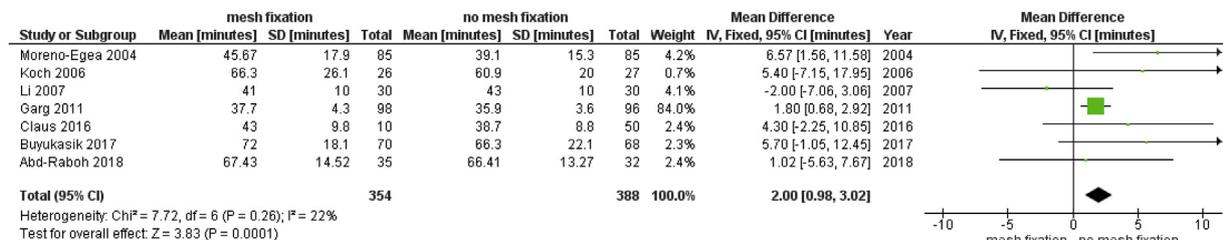
Procedure time. Mesh fixation technique was associated with a significantly longer procedure time than the mesh fixation (53.3 min vs 50.04 min MD: 2.00; 95% CI, 0.98–3.02, $P = 0.0001$). Heterogeneity among the studies was low ($I^2 = 22%$, $P < 0.0001$).

Seroma. Incidence of post-operative seroma was similar in both groups (OR: 0.63; 95% CI, 0.39–1.00, $P = 0.05$). Low heterogeneity existed among the included studies ($I^2 = 0%$, $P = 0.89$).

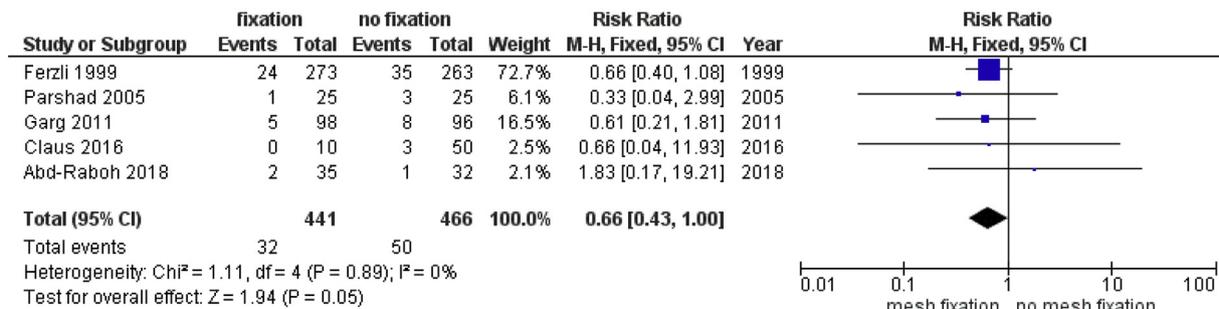
Length of hospital stay. There was no significant difference in



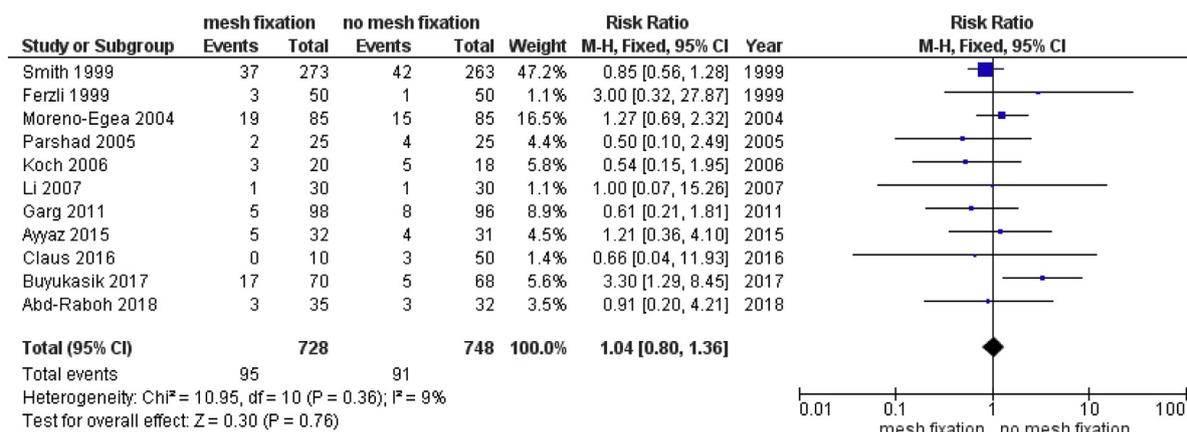
(a) Postoperative pain assessed by VAS



(b) Procedure time



(c) Seroma



(d) Overall morbidity

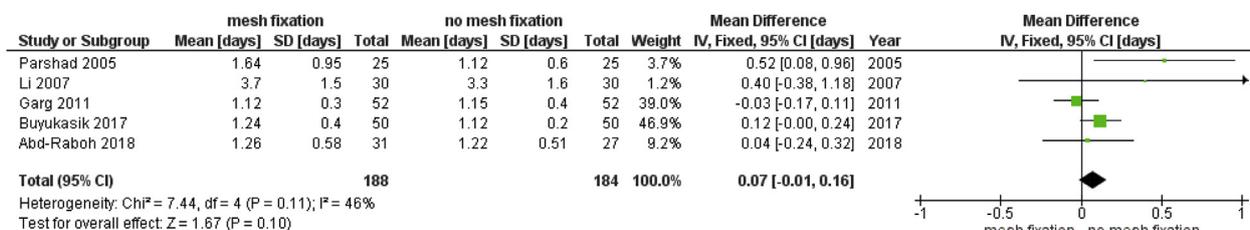
Fig. 3. Forest plots of comparison of (a) postoperative pain assessed by VAS, (b) procedure time, (c) seroma, (d) overall morbidity, (e) length of hospital stay, (f) time to normal activity, and (g) Recurrence. The solid squares denote the risk ratios (RRs) or mean difference (MD). The horizontal lines represent the 95% confidence intervals (CIs), and the diamond denotes the pooled effect size. M – H, Mantel Haenszel test.

length of hospital stay between the two groups (1.79 days vs 1.58 days MD: 0.07; 95% CI, -0.01-0.16, P = 0.10). Moderate heterogeneity among the included studies was detected (I² = 46%, P < 0.11).

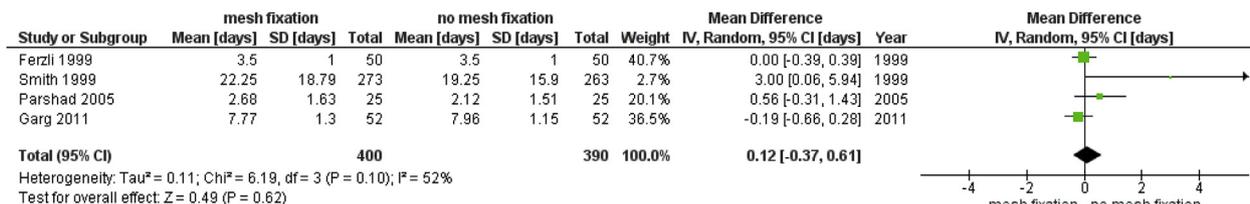
Overall perioperative morbidity. There was no significant difference in perioperative morbidity between the two groups (OR: 1.25;

95% CI, 0.83–1.89, P = 0.28). Between-study heterogeneity was low (I²:10%, P = 0.35).

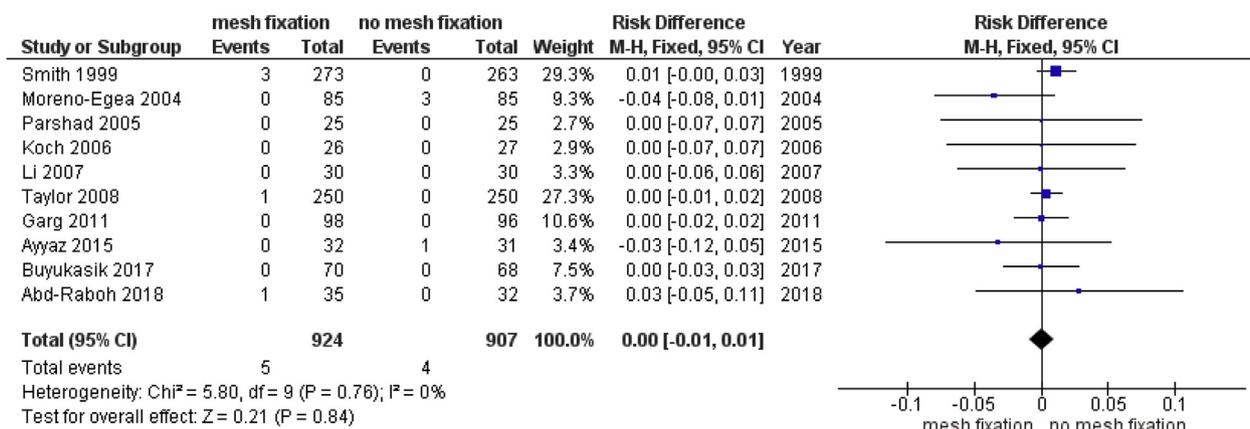
Time to normal activity. No significant difference was found in the time taken to normal activity between the two groups (MD: 0.00; 95% CI, -0.31-0.30, P = 0.98). There was low heterogeneity between-study



(e) Length of hospital stay



(f) Time to normal activity



(g) Recurrence

Fig. 3. (continued)

groups (I²:9%, P = 0.33).

Recurrence. There was no significant difference in the recurrence rate between mesh and no mesh fixation groups (RD: 0.00; 95% CI, -0.01-0.01, P = 0.59). There was low heterogeneity between-study groups (I²:0%, P = 0.77).

3.3.2. Unilateral hernia

Post-operative pain. Mesh fixation was associated with significantly higher postoperative pain assessed by VAS compared to no fixation technique (MD: 0.75; 95% CI, 0.02–1.49, P = 0.04). Between-study heterogeneity was significant (I²: 92%, P < 0.00001).

Procedure time. There was no significant difference between two groups in procedure time (MD: 2.88; 95% CI, -2.54-8.30, P = 0.30). Heterogeneity among the studies was moderate (I² = 66%, P = 0.05).

Seroma. There was no significant difference between two groups in seroma (OR: 0.60; 95% CI, 0.36–1.02, P = 0.06). Low heterogeneity existed among the included studies (I²: 0%, P = 0.84).

Length of hospital stay. Mesh fixation was associated with significantly longer length of hospital stay compared to no fixation technique (MD: 0.49; 95% CI, 0.11–0.88, P = 0.01). Between-study heterogeneity was low (I²: 0%, P = 0.79).

Overall perioperative morbidity. There was no significant difference in perioperative morbidity between the two groups (OR: 0.97; 95% CI, 0.71–1.32, P = 0.85). Between-study heterogeneity was low

(I²:0%, P = 0.19).

Time to normal activity. No significant difference was found in the time taken to normal activity between the two groups (MD: 0.44; 95% CI, -0.43-1.32, P = 0.32). There was moderate heterogeneity between-study groups (I²:60%, P = 0.08).

Recurrence. There was no significant difference in the recurrence rate between mesh and no mesh fixation groups (RD: 0.00; 95% CI, -0.02-0.01, P = 0.75). There was moderate heterogeneity between-study groups (I²:33%, P = 0.20).

3.4. Sensitivity analysis

Using random-effects or fixed-effect models did not affect the pooled effect size in any of the outcomes. The direction of pooled effect size remained unchanged when the OR, RR, or RD was calculated. Removal of study of Abd-Raboh [26] in the analysis of seroma, made the results statistically significant in favour of mesh fixation (p = 0.04). Removal of study by Ayyaz et al. [22] changed the direction of the effect size towards non-significance for postoperative pain. Also, removal of studies by Ferzli et al. [14], Parshad et al. [17], and Garg et al. [21] changed the direction of the effect size towards non-significance for procedure time (Supplementary Table 1).

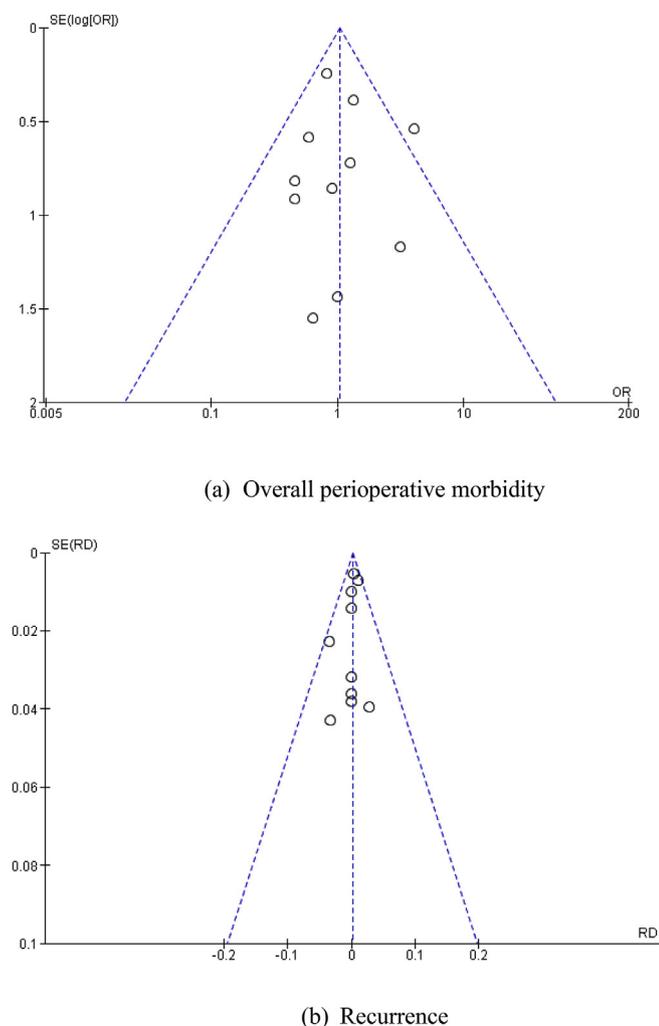


Fig. 4. Funnel plots of comparison of (a) Overall perioperative morbidity and (b) recurrence.

4. Discussion

To fix or not to fix the mesh? This has been a controversial question in laparoscopic approach for groin hernia repair. A comprehensive systematic review and meta-analysis of randomized studies was conducted to evaluate comparative outcomes of mesh fixation and no mesh fixation in patients undergoing laparoscopic groin hernia repair. The literature review identified 13 RCTs [14–26] reporting a total of 1731 patients (2021 groin hernias) of whom 853 patients (999 hernias) underwent laparoscopic groin hernia repair using the mesh fixation technique and the remaining 878 (1022 hernias) had laparoscopic groin hernia repair without mesh fixation.

The meta-analyses of outcomes demonstrated that mesh fixation technique was associated with significantly higher post-operative pain and longer procedure time compared to no mesh fixation technique. However, there was no significant difference in length of hospital stay, time taken to normal activities, overall complications, seroma formation and recurrence rate between two groups. The between-study heterogeneity in the analyses of procedure time, seroma, overall complications and recurrence rate was low indicating that the findings about these outcomes may be robust. Moreover, the heterogeneity among the included studies in the analysis of hospital stay and time to return to normal activities was moderate. High between-study heterogeneity in the analyses of post-operative pain indicates that the findings about this outcome may be less robust. The sub-group analysis demonstrated consistent results to our main analysis when only TEP repair was

considered.

Our findings with regards to length of hospital stay, overall complications, and recurrence rate are consistent with finding of a meta-analysis conducted by Sajid et al. [10] in 2012. However, our findings are not in agreement with those of Sajid et al. [10] on operative time and postoperative pain. Sajid et al. [10] found no significant difference between the two groups in terms of operative time and postoperative pain whereas we found significantly lower postoperative pain and shorter procedure time in favour of laparoscopic groin hernia repair without mesh fixation. Our pooled analysis included data from 13 RCTs compared to 8 RCTs in the study of Sajid et al. [10]. The additional 5 RCTs (studies details are presented in Tables 1–3) increased the number of pooled patients and hernias by 311 patients and 358 hernias, respectively, which may suggest our findings may be more robust and less subject to type 2 error considering the larger size of our pooled population. We found some discrepancies in our forest plot of procedure time and that of Sajid et al. [10]. While we included 3 new RCTs [23,24,26] in the analysis of procedure time, we believe 3 studies [14,15,20] should have been excluded from the analysis of procedure time by Sajid et al. [10]. Following a careful check, we noticed that Sajid et al. [10] have included inappropriate data from aforementioned 3 studies [14,15,20]. Neither of the aforementioned studies reported their standard deviation (SD) of the mean which is vital for analysis of procedure time as a continuous outcome parameter. The authors calculated the standard deviation of the mean using non-conventional methods (from p-value or mean and range) which, undoubtedly subject their findings to major bias. Calculating mean and standard deviation from median and range using the method described by Hozo et al. [27] has been widely accepted while calculating the SD from range and p value not. With regards to postoperative pain, we included 4 more RCTs [22,24–26] than Sajid et al. [10] which made the results significant in favour no fixation group.

Although the comparative clinical outcomes of laparoscopic groin hernia repair with or without mesh fixation have been extensively evaluated by randomized studies, the cost effectiveness as an important outcome has not been investigated sufficiently. Six of the included studies in this meta-analysis have reported the cost of their interventions. However, the reported costs by the included studies were in different currencies which made pooling of the available data impossible. Nevertheless, all 6 studies were in agreement that mesh fixation technique was more expensive considering use of staples/tackers. The economics of surgery is an important issue of its own regardless of the clinical efficacy. The cost effectiveness of hernia operation should be evaluated on its own merit and future studies should concentrate on cost-effectiveness as an independent outcome.

This meta-analysis demonstrated that mesh fixation prolongs the procedure time of laparoscopic groin hernia repair. Clearly, mesh fixation is an additional step which prolongs the procedure time. In the existence of comparable outcomes, reduced procedure time in favour of laparoscopic groin hernia repair without mesh fixation may indicate reduced general anaesthetic exposure, reduced cost, and, considering the elective nature of the procedure, more efficient and productive theatre list.

The current meta-analysis did not show any difference in recurrence rate between mesh fixation and no mesh fixation groups and actual number of events were too low in each group. It has to be taken into account that the follow up period in most of the included studies has not been long enough to appropriately assess this recurrence. It has been argued that even median follow-up period of 24 months is not sufficient to appropriately assess occurrence of recurrent abdominal wall hernia [28].

This study has some limitations which should be taken into account when interpreting our findings. The performance and detection bias were high in most of the included RCTs mainly due to lack of blinding. Although blinding can be challenging in most RCTs involving surgical interventions, the participants in the included studies could have easily

blinded to the intervention they received considering the nature of the intervention. Moreover, some of the included studies reported their continuous data as median and interquartile range. Although their mean and standard deviation were calculated using a widely acceptable method described by Hozo et al. [27], this might have subjected the findings to some degree of bias. Finally, the included studies did not provide appropriate data for analysis of cost or conversion to open procedure which were two of the secondary outcome parameters.

5. Conclusions

This meta-analysis demonstrated that avoiding mesh fixation with a stapler or tacker during laparoscopic groin hernia repair may reduce postoperative pain and procedure time. Moreover, it does not increase risk of recurrence, time to normal activity or perioperative morbidities. Future studies with adequate follow up period are encouraged to evaluate cost effectiveness of each approach.

Ethical approval

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Author contribution

Mokhtar Eltair and Shahin Hajibandeh equally contributed to this paper and joined first authorship is proposed.

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Data collection: Mokhtar E, Shahin H, Shahab H.

Analysis and interpretation: Mokhtar E, Shahin H, Shahab H.

Writing the article: Mokhtar E, Shahin H.

Critical revision of the article: All authors.

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Guarantor

Mokhtar eltair.

Provenance and peer review

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Data statement

The provided data on the study are available on the internet sites specified on the manuscript as per the methodology section.

Declaration of competing interest

No conflict of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ijvs.2019.10.004>.

References

- [1] Zib M, Gani J. Inguinal hernia repair: where to next? ANZ J. Surg. 72: 573–579.
- [2] M.S. Liem, Y. van der Graaf, C.J. van Steensel, et al., Comparison of conventional anterior surgery and laparoscopic surgery for inguinal-hernia repair, *N. Engl. J. Med.* 336 (2) (1997) 1541–1547 2002.
- [3] K. McCormack, N.W. Scott, P.M. Go, S. Ross, A.M. GrantEU Hernia Trialists Collaboration, Laparoscopic techniques versus open techniques for inguinal hernia repair, *Cochrane Database Syst. Rev.* 1 (2003) CD001785.
- [4] M.A. Memon, N.J. Cooper, B. Memon, M.I. Memon, K.R. Abrams, Meta-analysis of randomized clinical trials comparing open and laparoscopic inguinal hernia repair, *Br. J. Surg.* 90 (12) (2003) 1479–1492.
- [5] A.J. Voitk, The learning curve in laparoscopic inguinal hernia repair for the community general surgeon, *Can. J. Surg.* 41 (1998) 446–450.
- [6] K. Lawrence, D. McWhinnie, A. Goodwin, A. Gray, J. Gordon, J. Storie, J. Britton, J. Collin, An economic evaluation of laparoscopic versus open inguinal hernia repair, *J. Public Health Med.* 18 (1996) 41–44.
- [7] R.J. Fitzgibbons Jr., J. Camps, D.A. Cornet, N.X. Nguyen, B.S. Litke, R. Annibali, G.M. Salerno, Laparoscopic inguinal herniorrhaphy. Results of a multicenter trial, *Ann. Surg.* 221 (1995) 3–13.
- [8] E.L. Felix, C.A. Michas, M.H. Gonzalez Jr., Laparoscopic hernioplasty. TAPP vs TEP, *Surg. Endosc.* 9 (1995) 984–989.
- [9] B.L. Wake, K. McCormack, C. Fraser, L. Vale, J. Perez, A.M. Grant, Transabdominal pre-peritoneal (TAPP) vs totally extraperitoneal (TEP) laparoscopic techniques for inguinal hernia repair, *Cochrane Database Syst. Rev.* 1 (2005) CD004703.
- [10] M.S. Sajid, N. Ladwa, L. Kalra, K. Hutson, P. Sains, M.K. Baig, A meta-analysis examining the use of tacker fixation versus no-fixation of mesh in laparoscopic inguinal hernia repair, *Int. J. Surg.* 10 (2012) 224–231.
- [11] A. Liberati, D.G. Altman, J. Tetzlaff, C. Mulrow, P.C. Gotzsche, J.P. Ioannidis, M. Clarke, P.J. Devereaux, J. Kleijnen, D. Moher, The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: explanation and elaboration, *BMJ* 339 (2009) b2700.
- [12] R. Holzheimer, Inguinal Hernia: classification, diagnosis and treatment: classic, traumatic and Sportsman's hernia, *Eur. J. Med. Res.* 10 (3) (2005) 121–134.
- [13] Higgins JP, Altman DG, editors Chapter 8. Assessing risk of bias in included studies. In: Higgins JP, Green S, editors. *Cochrane Handbook for Systematic Reviews of Interventions*. Version 5.0.1 [updated September 2008]. Available at: https://hiv.cochrane.org/sites/hiv.cochrane.org/files/uploads/Ch08_Bias.pdf Accessed November 28.
- [14] G.S. Ferzli, E.E. Frezza, A.M. Pecoraro Jr., K.D. Ahern, Prospective randomized study of stapled versus unstapled mesh in a laparoscopic preperitoneal inguinal hernia repair, *J. Am. Coll. Surg.* 188 (1999) 461e5.
- [15] A.I. Smith, C.M. Royston, P.C. Sedman, Stapled and nonstapled laparoscopic transabdominal preperitoneal (TAPP) inguinal hernia repair. A prospective randomized trial, *Surg. Endosc.* 13 (1999) 804e6.
- [16] A. Moreno-Egea, J.A. Torralba Martínez, G. Morales Cuenca, J.L. Aguayo Albasini, Randomized clinical trial of fixation vs nonfixation of mesh in total extraperitoneal inguinal hernioplasty, *Arch. Surg.* 139 (2004) 1376e9.
- [17] R. Parshad, R. Kumar, P. Hazrah, S. Bal, A randomized comparison of the early outcome of stapled and unstapled techniques of laparoscopic total extraperitoneal inguinal hernia repair, *J. Soc. Laparoendosc. Surg.* 9 (2005) 403e7 2005.
- [18] C.A. Koch, S.M. Greenlee, D.R. Larson, J.R. Harrington, D.R. Farley, Randomized prospective study of totally extraperitoneal inguinal hernia repair: fixation versus no fixation of mesh, *J. Soc. Laparoendosc. Surg.* 10 (2006) 457e60.
- [19] J.W. Li, M.H. Zheng, H.Q. Li, H. Zhang, W.G. Hu, M.L. Wang, A randomized controlled clinical trial comparing stapling with non-stapling of mesh in laparoscopic total extraperitoneal inguinal hernioplasty, *Chin. J. Gen. Surg.* 22 (2007) 440e2.
- [20] C. Taylor, L. Layani, V. Liew, M. Ghusn, N. Crampton, S. White, Laparoscopic inguinal hernia repair without mesh fixation, early results of a large randomised clinical trial, *Surg. Endosc.* 22 (2008) 757e62.
- [21] P. Garg, S. Nair, M. Shereef, J.D. Thakur, N. Nain, G.R. Menon, et al., Mesh fixation compared to nonfixation in total extraperitoneal inguinal hernia repair: a randomized controlled trial in a rural center in India, *Surg. Endosc.* 25 (2011) 3300e6.
- [22] M. Ayyaz, M.W. Farooka, A.A. Malik, A. Khan, R. Mansoor, A.A. Toor, et al., Mesh fixation vs. non-fixation in total extra peritoneal mesh hernioplasty, *J. Pak. Med. Assoc.* 65 (3) (2015) 270e2.
- [23] C.M. Claus, G.M. Rocha, A.C. Campos, E.A. Bonin, D. Dimbarre, M.P. Loureiro, J.C. Coelho, Prospective, randomized and controlled study of mesh displacement after laparoscopic inguinal repair: fixation versus no fixation of mesh, *Surg. Endosc.* 30 (3) (2016) 1134–1140, <https://doi.org/10.1007/s00464-015-4314-7>.
- [24] K. Buyukasik, A. Ari, B. Akce, C. Tatar, O. Segmen, H. Bektas, Comparison of mesh fixation and non-fixation in laparoscopic totally extraperitoneal inguinal hernia repair, *Hernia* 21 (4) (2017) 543–812 (Osama Hasan).
- [25] S. Raghu Rami Reddy, T.U. Girish, B.J. Sharath Chandra, A prospective comparative study of total extraperitoneal inguinal hernia repair: fixation versus without fixation of the mesh, *Int. Surg. J* 4 (1) (2017) 166–169.
- [26] O.H. Abd-Raboh, M.A. Hablus, A.A. Elshora, S.A. Sabe, Comparative study between mesh fixation vs. non-fixation in totally extraperitoneal hernioplasty for inguinal hernia, *6 (1)* (2018) 23–28.
- [27] S. Hozo, B. Djulbegovic, I. Hozo, Estimating the mean and variance from the median, range, and the size of a sample, *BMC Med. Res. Methodol.* 5 (2005) 13.
- [28] S. Hajibandeh, S. Hajibandeh, A. Sreh, A. Khan, D. Subar, L. Jones, Laparoscopic versus open umbilical or paraumbilical hernia repair: a systematic review and meta-analysis, *Hernia* 21 (6) (2017) 905–916.