

Mesh-fixation technique for inguinal hernia repair: umbrella review

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Abstract

Background: Mesh-based repair is the standard of surgical care for symptomatic inguinal hernias. Many systematic reviews and meta-analyses (SRMAs) addressed various aspects of these procedures. This umbrella review aimed to report the evidence from all previous SRMAs for open and laparoscopic inguinal hernia repair.

Methods: SRMAs were identified from MEDLINE, Scopus, Cochrane, Embase, DARE, PROSPERO, CINAHL, JBISRS, EPPI-Centre, Wiley Online Library and ScienceDirect database according to PRISMA guidelines. Data including mesh-fixation techniques and surgical approach were extracted from selected SRMAs. The corrected covered area was calculated to address study overlap across reviews, and an excess significance test was used to assess potential bias. The outcomes of interest were hernia recurrence, chronic groin pain, operating time, postoperative pain, duration of hospital stay, return to daily life activities, and postoperative complication.

Results: Thirty SRMAs were included between 2010 and 2019: 16 focused on open repair, and 14 focused on laparoscopic repair, with a high degree of overlap (open repairs, 41 per cent; laparoscopic repairs, 30–57 per cent). Sufficient evidence was available on hernia recurrence, chronic groin pain, and operative time. Effects of glue on hernia recurrence were inconclusive in open and laparoscopy approaches, $P = 0.816$ and 0.946 respectively. Glue was significantly associated with lower persistent groin pain, in open repair (*versus* suture) and in laparoscopic repair (*versus* tack). SRMAs suggested that self-gripping mesh was associated with shorter operating time in open surgery, although with only a few minutes of improvement (0.36–7.85 min, $P < 0.001$).

Conclusion: In this umbrella review, chronic groin pain and operating time were the only outcomes for which there was sufficient evidence supporting the effectiveness respectively of glue and self-gripping mesh.

Introduction

Inguinal hernias are common surgical conditions, with a lifetime risk of approximately 27 per cent in men and 3 per cent in women¹. Mesh-based repair is the standard treatment for adult symptomatic inguinal hernias according to the International Guidelines for Groin Hernia Management², and it can be performed via an open or laparoscopic approach. Lichtenstein's technique is widely used for open hernia repair (OHR)^{3,4}, whereas total extraperitoneal repair (TEP) and transabdominal preperitoneal repair (TAPP) are standard techniques for laparoscopic hernia repair (LHR)^{3–5}.

Suture and tacker mesh fixations are techniques used for OHR and LHR respectively. The aim of fixation is long-term stability, but unfavourable effects of sutures or tacks have been reported, including chronic groin pain^{6,7}, vascular injury⁸ and internal organ injury⁹ (such as perforation, bending or lifting). Non-penetrating or atraumatic fixation techniques have been proposed as alternatives (such as glue and self-gripping mesh (SGM)) to prevent these outcomes. Recent guidelines for inguinal

hernia repair^{2,5} recommended mesh fixations in patients with large direct hernias (M3-EHS classification) and explored the association between mesh types, surgery types, and clinical outcomes (such as hernia recurrence, chronic groin pain, operating time and complications). For OHR, eight systematic reviews and meta-analyses (SRMAs)^{10–17} suggested the superiority of SGM, although this failed to reach statistical significance, and six SRMAs^{18–23} supported glue in decreasing postoperative pain. For LHR, three SRMAs^{24–26} favoured glue fixation for postoperative pain reduction, and four SRMAs^{27–30} supported no mesh fixation for reduced costs and operating times. Recently, a systematic review of randomized clinical trials (RCTs) has been published considering only chronic groin pain and hernia recurrence rate³¹; however, a few of other important outcomes, including complications and recovery time, were not considered. This umbrella review aimed to explore the evidence across all available SRMAs for inguinal hernia repair in all operating outcomes, addressing the quality, strength and limitations of SRMA evidence, and identify the evidence gaps and suggest areas for future research.

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Methods

The study was developed following the PRISMA-P guidelines^{32,33}, and was registered at PROSPERO (CRD 42018111773)³⁴ and reported consistently with current recommendations^{35,36}.

Data sources

Relevant studies were identified in published/unpublished studies, conference proceedings, theses and dissertations. The following electronic databases were searched: Scopus, MEDLINE via PubMed, Cochrane Database, Embase, Database of Abstracts of Reviews of Effects (DARE), PROSPERO register, CINAHL, JBI Database of Systematic Reviews and Implementation Reports (JBI-SRIS), EPPI-Centre, Wiley Online Library and ScienceDirect. Studies published between January 2010 and January 2020 were included. In addition, reference lists of identified studies were searched.

Search strategies

The scope of the umbrella review was defined in line with the PICO structure^{37,38}. The target population (P) was defined as adult patients who underwent any OHR or LHR. The interventions (I) and comparators (C) were combined for searching as mesh-fixation techniques, including suture, glue and SGM for open repair and metallic tack, no fixation, absorbable tack, suture, glue and SGM for laparoscopic repair. Types of outcomes (O) were not restricted and included hernia recurrence, chronic groin pain, acute postoperative pain, operating time, recovery time (duration of hospital stay, return to work and return to daily life) and complications (seroma, haematoma and urinary retention). The study designs included systematic review and meta-analysis. These search terms were combined within and between domains using conjunctions 'OR' and 'AND' respectively. The search terms are listed in [Appendix S1](#).

Selection of studies

SRMAs published in English or other languages translatable with Google Translate were selected if they met the following criteria: SRMAs of RCTs of adults with inguinal hernias who underwent OHR or LHR, comparisons of any mesh-fixation technique used between OHR (suture, glue and SGM) and LHR (tack, no fixation, glue, suture and SGM), and any outcome or adverse event was pooled.

Outcomes of interest

The primary outcomes of interest were hernia recurrence and chronic groin pain, defined according applied in the original studies. The secondary outcomes were postoperative pain, operating time, recovery time (duration of hospital stay, return to work and return to daily life) and complications, for example seroma, haematoma, urinary retention and surgical site infection.

Data extraction

Two reviewers independently extracted data. Any disagreement, regarding data extraction and bias assessment was discussed, and a consensus was reached, or the issue was adjudicated by a third author. The general characteristics and findings from the SRMAs were extracted separately for OHR and LHR studies. The following data were extracted: objectives, type of SRMAs, number of included studies, searching interval, publication year, risk of bias assessments, participant characteristics (such as age and sex), interventions, outcomes and methods of synthesis. In addition, findings from the SRMAs were extracted, including

intervention and comparator, number of studies, number of participants, method of pooling, pooled effect size (ES) with 95 per cent confidence interval (c.i.) for each outcome, heterogeneity diagnostics (including τ^2 and/or I^2 and test), subgroup analyses if any, publication bias assessments/results (with Egger's test and funnel plot) and various sources of bias (such as conflict of interest, funding sources, reporting bias and overall quality of evidence). Furthermore, information regarding individual RCTs for each SRMA was extracted (first author, year and journal) to construct a study-citation matrix across SRMAs. Last, outcomes and baseline risk/incidence for each outcome were extracted for each RCT and were used to calculate the excess significance test.

Quality assessment

The Risk of Bias in Systematic Reviews (ROBIS) checklist³⁹ was used for umbrella reviews concerning four domains: study eligibility criteria, methods used to identify and/or select studies, data collection and appraisal of studies, and synthesis/findings. The results were graded as low or high risk of bias if there was sufficient information to assess; otherwise, the results were graded as unclear.

Statistical analysis

The SRMA findings were described separately for OHR, LHR and each outcome. General characteristics, findings of intervention-comparator pairs and outcomes were described. The original ES, including the OR, risk ratio (RR), risk difference (RD), standardized mean difference, mean difference, and fixed/random-effect models are described. Summarized tables or forest plots were constructed from the extracted data.

To assess the bias of the SRMAs, the degree of overlap across SRMAs⁴⁰ was first determined using the covered area and corrected covered area (CCA). The CCA scores were classified as slight, moderate and high overlap, corresponding to less than 5, 5–15 and 15 or above respectively. To assess whether SRMAs had an excess of significant results compared with what would be expected, the excess significance test⁴¹ was calculated with the chi-square test. The level of significance for this test was set at $P < 0.100$.

ESs of individual studies were re-pooled using a random-effects model by the DerSimonian-Laird method if heterogeneity was present, otherwise a fixed-effects model by inverse variance was used. For those individual studies that were included more than once in previous SRMAs, they were included only once in re-pooling. Heterogeneity was assessed with the Cochran Q-test and I^2 statistic, presented if I^2 was 25 percent or higher, or $P < 0.100$. Finally, publication bias and small study effects were assessed with Egger's test, and the level of significance for this test was set at $P < 0.100$ ^{35,36}. The associations between mesh-fixation techniques and outcomes were categorized into strong, highly suggestive, suggestive, weak and non-significant³⁷ depending on the strength and validity of the evidence, such as the P value of the random-effects model, number of cases, presence of heterogeneity, small study effects and excess significance bias. Details are provided in [Appendix S2](#).

Results

Description of SRMAs

Of the 2915 studies identified, only 30 SRMAs met the eligibility criteria ([Fig. 1](#)). Twenty-eight SRMAs were direct meta-analyses (MAs), and two studies were network meta-analyses (NMAs)^{42,43}.

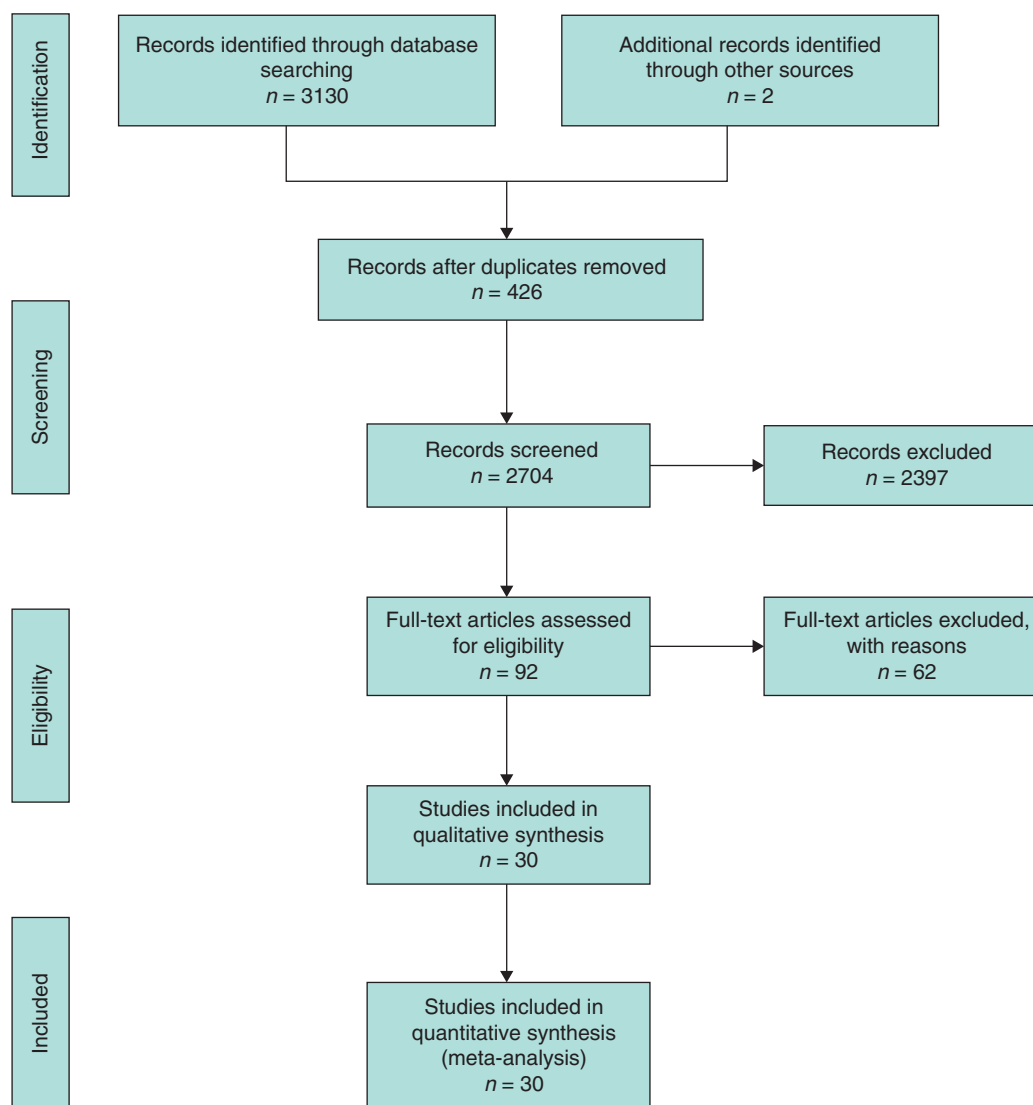


Fig. 1 PRISMA diagram of the selection of the studies

Sixteen SRMAs focused on OHR (all using the Lichtenstein technique), and 14 SRMAs focused on LHR (5 TEP, 1 TAPP and 8 mixed techniques). These SRMAs were published between 2010 and 2019 and included 4–28 studies each, with sample sizes ranging from 367 to 9 067 subjects, as shown in [Table 1](#). For OHR, six^{18–23} SRMAs compared glue to sutures, eight^{10–17} compared SGM to sutures, and one⁴⁴ compared non-suture techniques (any glue or SGM) to sutures. For LHR, seven^{24–26,45–48} and six SRMAs^{27–30,49,50} compared glue *versus* tack and no fixation *versus* tack respectively. Two SRMAs^{42,43} were NMAs. Ten OHR and 11 LHR SRMAs included only RCTs; the remaining 9 SRMAs pooled RCTs with observational data.

Inguinal hernia repair outcomes are shown in [Appendix S3](#). The primary outcomes of hernia recurrence and chronic groin pain were reported in 30 and 24 SRMAs respectively. The ‘in-hospital’ outcomes of operating time, postoperative pain and hospitalization were reported in 27, 17 and 13 SRMAs respectively. Complications after inguinal hernia repair were classified into overall complications (10 SRMAs), seroma (13 SRMAs), haematoma (11 SRMAs), seroma/haematoma (7 SRMAs), surgical infection (13 SRMAs), urinary retention (5 SRMAs), numbness/paraesthesia (2 SRMAs), discomfort

(2 SRMAs), foreign body sensation (2 SRMAs) and mesh infection (1 SRMA). The recovery time to daily activity and work were reported in 10 SRMAs and 1 SRMA respectively.

Methodological quality of systematic reviews

The methodological quality of the 30 SRMAs is summarized in [Table 2](#). Twenty-two SRMAs (73.33 per cent) were assessed as low risk of bias. The remaining eight SRMAs (26.67 per cent) were considered high risk due to domain 1 (identification and selection of studies, four SRMAs), domain 2 (identification and selection of study, one SRMA) or domain 3 (data collection and study appraisal, three SRMAs). Inter-rater agreement between the two reviewers for the overall risk of bias was consistent (Cohen’s $\kappa=0.92$). Moderate agreement was reached for domains 1 and 2, strong agreement for domain 3, and almost perfect agreement for domain 4.

Hernia recurrence

Hernia recurrence was the major outcome of concern and was examined in all 30 SRMAs. The ESs were mainly reported as ORs and RRs, with only a few studies using RD, and both fixed- and random-effects models were applied ([Appendix S4](#)). Most SRMAs

Table 1 Characteristic of the systematic reviews and meta-analyses included in the study

Author (year)	Type of operation	Comparison	Number of primary studies	Primary study participant number	Study designs included	Date of primary studies published	Outcome of interest*
Ladwa et al. (2013) ²⁰	Open	Glue versus suture	7	1259	RCT	2004–2012	①②③④⑤⑦
Colvin et al. (2013) ¹⁸	Open	Glue versus suture	10	1623	RCT	2004–2012	①②③④⑤⑥⑦
de Goede et al. (2013) ¹⁹	Open	Glue versus suture	7	1185	RCT	2004–2012	①②③④⑥
Liu et al. (2014) ²¹	Open	Glue versus suture	9	1623	RCT, prospective study	2005–2012	①②⑦
Sun et al. (2017) ²²	Open	Glue versus suture	12	1932	RCT, prospective study	2003–2014	①②③⑤⑥⑦
Lin et al. (2018) ²³	Open	Glue versus suture	13	2375	RCT	2009–2017	①②③⑦
Zhang et al. (2013) ¹⁰	Open	SGM versus suture	7	1353	RCT, comparative	2010–2013	①②③④⑤⑥⑦
Fang et al. (2014) ¹¹	Open	SGM versus suture	7	1353	RCT, comparative	2010–2013	①②③④⑦
Li et al. (2014) ¹²	Open	SGM versus suture	7	1353	RCT, comparative	2010–2013	①②③④⑦
Pandanaboyana et al. (2014) ¹³	Open	SGM versus suture	5	1170	RCT	2010–2013	①②③⑦
Sajid et al. (2014) ¹⁴	Open	SGM versus suture	4	1115	RCT	2010–2013	①②③⑤⑦
Wang et al. (2015) ¹⁵	Open	SGM versus suture	9	2130	RCT	2004–2014	①②③⑦
Ismail et al. (2016) ¹⁶	Open	SGM versus suture	19	3722	RCT, cohort study	2010–2016	①②③④⑦
Molegraaf et al. (2018) ¹⁷	Open	SGM versus suture	10	2541	RCT	2012–2017	①②③
van Steensel et al. (2019) ⁴⁴	Open	Non-suture versus suture	23	5190	RCT	2010–2017	①③④⑦
Rausa et al. (2019) ⁴²	Open	NMA	28	5495	RCT	2005–2017	①②③④⑦
Tam et al. (2010) ²⁷	TEP	No fixation versus tack	6	932	RCT	1999–2008	①③④⑤⑥⑦
Liu et al. (2010) ³⁰	TEP/TAPP	No fixation versus tack	8	1432	RCT	1999–2009	①③⑥⑦
Teng et al. (2011) ²⁹	TEP	No fixation versus tack	6	772	RCT	1999–2008	①③④⑤⑥⑦
Sajid et al. (2012) ²⁸	TEP/TAPP	No fixation versus tack	8	1386	RCT	1999–2011	①②③④⑤⑦
Lo et al. (2019) ⁵⁰	TEP	No fixation versus tack	10	1099	RCT	1999–2017	①②③④⑥⑦
Eltair et al. (2019) ⁴⁹	TEP/TAPP	No fixation versus tack	13	1731	RCT	1999–2108	①③④⑤⑥⑦
Kaul et al. (2012) ⁴⁶	TEP	Glue versus tack	3	367	Observational study	2005–2006	①②④⑤⑥⑦
Sajid et al. (2013) ²⁴	TEP/TAPP	Glue versus tack	5	1001	RCT	2005–2012	①②③④⑤⑦
Shah et al. (2014) ²⁵	TEP/TAPP	Glue versus tack	10	526, 1034	5 RCT, 5 non-RCT	2003–2013	①②⑦
Li et al. (2015) ²⁶	TEP/TAPP	Glue versus tack	8	1228	RCT	2005–2023	①②④⑦
Antoniou et al. (2016) ⁴⁵	TEP/TAPP	Glue versus tack	9	1454	RCT	2005–2014	①②③⑦
Shi et al. (2017) ⁴⁷	TAPP	Glue versus tack	10	430, 8637	RCT, comparative study	2007–2014	①②③⑦
Tavares et al. (2019) ⁴⁸	TEP/TAPP	Glue versus tack	13	1947	RCT	2005–2017	①⑦
Techapongsatorn et al. (2019) ⁴³	TEP	NMA	15	1783	RCT	1999–2017	①②③④⑤⑥⑦

*Remarks for outcome of interest: ① hernia recurrence, ② chronic groin pain, ③ operating time, ④ postoperative pain, ⑤ hospital stay, ⑥ recovery time, ⑦ complication. SGM, self-gripping mesh; non-suture, self-gripping mesh/glue; TEP, totally extraperitoneal repair; TAPP, transabdominal preperitoneal repair; RCT, randomized clinical trial; NMA, network meta-analysis.

do not report follow-up time, only one SRMA reported hernia recurrence at about 60 months.

Six SRMAs^{18–23} compared the effects of glue versus sutures in OHR, and ESs varied from 0.70 to 1.54; none was significant. Nine SRMAs^{10–17,42} compared SGM with sutures in OHR, and none was significant. One SRMA⁴² compared SGM with glue, and one⁴⁴ compared either SGM or glue versus sutures. Neither of these comparisons was significant.

Seven SRMAs^{27–30,43,49,50} compared no fixation to tack, and eight SRMAs^{24–26,43,46–48} compared glue with tack. The pooled

data demonstrated a hernia recurrence rate for suture of 1.93–2.68 per cent in OHR and 2.36 per cent for tack in LHR. Alternative glue fixation had a recurrence rate of 1.73 per cent in OHR and 2.00 per cent in LHR. SGM had a recurrence rate of approximately 1.6 per cent in OHR.

Chronic groin pain

Chronic groin pain was reported in 24 SRMAs (Appendix S5). Most SRMAs did not report time at assessments, but for those reported, the time was 3–72 months.

Table 2 Assessment of the methodological quality of the systematic reviews included, using the ROBIS instrument

Author (year)	Study eligibility criteria	Identification and selection of studies	Data collection and study appraisal	Synthesis and findings	Risk of bias in the review
Ladwa et al. (2013) ²⁰	😊	😊	😊	😊	😊
Colvin et al. (2013) ¹⁸	😊	😞	?	😊	😞
de Goede et al. (2013) ¹⁹	😊	?	?	😊	😊
Zhang et al. (2013) ¹⁰	😊	😊	😊	😊	😞
Fang et al. (2014) ¹¹	😊	😊	😊	😊	😊
Li et al. (2014) ¹²	😊	😊	😊	😊	😊
Pandanaboyana et al. (2014) ¹³	😊	😊	😊	😊	😊
Sajid et al. (2014) ¹⁴	?	😊	😊	😊	😞
Liu et al. (2014) ²¹	😊	😊	😊	😊	😞
Wang et al. (2015) ¹⁵	😊	😊	😊	😊	😊
Ismail et al. (2016) ¹⁶	😊	😊	😊	😊	😊
Sun et al. (2017) ²²	😊	😊	😊	😊	😊
Lin et al. (2018) ²³	😊	😊	😊	?	😊
Molegraaf et al. (2018) ¹⁷	😊	😊	😊	?	😊
Rausa et al. (2019) ⁴²	😊	😊	😊	😊	😊
van Steensel et al. (2019) ⁴⁴	😊	😊	😊	😊	😊
Tam et al. (2010) ²⁷	😊	😊	?	😊	😞
Liu et al. (2010) ³⁰	😊	😊	?	😊	😊
Teng et al. (2011) ²⁹	😊	😊	?	😊	😊
Kaul et al. (2012) ⁴⁶	😞	😞	😞	😊	😞
Sajid et al. (2012) ²⁸	😞	😊	😞	😊	😞
Sajid et al. (2013) ²⁴	😞	😊	😞	😊	😞
Shah et al. (2014) ²⁵	😞	😊	?	😊	😊
Li et al. 2015) ²⁶	😊	😊	😊	😊	😊
Antoniou et al. (2016) ⁴⁵	😊	😊	😊	😊	😊
Shi et al. (2017) ⁴⁷	😊	😊	😊	😊	😊
Techapongsatorn et al. (2019) ⁴³	😊	😊	😊	😊	😊
Lo et al. (2019) ⁵⁰	😊	😊	😊	😊	😊
Eltair et al. (2019) ⁴⁹	😊	😊	😊	😊	😊
Tavares et al. (2019) ⁴⁸	😊	😊	😊	😊	😊

😊, low risk; 😞, high risk; ?, unclear risk. ROBIS, Risk of Bias in Systematic Reviews.

Sixteen SRMAs reported chronic groin pain for OHR. Six^{18–23} SRMAs compared glue and sutures, and all these studies indicated that glue reduced the risk of chronic groin pain, with reductions of 12–70 per cent; four^{18–22} of these studies were statistically significant. Nine SRMAs^{10–17,42} compared SGM with sutures; none of these comparisons reached statistical significance. One SRMA⁴² compared SGM with glue, and one SRMA⁴⁴ compared SGM and glue with sutures; neither of these comparisons was significant.

Three^{28,43,49} LHR SRMAs compared no fixation with tack, and six^{24–26,43,45,46} SRMAs compared glue with tack. All ESs for the latter comparison were less than one, with a single study reaching statistical significance. The significant study indicated less groin pain for glue versus tack.

Operating time

Twenty-seven SRMAs reported operating time, but only 22 had sufficient data for re-pooling (Appendix S6).

Twelve SRMAs analysed operating time for OHR. Five^{18–20,22,23} SRMAs indicated that glue significantly decreased operating time by 0.15–4.60 min compared with sutures. Seven SRMAs^{11,13–17,42} also reported a significantly shorter operating time for SGM compared with sutures of 0.36–7.85 min. One SRMA⁴² indicated a significantly shorter operating time for glue or SGM versus sutures.

Seven SRMAs^{27–30,43,49,50} reported shorter operating times for no fixation versus tack; five^{27,29,30,49,50} of these studies reached statistical significance. Four SRMAs compared glue versus tack with inconsistent results.

Postoperative pain

The postoperative pain score was measured over the short-term (7 days or less), medium-term (6 months or less), long-term (more than 6 months) and overall postoperative periods (Appendix S7). Twelve SRMAs reported overall postoperative pain. Three SRMAs^{18–20} indicated that the use of glue resulted in lower

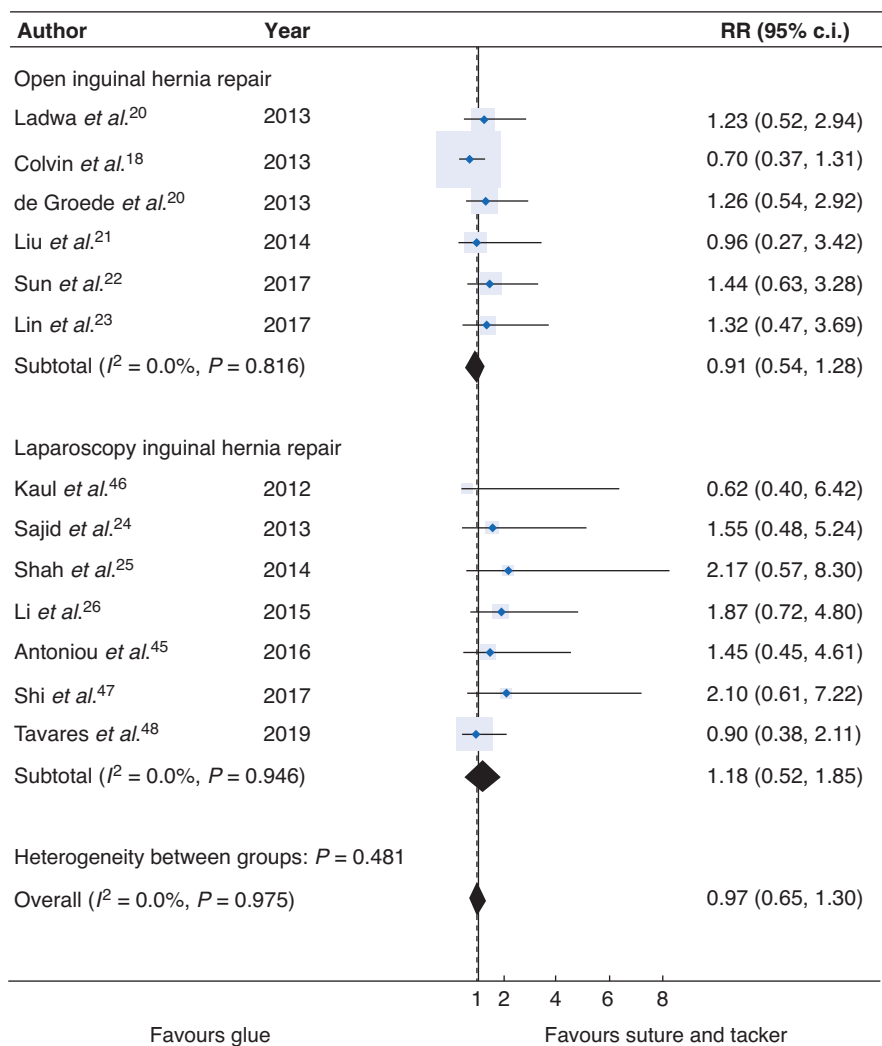


Fig. 2 The effect size of hernia recurrence on glue versus suture and tacker fixation in open and laparoscopic hernia repair

standardized pain scores (-7.92 to -0.31) compared with sutures in OHR; one of these studies was statistically significant¹⁸. One SRMA¹² for OHR compared the effect of SGM versus sutures, with no difference. Five SRMAs^{27–29,43,49} for LHR demonstrated that no fixation lowered postoperative pain scores by 0.59–0.09 points compared with tack; three of these comparisons were significant. Three SRMAs^{24,26,43} for LHR compared glue with tack with inconsistent effects.

Three SRMAs^{16,42,44} compared the effects of SGM with sutures on OHR in the short-term postoperative interval; all three SRMAs indicated that patients had significantly lower postoperative pain with SGM compared with the pain with sutures. Three SRMAs^{27,29,50} demonstrated that patients who underwent LHR with no fixation had lower postoperative pain scores compared with LHR with tack, but the differences were not significant.

Four SRMAs^{16,27,42,44} reported postoperative pain scores in the medium term. For OHR, two studies^{16,42} compared SGM and sutures for OHR, and one⁴⁴ study compared non-suture techniques and sutures. For LHR, one²⁷ SRMA compared no fixation with tacker. In all cases, the alternative mesh fixation (SGM, non-suture in OHR and no fixation in LHR) had lower medium-term postoperative pain scores than suture for OHR

and tacker for LHR; the comparison of non-suture techniques with sutures reached statistical significance.

Two SRMAs^{16,42} reported long-term postoperative pain scores for OHR. One review¹⁶ compared SGM with sutures, and the other review compared SGM with glue, but neither comparison was statistically significant.

Hospital stays

Ten SRMAs^{14,18,20,22,24,27–29,43,49} reported hospital stays ([Appendix S8](#)). For OHR, three SRMAs^{18,20,22} compared glue with sutures, and one SRMA¹⁴ compared SGM with sutures. None of the comparisons was statistically significant. For LHR, five SRMAs^{27–29,49} showed that the duration of hospital stay was slightly shorter (0.06–0.37 days) with no fixation compared with stays with tack; two of the SRMA comparisons were statistically significant.

Time to return to daily life activities

All three SRMAs^{18,19,22} for OHR indicated that the use of glue resulted in significantly shorter times (1.17–1.39 days) to return to daily life compared with the time with sutures. Six SRMAs^{27,29,30,43,49,50} for LHR showed no significant differences between no fixation and tack ([Appendix S9](#)).

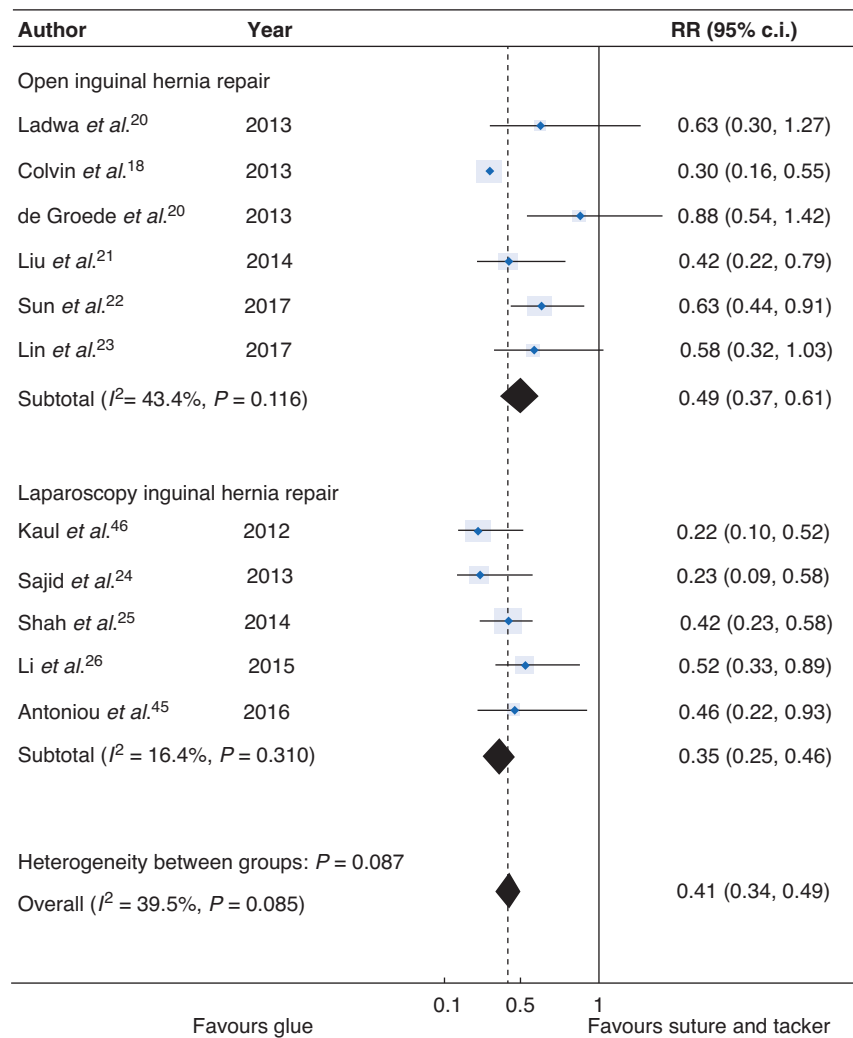


Fig. 3 The effect size of chronic groin pain on glue versus suture and tacker mesh fixation in open and laparoscopic hernia repair

Complications

SRMAs reported complications, including seroma (14 patients), wound infection (13 patients), haematoma (11 patients), overall morbidity (10 patients), seroma/haematoma (7 patients), urinary retention (5 patients), numbness (2 patients), foreign body sensation (2 patients), discomfort (2 patients) and mesh infection (1 patient) ([Appendix S10](#)). Five SRMAs^{18,20–22,30} for OHR compared complications using glue versus sutures; the use of glue resulted in fewer complications, including haematoma (ES=0.51–0.54, with two reaching statistical significance) and haematoma/seroma (ES=0.43, one was statistically significant). Nine SRMAs^{10–17,42} for OHR compared SGM with sutures and demonstrated conflicting results for ESs; none of the comparisons was statistically significant. Seven SRMAs^{27–30,43,49,50} in LHR compared no fixation with tacker with inconsistent results. Eight SRMAs in LHR compared glue with tack with inconsistent results.

Re-estimation of mesh-fixation effects across OHRs/LHRs

The same mesh fixation gave different results for OHR and LHR, thus only the effects of glue versus sutures in OHR and tacker in LHR were considered in re-pooling for both surgical techniques.

The ES for glue fixation showed that hernia recurrence rates were not significantly different when compared with sutures and tacker with a degree of heterogeneity I^2 of 0 per cent for both pooling ([Fig. 2](#)); however, glue significantly reduced chronic groin pain about 51 per cent and 65 per cent relative to the suture and tacker with the corresponding I^2 values of 43.4 per cent and 16.4 per cent ([Fig. 3](#)).

Analysis of the degree of overlap in studies

Citation matrices were generated to quantify the degree of overlap of individual studies for each outcome across the SRMAs. The estimated overlaps by CCAs were high. For OHR, the overlaps were for glue versus suture and 41 for SGM versus suture. For LHR, the overlaps were 57 for no fixation versus tack and 30 for glue versus tack. Thus, many of the same individual studies were repeatedly used in SRMAs (each SRMA did not provide additional information) ([Appendix S11](#)).

Excess significance test and evaluation of evidence grading

[Table 3](#) summarizes the evidence for those outcomes that show statistical significance in our meta-analysis. A test for excess

Table 3 Outcome of meta-analysis with suggestive evidence class and excess significant test

Author (year)	Comparison	Outcome	Largest study	Random-effects summary (95% c.i.)	P	Excess significance	
						O/E	P
Colvin et al. (2013) ¹⁸	Glue versus suture	Chronic groin pain	0.45 (0.13, 1.49)	0.30 (0.16, 0.55)	<0.001	0/2.01	0.892
Li et al. (2015) ²⁶	Glue versus tack	Chronic groin pain	-0.06 (-0.09, -0.04)	-0.06 (-0.08, -0.04)	<0.001	1/1.02	0.019
Fang et al. (2014) ¹¹	SGM versus suture	Operating time	-1.00 (-1.48, -0.52)	-5.42 (-7.78, -3.06)	<0.001	6/6	NA
Sajid et al. (2014) ¹⁴	SGM versus suture	Operating time	-0.33 (-0.53, -0.14)	-0.36 (-0.47, -0.24)	<0.001	4/3.38	0.636
Wang et al. (2015) ¹⁵	SGM versus suture	Operating time	-1.00 (-1.72, -0.28)	-5.90 (-7.98, -3.81)	<0.001	9/8	0.711
Molegraaf et al. (2018) ¹⁷	SGM versus suture	Operating time	-5.30 (-6.89, -3.71)	-7.58 (-9.58, -5.58)	<0.001	5/5	NA
Sajid et al. (2013) ²⁴	Glue versus tack	Operating time	-1.86 (-2.20, -1.53)	-0.65 (-1.55, 0.25)	<0.001	2/3.45	0.841

SGM, self-gripping mesh; NA, not applicable; O/E, the observed number of significant tests/ the expected number of significant tests.

Table 4 The summarized box of evidence for inguinal hernia mesh fixation

Outcome	Suggestive of mesh fixation
Hernia recurrence prevention	All techniques
Chronic groin pain prevention	Glue
Shortening of operating time	Glue, SGM
Early return to daily activities	Glue
Postoperative complication prevention	All techniques

SGM, self-gripping mesh.

significance was performed to assess whether the observed number of studies with statistical significance ($P < 0.050$) was higher than expected. One significant difference (the superiority of glue versus tack for groin pain) showed a significant difference between observed and expected numbers ($P < 0.100$), indicating a high potential for bias. The clinical takeaway messages are summarized in Table 4.

Discussion

This umbrella review considered a broad range of options and comparisons across both OHR and LHR and comprehensively surveyed all reported outcomes in the literature. Mesh-based hernia repair is regarded as the standard treatment for adult symptomatic inguinal hernia according to the International Guidelines for Groin Hernia Management. Mesh is used to reinforce the inguinal floor in mesh-based hernia repair. Outcomes are dependent on surgical techniques, patient factors, mesh types and fixation techniques. A flat mesh is recommended over a three-dimensional mesh for mesh-based repair, and SGM provides an alternative option. Several mesh-fixation techniques are used, including suture, glue or SGM for OHR and metallic tack, absorbable tack, glue, suture, SGM or non-fixation techniques for LHR. The available data from 28 SRMAs and 2 NMAs were integrated within an umbrella review methodology to assess various mesh-fixation effects on hernia recurrence and found none with a level of evidence consistent with class V. Considering that no significant differences were detected in this review of literature, similar to a previous study³¹, clinicians can be confident in applying any of these approaches for the primary outcome of hernia recurrence.

The ESs of all SRMAs identified reduced chronic groin pain, with many reaching statistical significance. This finding was substantiated by the test of excess significance. The reduction in pain with glue, and to some extent with SGM, was apparent in both the short and medium-term postoperative periods,

showing consistency over time, with class III level of evidence. Glue seemed to reduce chronic groin pain compared with tack in LHR, although these findings may be prone to bias. In addition, the re-pooling results showed moderate heterogeneity, which might be due to multifactorial factors including various definitions used in defining chronic groin pain, the knowledge of inguinal anatomy, proper nerve identification handling, optimization of prosthetic materials, mesh weight, and the careful use of mesh fixation^{42,51,52}.

This review disclosed that glue and SGM significantly reduce operating time compared with sutures for OHR with class III level of evidence. Although the surgical time was reduced by only a few minutes, this finding was consistent across multiple SRMAs for OHR. In contrast, the differences in surgical time were very inconsistent by mesh-fixation types for LHR. In addition, glue significantly reduces the time to return to daily activities compared with sutures. Although the ES was very modest (approximately 1 day), this result was significant across several SRMAs and was consistent and relevant to clinical outcomes in the reduction of short- and medium-term chronic groin pain.

Finally, few differences in complication rates were detected. Considering the volume of data available, the lack of any difference in adverse event rates probably reflects the equivalence of the various techniques rather than a lack of power to detect any differences, should they exist.

These results are in contrast with previous MAs. For OHR, five SRMAs reported the non-superiority of SGM, whereas five SRMAs favoured glue for decreasing postoperative pain. For LHR, three SRMAs favoured glue fixation for decreasing postoperative pain, three SRMAs favoured no mesh fixation, and one meta-study suggested that all mesh fixations were comparable. Nonetheless, each study used different definitions for each outcome measurement, which did not allow data synthesis. A standardized definition for future studies should be encouraged allowing feasibility of data synthesis for clinical effectiveness of inguinal hernia mesh fixation by balancing between risk (complication of mesh fixation) and benefit (lowering hernia recurrence).

The optimal choice of approach will likely depend on other considerations, such as familiarity with techniques and associated costs. The cost of glue is more expensive (for example, Histoacryl® costs approximately €155 in Thailand) than suture in OHR and metallic tack in LHR. Future research on the evaluation of cost-effectiveness or cost-utility analysis should be conducted to assess whether glue is more cost-effective than suture or metallic tacker, particularly in large direct hernias

(M3-EHS classification), in which the international guideline has recommended to apply mesh fixation².

Furthermore, this study has some limitations. Definitions used for outcome measures such as chronic groin pain varied between individual studies included in the SRMAs and were not consistently defined. Hernia recurrence was assessed at various times; with the small number of included studies, we were not able to perform a subgroup analysis by short-term and long-term effects.

Finally, various mesh-fixation techniques might be useful for prevention of hernia recurrence, including suture, glue, or SGM for OHR, and metallic tack, absorbable tack, glue, suture, SGM or non-fixation techniques for LHR. Glue in both OHR and LHR may be of benefit for less pain in the short- and medium-term postoperative periods and less chronic groin pain for OHR in the long term. In addition, glue in OHR may also result in a quicker return to daily activities, although the associated absolute ES was small.

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Disclosure

The authors declare no conflict of interest.

Supplementary material

Supplementary material is available at *BJS Open* online.

Data availability

The authors confirm that the data supporting the findings of this study are available within the article and its [supplementary materials](#).

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