BMC Surgery

RESEARCH

Open Access

Meta-analysis of RCTs on the safety of non-fixation of mesh in TAPP inguinal hernia repair: an updated meta-analysis

Tao Jiang[1†], Chen Zhang[2,4*†], Xiao-Ling Wang[3], Da-Chun Yue[4], Xiao-Ping Yuan[4] and Deng-Chao Wang[1]

Abstract

Objective This meta-analysis aims to compare the clinical efficacy of mesh non-fixation and fixation in laparoscopic transabdominal preperitoneal (TAPP) inguinal hernia repair, systematically evaluating the application value of the mesh non-fixation technique in clinical settings.

Methods A computerized search of PubMed, Embase, Cochrane Library, Web of Science, and ClinicalTrials.gov databases was conducted to identify randomized controlled trials (RCTs) comparing mesh non-fixation and fixation in TAPP inguinal hernia repair. Meta-analysis was performed using RevMan 5.3 software, and the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) evidence grading system was employed for outcome quality assessment. Publication bias analysis was performed using Begg's test. A trial sequential analysis (TSA) was performed using TSA 0.9.5.10 Beta software.

Results A total of nine RCTs involving 1,879 inguinal hernia patients were included. Meta-analysis results demonstrated that, compared to the fixation group, the non-fixation group exhibited significantly lower seroma occurrence rate [RR = 0.43, 95% CI (0.20, 0.89), $P = 0.02$, heterogeneity $P = 0.28$, I^2=22%], Visual Analog Scale (VAS) pain score at 6 months postoperatively [MD=-0.21, 95% CI (-0.29, -0.12), $P < 0.00001$, heterogeneity $P = 0.34$, I^2=0%], and cost [MD=-3.23 thousand yuan, 95% CI (-4.26, -2.19), $P < 0.00001$, heterogeneity $P = 0.0003$, I^2=92%]. There were no statistically significant differences in overall complication rate [RR = 0.88, 95% CI (0.62, 1.23), $P = 0.45$, heterogeneity $P = 0.11$, I^2=44%], overall infection event rate [RR = 0.96, 95% CI (0.36, 2.56), $P = 0.93$, heterogeneity $P = 0.62$, I^2=0%] and recurrence rate [RR = 0.75, 95% CI (0.28, 1.99), $P = 0.56$, heterogeneity $P = 0.44$, I^2=0%] between the two groups. The results of the TSA indicated that the observed lower seroma occurrence rate in the non-fixation group compared to the fixation group requires further validation through the inclusion of additional RCTs.

Conclusion Mesh non-fixation in TAPP inguinal hernia repair is deemed safe and does not elevate the risk of hernia recurrence. However, given certain limitations in this study, future comprehensive and reliable validation will require further multicenter, high-quality, large-sample double-blind RCTs.

Keywords Inguinal hernia, TAPP, Mesh, Meta-analysis

†Tao Jiang and Chen Zhang contributed equally to this work.

*Correspondence:
Chen Zhang
zhangchensurgery@163.com
[1]Department of General Surgery, Zigong Fourth People's Hospital, Zigong, Sichuan 643000, China
[2]Department of Trauma Center, Zigong Fourth People's Hospital, Zigong, Sichuan 643000, China
[3]Department of Network Engineering, School of Computer Science and Engineering, Sichuan University of Science & Engineering, Zigong, Sichuan 643000, China
[4]Department of Orthopedics, People's Hospital of Pingchang County, Pingchang, Sichuan 636400, China

Introduction

Inguinal hernia, as a common surgical condition, has undergone significant evolution in its treatment approach in recent years. The transition from traditional hernia repair surgeries to laparoscopic transabdominal preperitoneal repair (TAPP) has introduced a minimally invasive therapeutic option, improving the overall patient experience [1–4]. With continuous advancements in medical technology, attention in inguinal hernia treatment has expanded beyond the surgical methods to finer details, such as the fixation technique of mesh. In the management of inguinal hernia, the choice of mesh fixation has been a focal point of discussion in the medical community. Conventionally, robust mesh fixation has been employed during surgery; however, in recent years, the debate over the use of non-fixation techniques has gained attention [5, 6]. At the core of this controversy lies the question of whether a secure fixation of the mesh is necessary during TAPP surgery and whether non-fixation of the mesh could have a significant impact on clinical outcomes, particularly in terms of recurrence [7, 8].

This study employs a meta-analysis approach to comprehensively assess the clinical efficacy of mesh non-fixation and fixation techniques in TAPP inguinal hernia repair. The primary objective is to gain a thorough understanding of the outcomes associated with different surgical approaches. Emphasis is placed not only on comparing postoperative recurrence rates but also on various aspects, including complications, postoperative pain scores, and total costs. Through a comprehensive analysis of these key indicators, we aim to uncover the advantages and disadvantages of mesh fixation methods in TAPP inguinal hernia repair, providing clinicians with more comprehensive information to make informed decisions in surgical management. Additionally, this study utilizes the GRADE evidence grading system for a comprehensive evaluation of the quality of results, striving to deliver high-quality scientific evidence and enhance the credibility of the research. This effort will contribute to a clearer understanding within the medical community of the impact of different mesh fixation techniques on TAPP inguinal hernia repair surgical outcomes, offering more reliable evidence for the future treatment of inguinal hernias.

Materials and methods

We carried out and reported the systematic review in accordance with the guidelines outlined by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses for Protocols [9]. The registration code assigned to this review is INPLASY202410092.

Inclusion and exclusion criteria

Inclusion criteria

Inclusion Criteria: (1) Study Population: Adults with inguinal hernia, including primary or recurrent, unilateral or bilateral, direct or indirect hernias, aged 18 or older, and of any gender. (2) Intervention: TAPP inguinal hernia repair with mesh non-fixation or fixation, regardless of the type of mesh used. (3) Study Design: Randomized controlled trials conducted in English. (4) Outcome indicators: Seroma occurrence rate, overall complication rate (the combined rate of intraoperative complications, seroma, wound infection, urinary retention, hematoma, testicular problems, wound infections, and local numbness), overall infection event rate (including wound infection rate and mesh infection rate), VAS pain score at 6 months postoperatively, cost, and recurrence rate.

Exclusion criteria

Exclusion Criteria: (1) Non-RCTs; (2) Relevant reviews, meta-analyses, or duplicated publications; (3) Literature with inaccessible full text or unavailable data extraction; (4) Studies involving individuals aged below 18; (5) Surgical procedures involving totally extraperitoneal inguinal hernia.

Search strategy

A computerized search was conducted across multiple databases, including PubMed, Embase, Cochrane Library, Web of Science, and ClinicalTrials.gov. The search terms employed encompassed key terms such as inguinal hernia, groin hernia, TAPP, Transabdominal Preperitoneal, hernioplasty, mesh fixation, no-fixation, non-fixation, staple, tack, glue, randomized controlled trial, RCT. The search was conducted from the inception of the databases up to January 13, 2024. Additionally, a thorough examination of references in the included studies was performed to identify any relevant literature meeting our inclusion criteria.

Literature selection and data extraction

Two independent researchers conducted literature screening and data extraction, cross-verifying to ensure accuracy. In cases of disagreement, resolution was achieved through discussion or consultation with a third party. During the literature selection process, titles were initially reviewed, leading to the elimination of obviously irrelevant literature. Subsequently, abstracts and full texts were scrutinized to determine eligibility. In instances where clarification was necessary, direct communication via email or phone was initiated with the original authors to obtain crucial information vital to this study, but not clearly stated in the literature. The extracted data encompassed details such as the first author and publication

year, sample size, age, mesh fixation method, mesh type, follow-up time, and outcome indicators.

Quality assessment

Two independent researchers conducted a bias risk assessment for the included studies, with cross-verification of the results. The assessment of bias risk utilized the Risk of Bias (RoB) 1 tool, as recommended by the Cochrane Handbook 5.1.0. This tool encompasses seven aspects, including random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessors, completeness of outcome data, selective reporting, and other sources of bias. Each item was judged and categorized as high risk of bias, low risk of bias, or unclear, following the criteria outlined in the Cochrane Handbook [10].

Statistical analysis

Statistical analyses were performed using RevMan 5.3 software. For continuous data, the mean difference (MD) was employed as the effect size statistic, while for binary variables, the relative risk (RR) served as the effect size statistic. All effect sizes were accompanied by their respective 95% confidence intervals (CI). Heterogeneity among the included study results was assessed using the chi-square test and quantified with the I^2 statistic. If no statistical heterogeneity was observed among the studies ($P \geq 0.1$, $I^2 < 50\%$), a fixed-effects model was employed for the analysis. In the presence of statistical heterogeneity, the sources of heterogeneity were further explored. Following the exclusion of apparent clinical heterogeneity, a random-effects model was used for meta-analysis [11]. The significance level for meta-analysis was set at $\alpha = 0.05$. Substantial clinical heterogeneity was addressed through subgroup analysis, sensitivity analysis, or descriptive analysis. Publication bias analysis was performed using Begg's test. For indicators with more than 10 included studies, funnel plots were generated to assess publication bias [12]. A trial sequential analysis of the seroma occurrence rate was performed using TSA 0.9.5.10 Beta software. The required information size (RIS) was set as the sample size, with a Type I error rate of 5% and a power of 80%. The relative risk reduction was set at 20%, and the incidence in the control arm was established at 80% based on the results of the meta-analysis.

Assessment of evidence quality

In accordance with the GRADE criteria, we employed the GRADEprofiler version 3.6 tool to assess the quality of evidence for each outcome indicator. Based on five key aspects: risk of bias, consistency, indirectness, imprecision, and publication bias, we categorized the outcome indicators into four levels: high, moderate, low, and very low quality [13].

Results

Literature search results

Initially, a total of 268 articles were retrieved from various databases, and an additional one article was obtained through manual searching. After reviewing titles and abstracts, 46 duplicate articles were excluded, along with 146 articles unrelated to the research objectives, and 54 articles comprising empirical summaries, meta-analyses, and reviews. The remaining 22 articles underwent full-text screening. Among them, six articles were excluded for utilizing the totally extraperitoneal hernia repair technique, two articles for both groups using the fixed method for the mesh, and five articles for not being RCTs. Following this hierarchical screening process, a final selection of nine articles was included [8, 14–21]. The detailed screening process is illustrated in Fig. 1, and the basic information of the selected articles is summarized in Table 1.

Results of literature quality assessment

Among the nine RCTs, six studies [15–20] explicitly described the randomization methods employed. Allocation concealment was utilized in four studies [14, 16, 17, 20], while blinding of both participants and implementers was implemented in three studies [14, 17, 20]. Two studies [14, 20] employed blinding for outcome assessors. In one study [8], there was incomplete outcome data. None of the studies [8, 14–21] exhibited selective result reporting or other biases. As illustrated in Figs. 2 and 3.

Meta analysis results

Seroma occurrence rate

Seven studies [8, 14–19] (involving 1,703 patients with inguinal hernia) reported the seroma occurrence rate. The seroma occurrence rate in the non-fixation group was 9/709 (1.26%), while in the fixation group, it was 31/994 (3.11%). No statistical heterogeneity was observed among the studies ($P = 0.28$, $I^2 = 22\%$). Utilizing a fixed-effects model for meta-analysis, the pooled effect size indicated a lower seroma occurrence rate in the non-fixation group compared to the fixation group [RR = 0.43, 95% CI (0.20, 0.89), $P = 0.02$]. This difference was statistically significant, as illustrated in Fig. 4.

Overall complication rate

Six studies [8, 14–16, 20, 21] (involving 901 patients with inguinal hernia) reported the overall complication rate. The overall complication rate in the non-fixation group was 54/442 (12.2%), while in the fixation group, it was 63/459 (13.7%). No statistical heterogeneity was observed among the studies ($P = 0.11$, $I^2 = 44\%$). Utilizing a fixed-effects model for meta-analysis, the pooled effect size indicated that there was no statistically significant difference between the non-fixation group and the fixation

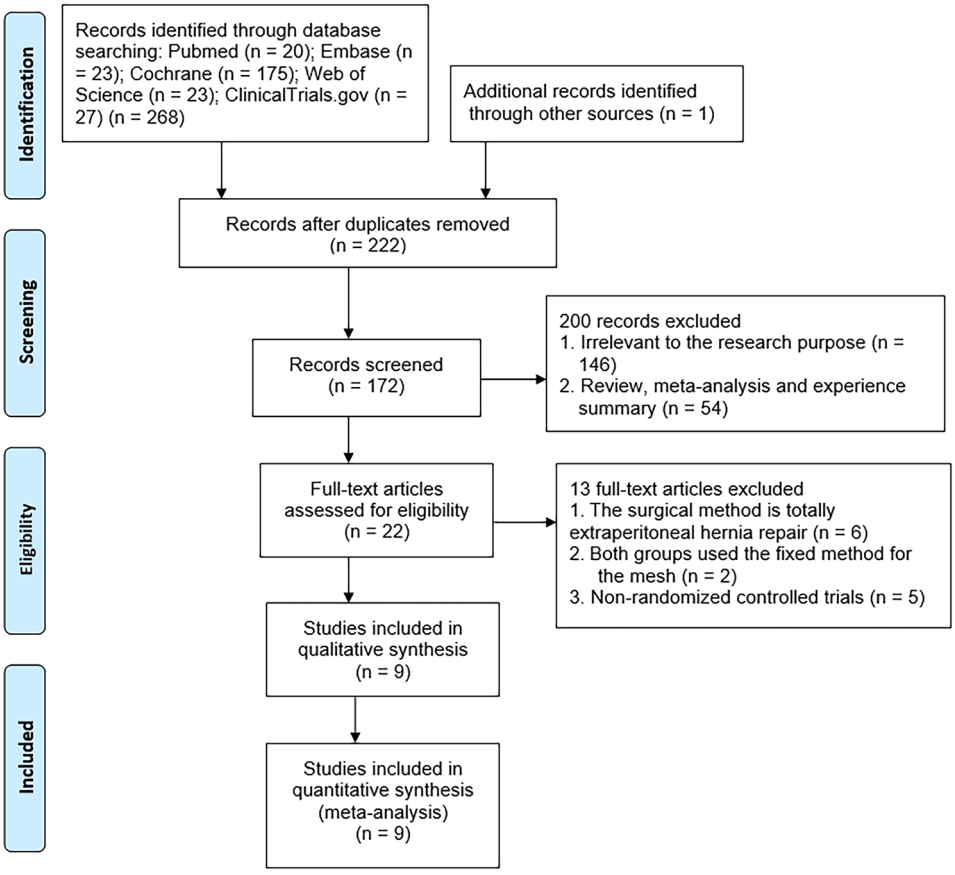

Fig. 1 Study selection

group in terms of the overall complication rate [RR=0.88, 95% CI (0.62, 1.23), P=0.45], as illustrated in Fig. 5.

Overall infection event rate

Seven studies [8, 15–19, 21] (involving 1,712 patients with inguinal hernia) reported the overall infection event rate. The overall infection event rate in the non-fixation group was 6/723 (0.83%), while in the fixation group, it was 7/989 (0.71%). No statistical heterogeneity was observed among the studies (P=0.62, I^2=0%). Utilizing a fixed-effects model for meta-analysis, the pooled effect size indicated that the difference in overall infection event rates between the two groups was not statistically significant [RR=0.96, 95% CI (0.36, 2.56), P=0.93], as illustrated in Fig. 6.

VAS pain score at 6 months postoperatively

Two studies [19, 20] (involving 190 patients with inguinal hernia) reported the VAS pain score at 6 months postoperatively. No statistical heterogeneity was observed among the studies (P=0.34, I^2=0%). Utilizing a fixed-effects model for meta-analysis, the pooled effect size indicated that the VAS pain score at 6 months postoperatively in the non-fixation group was lower than in the fixation group [MD=-0.21, 95% CI (-0.29, -0.12), P<0.00001]. This difference was statistically significant, as illustrated in Fig. 7.

Cost

Two studies [19, 21] (involving 176 patients with inguinal hernia) reported the cost. There was statistical heterogeneity among the studies (P=0.0003, I^2=92%). Utilizing a random-effects model for meta-analysis, the pooled effect size indicated that the cost in the non-fixation group was lower than in the fixation group [MD=-3.23 thousand yuan, 95% CI (-4.26, -2.19), P<0.00001]. This difference was statistically significant, as illustrated in Fig. 8.

Recurrence rate

Nine studies [8, 14–21] (involving 1,879 patients with inguinal hernia) reported the recurrence rate. The recurrence rate in the non-fixation group was 4/797 (0.50%), while in the fixation group, it was 8/1,082 (0.74%). No statistical heterogeneity was observed among the studies (P=0.44, I^2=0%). Utilizing a fixed-effects model for meta-analysis, the pooled effect size indicated that the difference in recurrence rates between the non-fixation

Table 1 Characteristics of the studies included in this meta-analysis

First author and publication year	Country	Group	Sample size (M/F)	Age (years)	Fixation method	Mesh type	Follow-up time (months)	Recurrence rate	Outcome indicators
Azevedo 2022 [14]	Brazil	Non-fixation	21 (19/2)	Na	Non-fixation	Heavyweight polypropylene mesh (least 15 cm × 12 cm)	24	0%	①②⑥
		Fixation	21 (21/0)	Na	Fibrin glue	Heavyweight polypropylene mesh (least 15 cm × 12 cm)	24	0%	
		Fixation	21 (21/0)	Na	Tack	Heavyweight polypropylene mesh (least 15 cm × 12 cm)	24	0%	
Cambal 2012 [15]	Slovakia	Non-fixation	50 (41/9)	52.6 ± 14.9	Non-fixation	Self-gripping mesh (10 × 15 cm)	3	0%	①②③⑥
		Fixation	50 (37/13)	50.3 ± 15.8	Fibrin glue	Self-gripping mesh (10 × 15 cm)	3	0%	
Ferrarese 2016 [16]	Italy	Non-fixation	30 (30/0)	53 ± 11.0	Non-fixation	Self-gripping mesh	3	0%	①②③⑥
		Fixation	30 (30/0)	53.3 ± 10.9	Fibrin glue	Polypropylene mesh	3	3.33%	
Habeeb 2020 [17]	Egypt	Non-fixation	266 (260/6)	24.1 ± 5.9	Non-fixation	Polypropylene mesh (10 × 15 cm)	18	0.75%	①③⑥
		Fixation	266 (253/13)	24.1 ± 5.9	Tacker	Polypropylene mesh (10 × 15 cm)	18	0.37%	
		Fixation	266 (258/8)	24.1 ± 5.9	Fistoacryl	Polypropylene mesh (10 × 15 cm)	18	0.75%	
Kalidarei 2019 [18]	Iran	Non-fixation	39 (32/7)	53.8 ± 8.4	Non-fixation	Prolene Mesh (10 cm × 15 cm)	6	5.1%	①③⑥
		Fixation	41 (31/10)	50.5 ± 10.2	Suture or spiral tacks	Prolene Mesh (10 cm × 15 cm)	6	0%	
Li 2017 [19]	China	Non-fixation	50 (50/0)	43.6 ± 14.1	Non-fixation	Easyprosthes lightweight 3D repair patch (12 cm × 16 cm)	6	0%	①③④⑤⑥
		Fixation	50 (50/0)	42.5 ± 12.8	Absorbable stapler	Easyprosthes lightweight 3D repair patch (12 cm × 16 cm)	6	0%	
Meshkati 2023 [20]	Iran	Non-fixation	50 (48/2)	39.6 ± 13.5	Non-fixation	Polypropylene mesh (15 × 13 cm)	6	0%	②④⑥
		Fixation	50 (50/0)	42.2 ± 14.3	Absorbable tacks	Polypropylene mesh (15 × 13 cm)	6	2%	
Smith 1999 [21]	Australia	Non-fixation	253 (247/6)	53 (14–85)	Non-fixation	Polypropylene mesh (10 × 15 cm)	16 (1–32)	0%	①②③⑥
		Fixation	249 (239/10)	54 (15–86)	Stapling device	Polypropylene mesh (10 × 15 cm)	16 (1–32)	1.20%	
Wang 2018 [22]	China	Non-fixation	38 (Na/Na)	47 (16–78)	Non-fixation	Polypropylene mesh (10 × 15 cm)	15 (6–24)	0%	②③⑤⑥
		Fixation	38 (Na/Na)	47 (16–78)	Tacker	Polypropylene mesh (10 × 15 cm)	15 (6–24)	0%	

①Seroma occurrence rate; ②overall complication rate; ③overall infection event rate; ④VAS pain score at 6 months postoperatively; ⑤cost; ⑥recurrence rate. F: female; M: male; m: month; Na: not available

group and the fixation group was not statistically significant [RR = 0.75, 95% CI (0.28, 1.99), $P = 0.56$], as illustrated in Fig. 9.

Subgroup analysis

Subgroup analyses were conducted based on the method of mesh fixation for outcome indicators that included more than two studies. These were divided into the invasive mesh fixation group and the non-invasive mesh fixation group. The detailed results of the subgroup analysis are shown in Table 2.

Publication bias analysis

The Begg's test results for Seroma occurrence rate, overall complication rate, overall infection event rate, VAS pain score at 6 months postoperatively, cost, and recurrence rate were $P = 0.221$, $P = 0.452$, $P = 1.000$, $P = 1.000$, $P = 1.000$, and $P = 1.000$, respectively. No publication bias detected.

Results of the TSA

The TSA results indicated that, although the Z-statistic exceeded 1.96 ($P < 0.05$), the Z-curve did not cross the

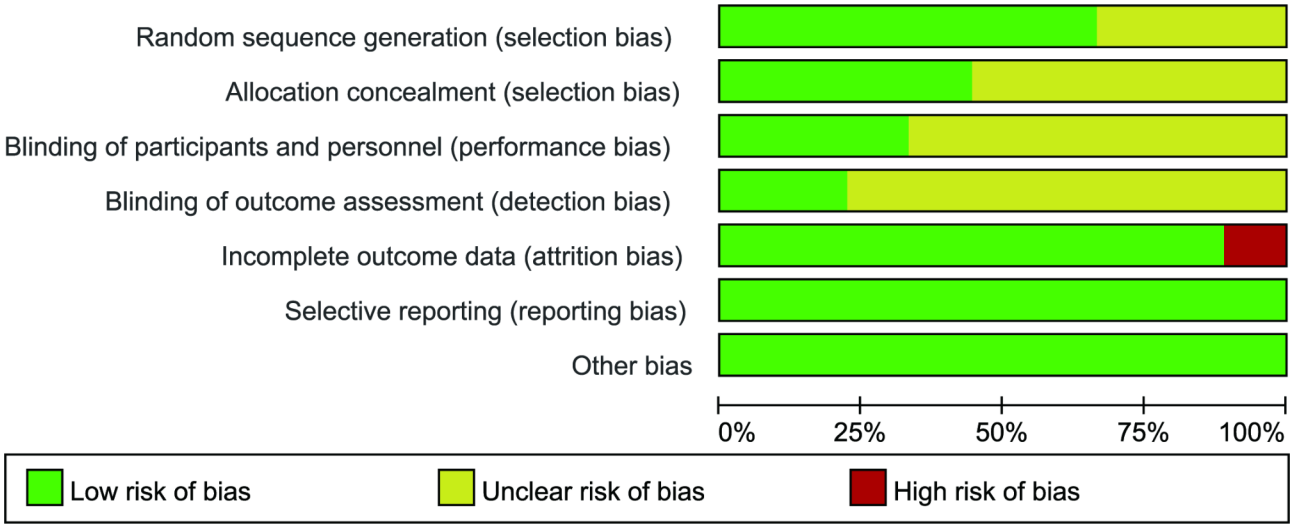

Fig. 2 Risk of bias graph for RCTs included in this study

trial sequential boundary, and the cumulative information size remained below the RIS. Consequently, additional RCTs are necessary to further validate this finding, as illustrated in Fig. 10.

Grade evidence quality grading results

The evidence grade for seroma occurrence rate and VAS pain score at 6 months postoperatively, is moderate, while the evidence grades foroverall complication rate, overall infection event rate, cost, and recurrence rate are low, as illustrated in Table 3.

Discussion

In TAPP inguinal hernia repair, the fixation method for the mesh has always been a focal point for surgeons. Traditionally, ithas been considered a standardized surgical procedure. However, with the continuous evolution of medical technology, an increasing number of studies have explored the approach of mesh non-fixation. This has sparked a debate regarding the safety and efficacy of non-fixation compared to fixation in TAPP inguinal hernia repair [7, 8]. In this research context, we conducted a meta-analysis aiming to comprehensively assess the clinical efficacy of both non-fixation and fixation approaches in TAPP inguinal hernia repair, providing more accurate guidance for clinical practice. The evaluated parameters include seroma occurrence rate, overall complication rate, overall infection event rate, VAS pain score at 6 months postoperatively, cost, and recurrence rate. Through this study, our aim is to provide surgeons with more comprehensive and scientifically informed decision support, aiding them in selecting the most suitable mesh management approach during TAPP inguinal hernia repair, whether it be fixation or non-fixation.

In our meta-analysis, we found that in TAPP inguinal hernia repair, the use of non-fixation mesh, compared to fixation mesh is associated with lower seroma occurrence rate, which may be attributed to multiple factors. Firstly, the non-fixation mesh technique may reduce mechanical stimulation to surrounding tissues, thereby lowering the risk of vascular injury and bleeding. The use of non-fixation mesh might promote natural tissue healing, decrease the chance of seroma formation, and maintain the physiological process of normal healing. Non-fixation mesh may also reduce postoperative inflammatory reactions, further slowing down seroma development [22, 23]. However, the TSA results indicated that additional RCTs are required to further validate this finding. The non-fixation mesh approach evidently simplifies surgery, reducing the complexity of instrument use and tissue manipulation, thereby minimizing potential complications. Additionally, non-fixation mesh may decrease additional damage to surrounding tissues, aiding in lowering complications associated with instrument use and tissue manipulation [24–26]. However, the results of this meta-analysis indicate that there is no statistically significant difference between the non-fixation group and the fixation group in terms of overall complication rate. These findings may be influenced by factors such as study design, sample size, research quality, individual patient characteristics, and surgical team experience, and further confirmation is required through large-sample, high-quality RCTs. Compared to fixation mesh, non-fixation mesh may result in less tissue tension and discomfort, contributing to alleviating long-term pain. Additionally, the use of non-fixation mesh may reduce manipulation and stimulation of surrounding nerve structures, helping to alleviate neuropathic pain in patients during the months following surgery. Moreover, non-fixation

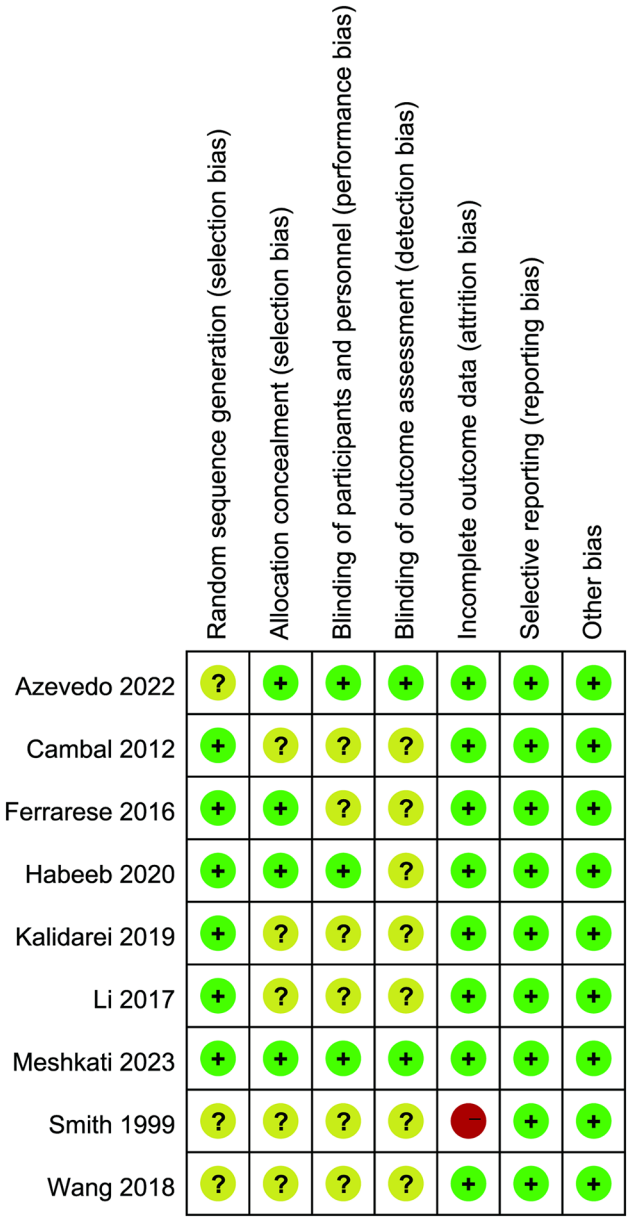

Fig. 3 Summary of the risk of bias analysis for the RCTs included in this study

mesh may lead to a milder postoperative inflammatory response, slowing down the progression of pain [24, 27–29]. Therefore, the VAS pain score at 6 months postoperatively in the non-fixation group is lower than in the fixation group. However, only two studies reported this outcome, and there is considerable heterogeneity, necessitating further validation through more RCTs in the future. The cost in the non-fixation group is lower than in the fixation group. This is attributed to the reduced need for surgical instruments and materials in the non-fixation group, as there is no requirement for additional fixation materials. This significantly decreases the consumable costs associated with the surgery [21, 26, 29, 30]. The success of inguinal hernia repair is largely contingent on the recurrence rate, and factors contributing to postoperative hernia recurrence are multifaceted, closely tied to mesh size, mesh displacement, contraction, and the type of hernia [15, 31]. In this meta-analysis, the recurrence rate in the non-fixation group was 0.50%, while in the fixation group, it was 0.74%. The absence of a statistically significant difference in recurrence rates between the two groups suggests that the non-fixation group did not increase the hernia recurrence rate and is considered safe. In the studies included in this meta-analysis, we observed that the follow-up times in some studies were relatively short, which may have an impact on the evaluation of recurrence rates. Therefore, we recommend extending follow-up times in future research to comprehensively assess surgical outcomes. Prolonged follow-up times help more accurately capture potential hernia recurrence, provide more reliable data support, and thereby gain a more comprehensive understanding of the long-term effects of non-fixation mesh in TAPP inguinal hernia repair.

This study also has certain limitations: (1) Some included studies had small sample sizes, and most studies lacked clear descriptions of randomization methods, blinding, and allocation concealment. (2) Variability in surgeon expertise, surgical procedures, mesh materials, and fixation techniques among the included studies inevitably influenced the outcome analysis. (3) Inconsistent follow-up durations across studies, with some having relatively short follow-up periods, resulted in limitations when assessing the long-term risk of hernia recurrence. (4) Due to limited data, early postoperative outcomes such as VAS pain scores and rates of chronic pain were not assessed, and subgroup analyses for different fixation methods (e.g., glue fixation, tack fixation) were not conducted. (5) In some studies, self-gripping mesh was used, which inherently possesses fixation properties, making comparisons very difficult. (6) The evidence quality for the majority of outcome indicators assessed by GRADE was rated as low.

In conclusion, the non-fixation of mesh in TAPP inguinal hernia repair is considered safe and does not increase the risk of hernia recurrence postoperatively. However, due to some limitations in this study, comprehensive and reliable validation is still required through future multicenter, high-quality, large-sample, double-blind RCTs.

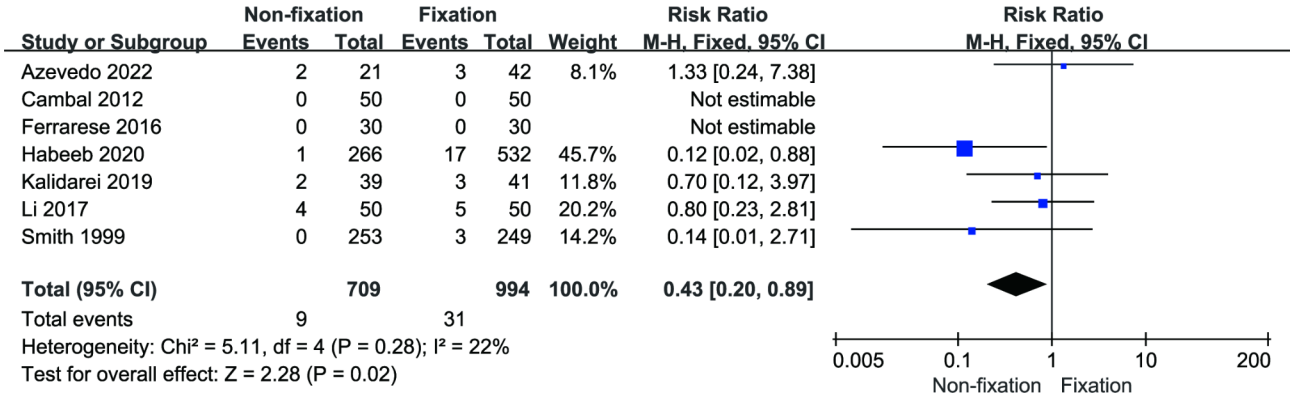

Fig. 4 Forest plot of meta-analysis comparing seroma occurrence rate between the two groups

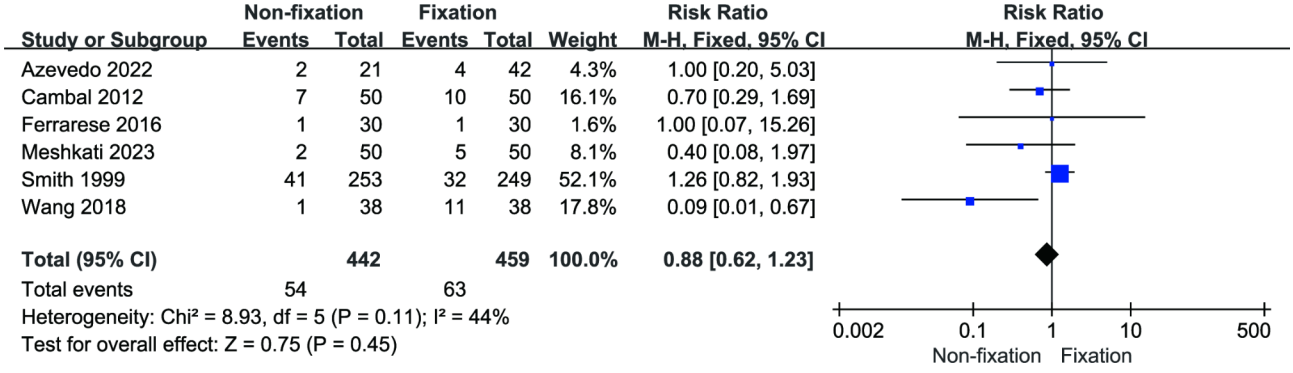

Fig. 5 Forest plot of meta-analysis comparing overall complication rate between the two groups

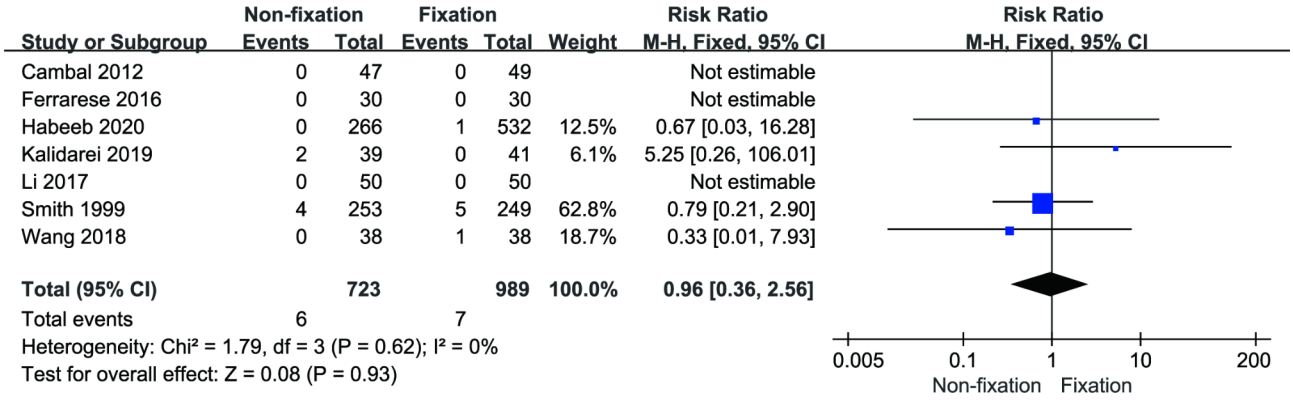

Fig. 6 Forest plot of meta-analysis comparing overall infection event rate between the two groups

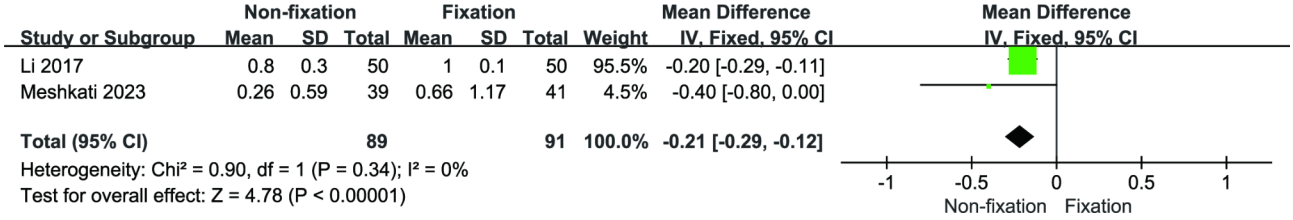

Fig. 7 Forest plot of meta-analysis comparing VAS pain score at 6 months postoperatively between the two groups

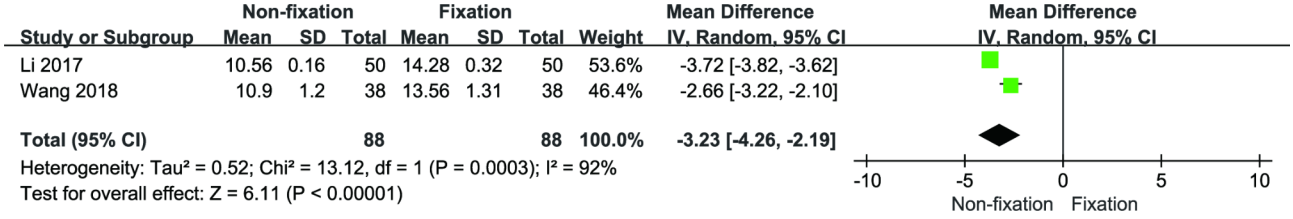

Fig. 8 Forest plot of meta-analysis comparing cost between the two groups

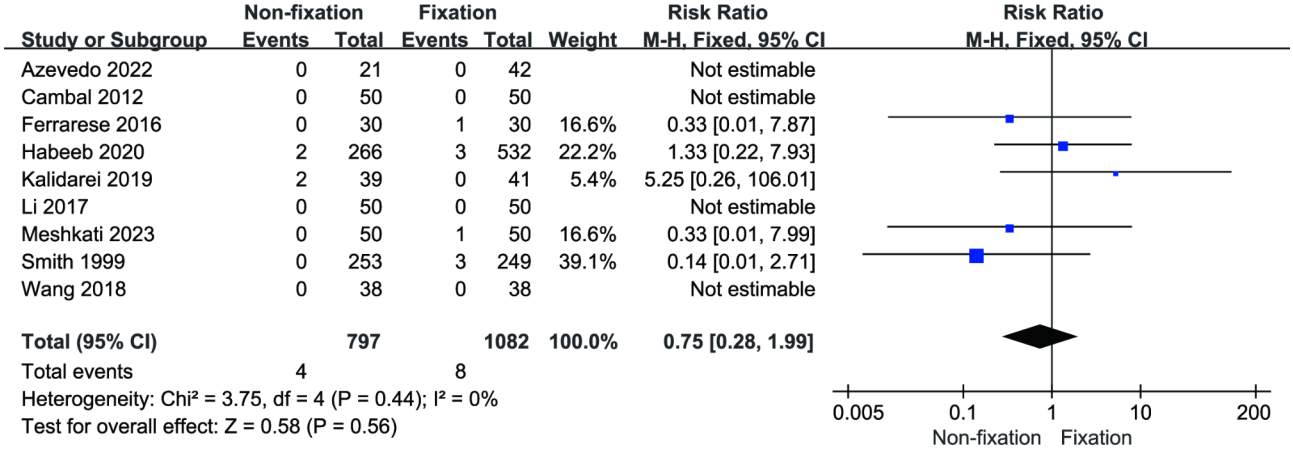

Fig. 9 Forest plot of meta-analysis comparing recurrence rate between the two groups

Table 2 The results of the subgroup analysis based on different fixation methods

		Number of	Sample	Heterogeneity test results			
Outcome	Subgroup	studies	size	P-value	I^2 Value	Effect model	Meta-analysis results
Seroma occurrence rate	Invasive mesh fixation	[14, 17–19, 21]	1256	0.78	0	Fixed	RR = 0.58, 95% CI (0.27, 1.26), *P* = 0.17
	Non-invasive mesh fixation	4 [14–17]	734	0.03	79	Random	RR = 0.36, 95% CI (0.01, 10.39), *P* = 0.55
Overall complication rate	Invasive mesh fixation	4 [14, 20–22]	720	0.04	64	Random	RR = 0.91, 95% CI (0.62, 1.32), *P* = 0.62
	Non-invasive mesh fixation	3 [14–16]	202	0.93	0	Fixed	RR = 0.77, 95% CI (0.36, 1.65), *P* = 0.50
Overall infection event rate	Invasive mesh fixation	5 [17–19, 21, 22]	1290	0.55	0	Fixed	RR = 0.88, 95% CI (0.33, 2.33), *P* = 0.80
	Non-invasive mesh fixation	3 [15–17]	688	Not estimable	Not estimable	Not estimable	Not estimable
Recurrence rate	Invasive mesh fixation	7 [14, 17–22]	1432	0.30	18	Fixed	RR = 0.85, 95% CI (0.28, 2.62), *P* = 0.78
	Non-invasive mesh fixation	4 [14–17]	734	0.56	0	Fixed	RR = 0.71, 95% CI (0.14, 3.58), *P* = 0.68

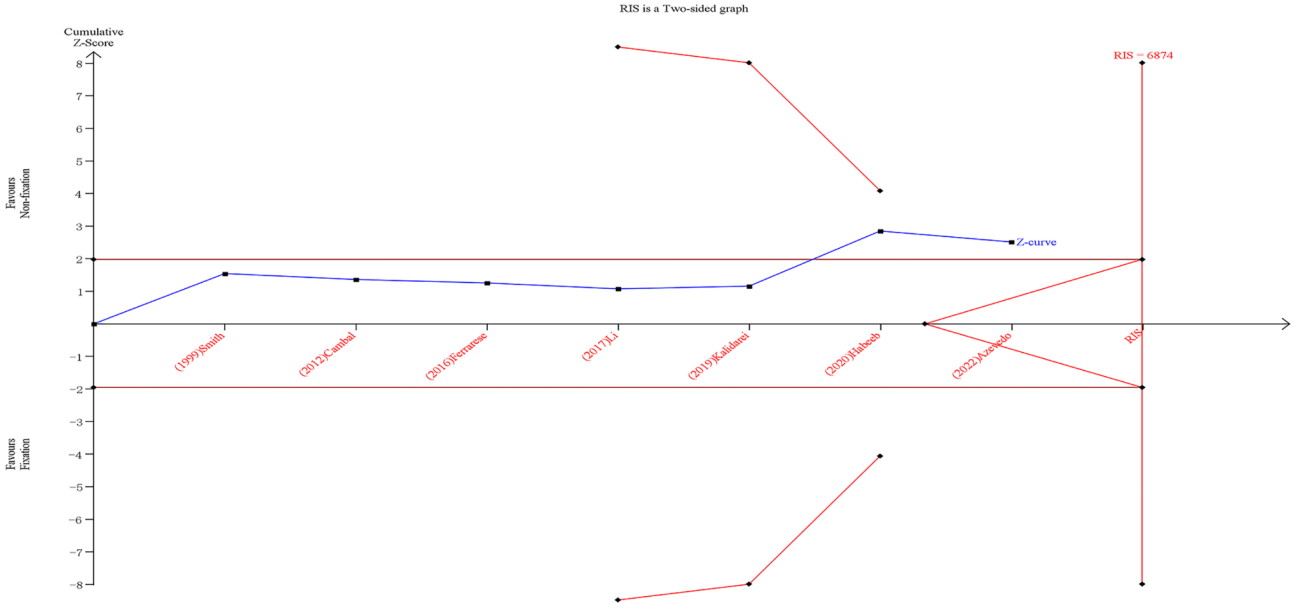

Fig. 10 Results of the TSA

Table 3 GRADE assessment of outcome measures

Quality assessment							No of patients		Effect		Quality	Importance
No of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Seroma occurrence rate	Control	Relative (95% CI)	Absolute		
Seroma occurrence rate												
7	randomised trials	serious[1,2]	no serious inconsistency	no serious indirectness	no serious imprecision	none	9/709 (1.3%)	31/994 (3.1%) 3.2%	RR 0.43 (0.2 to 0.89)	18 fewer per 1000 (from 3 fewer to 25 fewer) 18 fewer per 1000 (from 4 fewer to 26 fewer)	⊕⊕⊕O MODERATE	IMPORTANT
overall complication rate												
6	randomised trials	serious[1,2]	no serious inconsistency	no serious indirectness	serious[3]	none	54/442 (12.2%)	63/459 (13.7%) 11.4%	RR 0.88 (0.62 to 1.23)	16 fewer per 1000 (from 52 fewer to 32 more) 14 fewer per 1000 (from 43 fewer to 26 more)	⊕⊕OO LOW	IMPORTANT
overall infection event rate												
7	randomised trials	serious[1,2]	no serious inconsistency	no serious indirectness	serious[3]	none	6/723 (0.8%)	7/989 (0.7%) 0%	RR 0.96 (0.36 to 2.56)	0 fewer per 1000 (from 5 fewer to 11 more) -	⊕⊕OO LOW	IMPORTANT
VAS pain score at 6 months postoperatively (Better indicated by lower values)												
2	randomised trials	serious[1,2]	no serious inconsistency	no serious indirectness	no serious imprecision	none	89	91	-	MD 0.21 lower (0.29 to 0.12 lower)	⊕⊕⊕O MODERATE	IMPORTANT
cost (Better indicated by lower values)												
2	randomised trials	serious[1,2]	serious[4]	no serious indirectness	no serious imprecision	none	88	88	-	MD 3.23 lower (4.26 to 2.19 lower)	⊕⊕OO LOW	IMPORTANT
recurrence rate												
9	randomised trials	serious[1,2]	no serious inconsistency	no serious indirectness	serious[3]	none	4/797 (0.5%)	8/1082 (0.74%) 0%	RR 0.75 (0.28 to 1.99)	2 fewer per 1000 (from 5 fewer to 7 more) -	⊕⊕OO LOW	CRITICAL

CI: Confdence interval; GRADE: Grading of Recommendations Assessment, Development, and Evaluation; MD: Mean diference; RR: Risk ratio

[1] Specific randomization methods were not described

[2] Lack of allocation concealment and lack of blinding

[3] Wide confdence interval

[4] I2>50%

Abbreviations

CI	Confidence Interval
F	Female
GRADE	Grading of Recommendations, Assessment, Development, and Evaluation
INPLASY	International Platform of Registered Systematic Review and Meta-analysis Protocols
M	Male
m	Month
MD	Mean Difference
Na	Not available
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
RCT	Randomized Controlled Trial
RR	Relative Risk
TAPP	Transabdominal Preperitoneal
VAS	Visual Analog Scale

Acknowledgements
Not applicable.

Author contributions
Tao Jiang: Conceived and designed the study, collected data, and contributed to the writing of the manuscript. Played a pivotal role in the interpretation of data and the critical revision of the manuscript.Chen Zhang: Assisted with the design of the study, data analysis, and interpretation. Contributed significantly to the writing and critical revision of the article. Handled correspondence and acted as the primary contact for project coordination.Xiao-Ling Wang: Led the data collection efforts, contributed to the design of the study, and assisted in the analysis of the data. Played a key role in revising the manuscript critically for important intellectual content.Da-Chun Yue: Participated in data analysis and interpretation. Contributed to writing sections of the manuscript and critically revising the content for important intellectual perspectives.Xiao-Ping Yuan: Provided critical feedback and helped shape the research, analysis, and manuscript. Contributed to the conception and design of the study.Deng-Chao Wang: Contributed to the conception and design of the study, oversaw the entire project, and ensured the accuracy of the data and analysis. Involved in providing final approval of the version to be published.

Funding
No funding was received for this study.

Data availability
All data generated or analyzed during this study were included in this published article.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Received: 18 August 2024 / Accepted: 10 October 2024
Published online: 17 October 2024

References

1. Köckerling F, Simons MP. Current concepts of inguinal hernia repair. Visc Med. 2018;34(2):145–50.
2. Perez AJ, Strassle PD, Sadava EE, Gaber C, Schlottmann F. Nationwide analysis of inpatient laparoscopic versus open inguinal hernia repair. J Laparoendosc Adv Surg Tech. 2020;30(3):292–8.
3. Takata MC, Duh QY. Laparoscopic inguinal hernia repair. Surg Clin North Am. 2008;88(1):157–78.
4. Wu JJ, Way JA, Eslick GD, Cox MR. Transabdominal pre-peritoneal versus open repair for primary unilateral inguinal hernia: a meta-analysis. World J Surg. 2018;42:1304–11.
5. Sajid MS, Ladwa N, Kalra L, Kalra, Hutson K, Sains P, et al. A meta-analysis examining the use of tacker fixation versus no-fixation of mesh in laparoscopic inguinal hernia repair. Int J Surg. 2012;10(5):224–31.
6. Claus CMP, Rocha GM, Campos ACL, Paulin JAN, Coelho JCU. Mesh displacement after bilateral inguinal hernia repair with no fixation. JSLS. 2017;21(3):e201700033.
7. Mayer F, Niebuhr H, Lechner M, Dinnewitzer A, Köhler G, Hukauf M, et al. When is mesh fixation in TAPP-repair of primary inguinal hernia repair necessary? The register-based analysis of 11,230 cases. Surg Endosc. 2016;30:4363–71.
8. Smith AI, Royston CMS, Sedman PC. Stapled and nonstapled laparoscopic transabdominal preperitoneal (TAPP) inguinal hernia repair: a prospective randomized trial. Surg Endosc. 1999;13:804–6.
9. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. J Clin Epidemiol. 2021;134:178–89.
10. Higgins JPT, Altman DG, Gotzsche PC, Jüni P, Moher D, Oxman AD, et al. The cochrane collaboration's tool for assessing risk of bias in randomised trials. BMJ. 2011;343:343–d5928.
11. Higgins JPT, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta-analyses. BMJ. 2003;327(7414):557–60.
12. Sedgwick P, Marston L. How to read a funnel plot in a meta-analysis. BMJ. 2015;351:h4718.
13. Zhang Y, Akl EA, Schünemann HJ. Using systematic reviews in guideline development: the GRADE approach. Res Synth Methods. 2019;10:312–29.
14. Azevedo MA, Oliveira GBT, Malheiros CA, Roll S. Are there differences in chronic pain after laparoscopic inguinal hernia repair using the transabdominal technique comparing with fixation of the mesh with staples, with glue or without fixation? A clinical randomized, double-blind trial. ABCD Arq Bras Cir Dig. 2022;35.
15. Cambal M, Zonca P, Hrbaty B. Comparison of self-gripping mesh with mesh fixation with fibrin-glue in laparoscopic hernia repair (TAPP). Bratisl Lek Listy. 2012;113(2):103–7.
16. Ferrarese A, Bindi M, Rivelli M, Solej M, Enrico S, Martino V. Self-gripping mesh versus fibrin glue fixation in laparoscopic inguinal hernia repair: a randomized prospective clinical trial in young and elderly patients. Open Med. 2016;11(1):497–508.
17. Habeeb TAAM, Mokhtar MM, Sieda B, Osman G, Ibrahim A, Metwalli AM, et al. Changing the innate consensus about mesh fixation in trans-abdominal preperitoneal laparoscopic inguinal hernioplasty in adults: short and long term outcome. Randomized controlled clinical trial. Int J Surg. 2020;83:117–24.
18. Kalidarei B, Mahmoodieh M, Sharbu Z. Comparison of mesh ixation and nonixation in laparoscopic transabdominal preperitoneal repair of inguinal hernia. Formos J Surg. 2019;52(6):212–20.
19. Li W, Sun D, Sun Y, Cen Y, Li S, Xu Q, et al. The effect of transabdominal preperitoneal (TAPP) inguinal hernioplasty on chronic pain and quality of life of patients: mesh fixation versus non-fixation. Surg Endosc. 2017;31:4238–43.
20. Meshkati Yazd SM, Kiany F, Shahriarirad R, Kamran H, Karoobi, Mohammadreza, Mehri Ghasem. Comparison of mesh fixation and non-fixation in transabdominal preperitoneal (TAPP) inguinal hernia repair: a randomized control trial. Surg Endosc. 2023;37:1–8.
21. Wang L, Jin X, Wang H, Zhou X. Laparoscopic transabdominal preperitoneal procedure with and without mesh-fixation for inguinal hernia repairs. Int J Clin Med. 2018;11(8):8651–5.
22. Kumar A, Kaistha S, Gangavatiker R. Non-fixation versus fixation of mesh in totally extraperitoneal repair of inguinal hernia: a comparative study. Indian J Surg. 2018;80:128–33.
23. Meyer A, Dulucq J, Mahajna A. Laparoscopic hernia repair: nonfixation mesh is feasibly? ABCD Arq Bras Cir Dig. 2013;26:27–30.
24. Buyukasik K, Ari A, Akce B, Tatar C, Segmen O, Bektas H. Comparison of mesh fixation and non-fixation in laparoscopic totally extraperitoneal inguinal hernia repair. Hernia. 2017;21:543–8.
25. Golani S, Middleton P. Long-term follow-up of laparoscopic total extraperitoneal (TEP) repair in inguinal hernia without mesh fixation. Hernia. 2017;21:37–43.
26. Tam KW, Liang HH, Chai CY. Outcomes of staple fixation of mesh versus non-fixation in laparoscopic total extraperitoneal inguinal repair: a meta-analysis of randomized controlled trials. World J Surg. 2010;34:3065–74.

27. Dong H, Li L, Feng HH, Wang DC. Safety of unfixed mesh in laparoscopic total extraperitoneal inguinal hernia repair: a meta-analysis of randomized controlled trials. Surg Open Sci. 2023;16:138–47.
28. Antoniou SA, Köhler G, Antoniou GA, Muysoms FE, Pointner R, Granderath FA. Meta-analysis of randomized trials comparing nonpenetrating vs mechanical mesh fixation in laparoscopic inguinal hernia repair. Am J Surg. 2016;211(1):239–49. e2.
29. Eltair M, Hajibandeh S, Hajibandeh S, Balakrishnan S, Alyamani A, Radoi D, et al. Meta-analysis of laparoscopic groin hernia repair with or without mesh fixation. Int J Surg. 2019;71:190–9.
30. Teng YJ, Pan SM, Liu YL, Yang KH, Zhang YC, Tian JH, et al. A meta-analysis of randomized controlled trials of fixation versus nonfixation of mesh in laparoscopic total extraperitoneal inguinal hernia repair. Surg Endosc. 2011;25:2849–58.
31. Ersoz F, Culcu S, Duzkoylu Y, Bektas H, Sari S, Arikan S et al. The comparison of Lichtenstein procedure with and without mesh-fixation for inguinal hernia repair. *Surg Res Pract*. 2016;2016.

Publisher's note