Laparoscopic Versus Open Preperitoneal Mesh Repair of Inguinal Hernia: an Integrated Systematic Review and Meta-analysis of Published Randomized Controlled Trials

Muhammad Shafique Sajid¹ · Jennifer Caswell¹ · Krishna K. Singh¹

Received: 27 June 2014 / Accepted: 14 April 2015 / Published online: 28 April 2015
© Association of Surgeons of India 2015

Abstract The objective of this article is to systematically analyse the randomized, controlled trials comparing open (OPPR) versus laparoscopic (LPPR) preperitoneal mesh repair of inguinal hernia. Randomized, controlled trials comparing OPPR versus LPPR of inguinal hernia were analysed systematically using RevMan®, and combined outcomes were expressed as odds ratio (OR) and standardized mean difference (SMD). Ten randomized trials evaluating 1286 patients were retrieved from the electronic databases. There were 606 patients in the OPPR repair group and 680 patients in the LPPR group. There was significant heterogeneity among trials ($p < 0.0001$). Therefore, in the random effects model, LPPR was associated with longer operative time and relatively lesser postoperative pain in the case of the trans-abdominal preperitoneal approach. Statistically, both OPPR and LPPR were equivalent in terms of developing chronic groin pain, recurrence and postoperative complications. OPPR of inguinal hernia is associated with shorter operative time and comparable with LPPR (both total extraperitoneal and trans-abdominal

preperitoneal approaches) in terms of risk of chronic groin pain, recurrence and complications.

Keywords Inguinal hernia · Preperitoneal mesh repair · Laparoscopic inguinal hernia repair · Chronic groin pain · Recurrence

Introduction

Numerous studies have been reported in the medical literature in attempts to improve the outcome measures following inguinal hernia operations, and due to this fact, the procedure is evolving vastly and immensely, predominantly over the last few decades. Recurrence of inguinal hernia was a significant problem in early days of hernia surgery; however, with the introduction of the tension-free mesh repair, the Lichtenstein repair [1], decline in the recurrence rate of hernia was consistently reported, and now it is as low as 1–4 % [2–6], a drop from up to 50 to 60 %. Simultaneously, with this drop in the hernia recurrence rate, investigators and surgeons started facing rather different and unique challenges of an increased incidence of chronic groin pain (CGP), foreign body sensations, reduced groin elasticity and impaired groin compliance following mesh repair of both laparoscopic and open inguinal hernia. The mechanisms involved in the development of CGP following mesh repair of inguinal hernia repair are multifactorial. Contributing factors can be divided into three major categories. Patient-related factors include previous use of analgesics, previous groin operations, anxiety disorders, depressive disorders, impaired immunity, diabetes mellitus and various forms of neurological disorders [7–9]. Hernia surgery-related factors include wound

Declaration We are delighted to declare that the abstract of this article has been presented at the 100th Annual General Meeting of Association of Surgeons of Great Britain & Ireland in Glasgow on 1–3 May 2013. The abstract has been published in *British Journal of Surgery* (Br J Surg 2013; 100 (S7): 41).

✉ Muhammad Shafique Sajid
surgeon1wrh@hotmail.com

¹ Department of General, Endoscopic and Laparoscopic Colorectal Surgery, Worthing Hospital, Washington Suite, North Wing, Worthing, West Sussex BN11 2DH, UK

Fig. 1 PRISMA flow chart showing trial selection methodology

haematoma, surgical site infection, regional nerve injury, stitch ligation or entrapment of the regional nerves and tension repair of inguinal hernia [10, 11]. Mesh biomaterial in the form of lightweight mesh and heavyweight mesh has also been reported to be involved in the aetiology and pathogenesis of chronic groin pain [12–15]. Mesh fixation techniques potentially contributing to the development of chronic groin pain include the use of staples, tackers, sutures, autologous glues and synthetic glues [16–21]. Various measures to counteract the issues related to CGP and less predominantly related to hernia recurrence are being explored continuously. Placement of mesh in the preperitoneal space to avoid direct regional nerve dissection and their exposure to bioactive synthetic mesh during laparoscopic approach in inguinal hernia surgery led a way forward to achieve the same objective. However, preperitoneal mesh placement by open approach could not be adopted with open arms for unknown reasons. The objective of this article is to systematically analyse the randomized, controlled trials comparing open (OPPR) versus laparoscopic (LPPR) preperitoneal mesh repair of inguinal hernia in terms of their effectiveness in controlling the development of CGP and hernia recurrence.

Methods

Identification of Trials

Randomized, controlled trials (irrespective of language, country of origin, hospital of origin, blinding, sample size or publication status) comparing OPPR versus LPPR were included in this review. We included all trials in which a mesh was placed in the preperitoneal space through a trans-inguinal incision or any other open approach including Nyhus technique and Ugahary technique. The Cochrane Colorectal Cancer Group (CCCG) Controlled Trials Register, the Cochrane Central Register of Controlled Trials (CENTRAL) in the Cochrane Library, MEDLINE, Embase and Science Citation Index Expanded were searched for articles published up to June 2014 using the Medical Subject Headings (MeSH) terms “inguinal hernia” and “groin hernia” in combination with free-text search terms, such as “mesh repair of inguinal hernia”, “transinguinal preperitoneal repair”, “sutureless repair”, “laparoscopic repair”, “total extraperitoneal repair”, “trans-abdominal preperitoneal repair” and “open hernia repair”. A filter for identifying randomized, controlled trials recommended by the Cochrane Collaboration [22] was used to filter out non-randomized studies in MEDLINE and Embase. The

Table 1 Characteristics of included trials

Trial	Year	Country	Age in years	Male/female	Duration of follow-up	Hernia details
Aitola et al. [32] OPPR LPPR	1998	Finland	55 (16–78) 53 (22–80)	41: 8	18 months	Bilateral inguinal hernia Primary inguinal hernia Recurrent inguinal hernia
Bostanci et al. [33] OPPR LPPR	1998	Turkey	31 (20–71) 25 (20–59)	63: 1	24 months	Primary inguinal hernia
Gunal et al. [34] OPPR LPPR TAPP TEP	2007	Turkey	23.85±0.4925.72±1.0922.38±0.65	Males only	96 months	Primary inguinal hernia
Hamza et al. [35] OPPR LPPR TAPP TEP	2010	Egypt	35.67±12.9636.73±12.0634.91±13.0	Males only	12 months	Primary inguinal hernia
Johansson et al. [36] OPPR LPPR	1999	Sweden	56.8±9.4 55.9±9.7	Male only	12 months	Primary inguinal hernia Recurrent inguinal hernia
Kawji et al. [37] OPPR LPPR TAPP	1999	Austria	65 48	Mixed group	18 months	Primary inguinal hernia
Ozmen et al. [38] OPPR LPPR	2004	Turkey	41(26–68) 51(25–70)	39: 1 36: 4	Not given	Primary inguinal hernia Recurrent inguinal hernia
Simmermacher et al. [39] OPPR LPPR	2000	Netherlands	54	Mixed group	Not reported	Primary inguinal hernia
Sinha et al. [40] OPPR LPPR	2006	India	All adults over 18	Male	12 months	Recurrent inguinal hernia Unilateral inguinal hernia Bilateral inguinal hernia
Varansev et al. [41] OPPR LPPR	2002	Turkey	50.7±15.3 54.6±12.8	36: 5	1 week	Primary inguinal and femoral hernia

TAPP trans-inguinal preperitoneal hernia repair, *LR* Liechtenstein repair

Table 2 Treatment protocol adopted in included trials

Trial	Open preperitoneal hernia repair	Laparoscopic preperitoneal hernia repair
Aitola et al. [32]	<ul style="list-style-type: none"> • Trans-inguinal preperitoneal hernia repair • 6×12-cm Marlex mesh • Suture mesh fixation 	<ul style="list-style-type: none"> • Standard TAPP • 6×12-cm Marlex mesh • Staple mesh fixation
Bostanci et al. [33]	<ul style="list-style-type: none"> • Standard TIPP repair • 6×8-cm Prolene mesh • Suture mesh fixation technique 	<ul style="list-style-type: none"> • Standard TEP • 6×8-cm Prolene mesh • No mesh fixation technique reported
Gunal et al. [34]	<ul style="list-style-type: none"> • Nyhus preperitoneal approach • 6×12-cm Prolene mesh was used • Mesh and fixation technique not reported 	<ul style="list-style-type: none"> • Standard TAPP and TEP approach • 6×12-cm Prolene mesh was used • Stapler was used for mesh fixation
Hamza et al. [35]	<ul style="list-style-type: none"> • Standard TIPP repair of inguinal hernia • Mesh and fixation technique not reported 	<ul style="list-style-type: none"> • Standard TAPP and TEP approach • Mesh and fixation technique not reported
Johansson et al. [36]	<ul style="list-style-type: none"> • TIPP repair of inguinal hernia • 10×15-cm Prolene mesh was used • Mesh fixation by monofilamentous non-absorbable sutures 	<ul style="list-style-type: none"> • 3-port TAPP approach • 10×15-cm Prolene mesh was used • Mesh fixed with staples
Kawji et al. [37]	<ul style="list-style-type: none"> • Wantz TIPP repair of inguinal hernia • Mesh and fixation technique not reported 	<ul style="list-style-type: none"> • Standard TAPP approach • Mesh and fixation technique not reported
Ozmen et al. [38]	<ul style="list-style-type: none"> • Nyhus preperitoneal approach • Prolene mesh 10×15 cm • Mesh fixed with stitches 	<ul style="list-style-type: none"> • Standard TEP approach • Prolene mesh 10×15 cm • Tacker mesh fixation
Simmermacher et al. [39]	<ul style="list-style-type: none"> • Ugahary (gridiron) approach • Prolene mesh 6×4 cm • No mesh fixation 	<ul style="list-style-type: none"> • Standard TEP approach • Prolene mesh 6×4 cm • No mesh fixation
Sinha et al. [40]	<ul style="list-style-type: none"> • Standard TIPP repair of inguinal hernia • Prolene mesh 6×4 cm • No mesh fixation 	<ul style="list-style-type: none"> • Standard TEP approach • Prolene mesh 6×4 cm • Tacker mesh fixation
Vatansev et al. [41]	<ul style="list-style-type: none"> • Nyhus preperitoneal approach • Mesh and fixation technique not reported 	<ul style="list-style-type: none"> • Standard TEP approach • Mesh and fixation technique not reported

TIPP trans-inguinal preperitoneal hernia repair, *TEP* total extraperitoneal preperitoneal, *TAPP* trans-abdominal preperitoneal

references from the included trials were searched to identify additional trials.

Data Extraction

Two authors independently identified the trials for inclusion and exclusion and extracted the data. The accuracy of the extracted data was further confirmed by a third author. There were no discrepancies in the selection of the trials or in data extraction between the reviewers, except in the case of recording the severity of pain according to the measurement scales and timing of the recorded data. All reviewers agreed that blinding was impossible to achieve in the case of the operating surgeon. However, there was disagreement with regard to whether the trials should be classified as having a high or low risk of bias based on four parameters, i.e. randomization technique, power calculations, blinding and intention-to-treat analysis. It was agreed that the lack of an adequate randomization technique and an intention-to-treat analysis would result in the trials being classified as having a high risk of bias. In case of any unclear or missing information, the reviewers planned to

obtain those by contacting the authors of the individual trials.

Statistical Analysis

The software package RevMan 5.1.2 [23], provided by the Cochrane Collaboration, was used for the statistical analysis to achieve a combined outcome. The odds ratio (OR) with a 95 % confidence interval (CI) was calculated for binary data, and the standardized mean difference (SMD) with a 95 % CI was calculated for continuous data variables. The random effects model [24, 25] was used to calculate the combined outcomes of both binary and continuous variables. Heterogeneity was explored using the χ^2 test, with significance set at $p < 0.05$, and was quantified [26] using I^2 , with a maximum value of 30 % identifying low heterogeneity. The Mantel-Haenszel method was used for the calculation of OR under the random effects models [27]. In a sensitivity analysis, 0.5 was added to each cell frequency for trials in which no event occurred in either the treatment or control group, according to the method recommended by Deeks et al. [28]. If the standard deviation was not

Table 3 Variables used for meta-analysis

Trial	Patients (<i>n</i>)	Operation time	Perioperative pain (30 days)	Complications	Chronic groin pain	Recurrence
Aitola et al. [32]						
OPPR	25	55±14.3 ^b	Not reported	2	0	2
LPPR	24	66±14.3		5	0	3
Bostanci et al. [33]						
OPPR	32	35±11.25 ^a	3.90±1.44	4	1	0
LPPR	32	58±11.25	0.96±1.53	2	1	0
Gunal et al. [34] ^c						
OPPR	39	36.54±1.55	3.7±1	9	0	1
LPPR TAPP	39	104.49±8.1	3.25±1.0	5	0	1
TEP	40	57.37±3.84	3.3±1.2	5	0	0
Hamza et al. [35] ^c						
OPPR	25	54.5±13.2	4.93±1.62	2	0	0
LPPR TAPP	25	96.12±22.5	4.13±1.12	1	0	1
TEP	25	77.4±43.21	3.98±4.35	1	0	1
Johansson et al. [36] ^c						
OPPR	200	38±14	Not reported	49	8	11
LPPR	200	65±25		66	3	4
Kawji et al. [37] ^d						
OPPR	21	Not investigated	2.9±1.01	3	0	0
LPPR	35		2.1±1.0	1	0	0
Ozmen et al. [38]						
OPPR	40	85±27.5 ^a	Not reported	11	0	Not reported
LPPR	40	69±31.25		7	2	
Simmernacher et al. [39]						
OPPR	82	27±22.8 ^b	Not reported	8	Not reported	Not reported
LPPR	80	39±22.8		13		
Sinha et al. [40]						
OPPR	121	31.2±21 ^b	Not reported	2	0	2
LPPR	120	22.2±21		5	0	4
Vatansev et al. [41] ^c						
OPPR	21	51.9±6.5	Not reported	Not reported	Not reported	Not reported
LR	20	58.6±9.7				

^a Standard deviation estimated from the range^b Standard deviation estimated from the *p* value^c Four-arm randomized, controlled trial. Data of OPPR and LPPR arms was used for combined analysis^d Five-arm randomized, controlled trial. Data of OPPR and LPPR arms was used for combined analysis^e Three-arm randomized, controlled trial. Data of OPPR and LPPR arms was used for combined analysis

available, then it was calculated according to the guidelines of the Cochrane Collaboration [22]. This process involved assumptions that both groups had the same variance, which may not have been true, and variance was either estimated from the range or from the *p* value. The estimate of the difference between both techniques was pooled, depending upon the effect weights in results determined by each trial estimate variance. A forest plot was used for the graphical display of the

results. The square around the estimate stood for the accuracy of the estimation (sample size), and the horizontal line represented the 95 % CI. The methodological quality of the included trials was initially assessed using the published guidelines of Jadad et al. and Chalmers et al. [29, 30]. Based on the quality of the included randomized, controlled trials, the strength and summary of the evidence were further evaluated by GradePro[®] [31], a tool provided by the Cochrane Collaboration.

We classified chronic groin pain and recurrence as primary outcome measures. Duration of operation, postoperative pain and postoperative complications were analysed as secondary outcome measures.

Results

The PRISMA flow chart to explain the literature search strategy and trial selection is given in Fig. 1. Ten randomized, controlled trials [32–41] recruiting 1286 patients were retrieved from commonly used standard medical electronic databases. There were 606 patients in the OPPR repair group and 680 patients in the LPPR group. The characteristics of the included trials are given in Table 1. The salient features and treatment protocols adopted in the included randomized, controlled trials are given in Table 2. The short summary of data and selected primary and secondary outcome measures used to achieve a summated statistical effect are given in Table 3. Three included trials [34, 35, 41] reported four study arms, but their exclusive data pertaining to OPPR and LPPR was used for this analysis. Similarly, we used data of OPPR versus LPPR arms from two trials which reported three and five study arms [36, 37].

Methodological Quality of Included Studies

According to Jadad et al. and Chalmers et al. [29, 30], the quality of the majority of included trials was low due to the inadequate randomization technique and absence of adequate allocation concealment, power calculations, blinding and intention-to-treat analysis (Table 4).

Based on the quality of included randomized controlled trials, the strength and summary of evidence analysed on GradePro^{®31} are given in Fig. 2.

Primary Outcomes Measures

Chronic Groin Pain Eight randomized, controlled trials [32–38, 40] contributed to the combined calculation of this variable. There was moderate heterogeneity ($\text{Tau}^2=0.43$, $\text{chi}^2=2.60$, $\text{df}=2$, [$p=0.27$]; $I^2=23\%$) among trials. In the random effects model (OR, 1.34; 95 % CI, 0.32, 5.64; $z=0.40$; $p=0.69$; Fig. 3), the risk of developing chronic groin pain following OPPR and LPPR was statistically similar.

Recurrence Seven randomized, controlled trials [32–38] contributed to the combined calculation of this variable. There was no heterogeneity among trials ($\text{Tau}^2=0.08$, $\text{chi}^2=4.35$, $\text{df}=4$, [$p=0.36$]; $I^2=0\%$). In the random effects model (OR, 1.21; 95 % CI, 0.52, 2.83; $z=0.45$; $p=0.65$; Fig. 4), the risk of developing recurrent inguinal hernia following OPPR and LPPR was statistically similar.

Secondary Outcomes Measures

Postoperative Complications Nine randomized, controlled trials [32–40] contributed to the combined calculation of this variable. There was moderate heterogeneity ($\text{Tau}^2=0.21$, $\text{chi}^2=13.32$, $\text{df}=8$, [$p=0.10$]; $I^2=40\%$) among trials. In the random effects model (OR, 1.00; 95 % CI, 0.60, 1.68; $z=0.01$; $p=0.99$; Fig. 5), the risk of developing postoperative complications was statistically similar in both groups.

Table 4 Quality assessment of included trials

Trial	Randomization technique	Power calculations	Blinding	Intention-to-treat analysis	Allocation Concealment
Aitola et al. [32]	Admission order	No	No	No	No
Bostanci et al. [33]	Admission order	No	Unclear	No	Adequate
Gunel et al. [34]	Random allocation	No	No	No	Inadequate
Hamza et al. [35]	Random number allocation	No	Yes	No	Inadequate
Johansson et al. [36]	Computer generated	Yes	Yes	Yes	Adequate
Kawji et al. [37]	Unclear	No	No	No	Inadequate
Ozmen et al. [38]	Random number table	No	No	No	Inadequate
Simmermacher et al. [39]	Random numbers	No	No	No	Inadequate
Sinha et al. [40]	Alternation principle	No	No	No	Inadequate
Vatansev et al. [41]	Sealed envelopes	No	No	No	Adequate

OPPR compared to LPPR for inguinal hernia

Patient or population: patients with inguinal hernia

Settings:

Intervention: OPPR

Comparison: LPPR

Outcomes	Illustrative comparative risks* (95% CI)		Relative effect (95% CI)	No of Participants (studies)	Quality of the evidence (GRADE)	Comments
	Assumed risk LPPR	Corresponding risk OPPR				
Chronic groin pain	Study population		OR 1.34 (0.32 to 5.64)	1164 (8 studies)	⊕⊕⊕⊕ moderate	
Odds ratio	9 per 1000	12 per 1000 (3 to 49)				
Follow-up: 3–96 months	Moderate					
	0 per 1000	0 per 1000 (0 to 0)				
Recurrence	Study population		OR 1.21 (0.52 to 2.83)	1003 (7 studies)	⊕⊕⊕⊕ moderate	
Odds ratio	26 per 1000	31 per 1000 (14 to 70)				
Follow-up: 3–96 months	Moderate					
	20 per 1000	24 per 1000 (11 to 55)				

*The basis for the **assumed risk** (e.g. the median control group risk across studies) is provided in footnotes. The **corresponding risk** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).

CI: Confidence interval; OR: Odds ratio;

GRADE Working Group grades of evidence

High quality: Further research is very unlikely to change our confidence in the estimate of effect.**Moderate quality:** Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.**Low quality:** Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.**Very low quality:** We are very uncertain about the estimate.**Fig. 2** Strength and summary of the evidence analysed on GradePro®

Duration of Operation: OPPR Versus LPPR (TAPP) Four randomized, controlled trials [32, 34–36] contributed to the combined calculation of this variable. There was significant heterogeneity ($\text{Tau}^2=3.36$; $\text{chi}^2=118.18$, $\text{df}=3$, [$p<0.00001$]; $I^2=97\%$) among trials. Therefore, in the random effects model (SMD, -03.56 ; 95 % CI, -05.43 , -1.69 ; $z=3.73$; $p<0.0002$; Fig. 6), the duration of operation for OPPR was shorter than LPPR.

Duration of Operation: OPPR Versus LPPR (TEP) Seven randomized, controlled trials [34–36, 38–41] contributed to the combined calculation of this variable. There was significant heterogeneity ($\text{Tau}^2=1.71$; $\text{chi}^2=201.31$, $\text{df}=6$, [$p<0.00001$]; $I^2=97\%$) among trials. Therefore, in the

random effects model (SMD, -1.14 ; 95 % CI, -2.13 , -0.14 ; $z=2.24$; $p<0.03$; Fig. 7), the duration of operation for OPPR was shorter than LPPR.

Postoperative Pain: OPPR Versus LPPR (TAPP) Three randomized, controlled trials [34, 35, 37] contributed to the combined calculation of this variable. There was no heterogeneity ($\text{Tau}^2=0.01$; $\text{chi}^2=2.28$, $\text{df}=2$, [$p=0.32$]; $I^2=12\%$) among trials. Therefore, in the random effects model (SMD, 0.32 ; 95 % CI, 0.01 , 0.64 ; $z=2.01$; $p<0.04$; Fig. 8), the LPPR (TAPP) was associated with lesser postoperative pain.

Postoperative Pain: OPPR Versus LPPR (TEP) Three randomized, controlled trials [33–35] contributed to the

Fig. 3 Forest plot for chronic groin pain following OPPR versus LPPR. Odds ratios are shown with 95 % confidence intervals. *OPPR* open preperitoneal repair, *LPPR* laparoscopic preperitoneal repair

Fig. 4 Forest plot for recurrence following OPPR versus LPPR. Odds ratios are shown with 95 % confidence intervals. *OPPR* open preperitoneal repair, *LPPR* laparoscopic preperitoneal repair

Fig. 5 Forest plot for postoperative complications following OPPR versus LPPR. Odds ratios are shown with 95 % confidence intervals. *OPPR* open preperitoneal repair, *LPPR* laparoscopic preperitoneal repair

Fig. 6 Forest plot for duration of operation following OPPR repair versus LPPR (TAPP). Standardized mean difference is shown with 95 % confidence intervals. *OPPR* open preperitoneal repair, *LPPR* laparoscopic preperitoneal repair, *TAPP* trans-abdominal preperitoneal

Fig. 7 Forest plot for duration of operation following OPPR repair versus LPPR (TEP). Standardized mean difference is shown with 95 % confidence intervals. *OPPR* open preperitoneal repair, *LPPR* laparoscopic preperitoneal repair, *TEP* total extraperitoneal repair

Fig. 8 Forest plot for postoperative pain following OPPR repair versus LPPR (TAPP). Standardized mean difference is shown with 95 % confidence intervals. *OPPR* open preperitoneal repair, *LPPR* laparoscopic preperitoneal repair, *TAPP* trans-abdominal preperitoneal

Fig. 9 Forest plot for postoperative pain following OPPR repair versus LPPR (TEP). Standardized mean difference is shown with 95 % confidence intervals. OPPR open preperitoneal repair, LPPR laparoscopic preperitoneal repair, TEP total extraperitoneal repair

combined calculation of this variable. There was no heterogeneity ($\tau^2 = 70.00$; $\chi^2 = 21.04$, $df = 2$, [$p < 0.0001$]; $I^2 = 90\%$) among trials. In the random effects model (SMD, 0.85; 95 % CI, -0.14, 1.85; $z = 1.68$; $p = 0.09$; Fig. 9), the LPPR (TEP) was associated with lesser postoperative pain but statistically it was not significant.

Discussion

This systematic review demonstrates that OPPR of inguinal hernia is associated with shorter operative time and comparable with LPPR (both total extraperitoneal and trans-abdominal preperitoneal approaches) in terms of risk of chronic groin pain, recurrence, complications and postoperative pain. Based on the results of this review article, routine use of OPPR may be considered for inguinal hernia repair. The potential advantages of OPPR will be economical. The current literature failed to report any randomized, controlled trial comparing the economic burden and cost of OPPR and LPPR. Therefore, a definitive conclusion on the cost-effectiveness of OPPR may not be inferred from this study. However, there are several studies which reported the cost-effectiveness of laparoscopic inguinal hernia repair compared to conventional open repair [42–44]. The estimated cost of LPPR is US\$1250 compared to US\$600 for OPPR. OPPR of inguinal hernia has also been proven more effective against Lichtenstein repair [42, 45, 46] due to lower risk of developing chronic groin pain, and it is comparable in terms of risk of hernia recurrence, postoperative complications, duration of operation and intensity of postoperative pain. The difference of cost between TEP and TAPP repair of the inguinal hernia is not reported in the medical literature yet. However, two published studies have reported minimal difference or TAPP being slightly expensive [47, 48].

Authors are aware of the fact that OPPR of inguinal hernia is not performed routinely and surgeons may have to learn the procedure before implementing into the current surgical practice. Authors believe it is a simple procedure and the learning curve will be less steeper compared to the learning curve for laparoscopic repair of the inguinal hernia. The purpose of this article is to not to direct hernia surgeons but highlight an alternative approach of the inguinal hernia repair which may

be as effective as the laparoscopic approach with aforementioned advantages.

There are several limitations to the present review. There were significant differences in inclusion and exclusion criteria among the included randomized, controlled trials such as the recruitment of unilateral inguinal hernia, bilateral inguinal hernia, recurrent inguinal hernia and femoral hernia. Further sub-classification of the inguinal hernia in the form of direct and indirect was also not considered at the time of patient selection. Varying degrees of differences also existed among included randomized, controlled trials regarding the definitions of “chronic groin pain” and “measurement scales for postoperative pain”. Randomized, controlled trials with fewer patients in this review may not have been sufficient to recognize small differences in outcomes. Included trials with more than two treatment arms may also be considered a biased approach for inclusion. Quality of included trials was poor due to inadequate randomization technique, allocation concealment, power calculations, blinding and intention-to-treat analysis (Table 4). Variables like foreign body sensation, groin stiffness and decreased groin compliance should have been considered because displaced and rolled up mesh is likely to cause these symptoms. Studies evaluating cost-effectiveness and health-related quality of measurement should also be considered before recommending the routine use of OPPR for inguinal hernia. Our conclusion is based on the summated outcome of ten randomized, controlled trials, but it should be considered cautiously because the quality of the majority of included trials was poor. There is still a lack of stronger evidence to support the routine use of OPPR, but it can be considered an alternative and may be applied in a selected group of patients in the beginning. The statistical equivalence shown in primary outcomes of both limbs of this study does not mean a clinical equivalence, and therefore, the most important implication of this article is to pave the pathway for further research to achieve stronger evidence. A major, multicentre, randomized, controlled trial of high quality according to CONSORT guidelines is mandatory to validate these

findings. Further trials to evaluate the feasibility of OPPR in patients with severe obesity bilateral inguinal hernia, open appendectomy for right inguinal hernias, lower abdominal surgery and open prostatectomy need to be considered to define an optimum inclusion and exclusion criteria for this approach.

Conflict of Interest None to declare

Funding None to declare

References

- Amid PK (2004) Lichtenstein tension-free hernioplasty: its inception, evolution, and principles. *Hernia* 8:1–7
- Heikkinen T, Bringman S, Ohtonen P, Kunelius P, Haukipuro K, Kulkko A (2004) Five-year outcome of laparoscopic and Lichtenstein hernioplasties. *Surg Endosc* 18:518–522
- Lepere M, Benchetrit S, Debaert M, Detruit B, Dufiho A, Gaujoux D, Lagoutte J, Saint Leon LM, Parvis d'Escurac X, Rico E, Sorrentino J, Therin M (2000) A multicentric comparison of transabdominal versus totally extraperitoneal laparoscopic hernia repair using PARIETEX meshes. *JSLs* 4:147–153
- Olmi S, Erba L, Magnone S, Bertolini A, Mastropasqua E, Perego P, Massimini D, Zanandrea G, Russo R, Croce E (2005) Prospective study of laparoscopic treatment of incisional hernia by means of the use of composite mesh: indications, complications, mesh fixation materials, and results. *Chir Ital* 57:709–716, in **Italian**
- MacFadyen BV Jr, Mathis CR (1994) Inguinal herniorrhaphy: complications and recurrences. *Semin Laparosc Surg* 1:128–140
- McCormack K, Scott NW, Go PM, Ross S, Grant AM (2003) Laparoscopic techniques versus open techniques for inguinal hernia repair. *Cochrane Database* 1, CD001785
- Aasvang EK, Kehlet HB (2007) Chronic pain after childhood groin hernia repair. *J Pediatr Surg* 42:1403–1408
- Kehlet H, Aasvang EK (2011) Chronic groin pain after groin hernia repair. *Ugeskr Laeger* 173:45–47
- Staal E, Nienhuijs SW, Keemers-Gels ME, Rosman C, Strobbe LJ (2008) The impact of pain on daily activities following open mesh inguinal hernia repair. *Hernia* 12:153–157
- Amid PK, Chen DC (2011) Surgical treatment of chronic groin and testicular pain after laparoscopic and open preperitoneal inguinal hernia repair. *J Am Coll Surg* 213:531–536
- Hakeem A, Shanmugam V (2011) Current trends in the diagnosis and management of post-herniorrhaphy chronic groin pain. *World J Gastrointest Surg* 3:73–81
- Bringman S, Heikkinen TJ, Wollert S, Osterberg J, Smedberg S, Granlund H, Felländer G (2004) One year results of a randomised controlled multi-centre study comparing Prolene and Vypro II-mesh in Lichtenstein hernioplasty. *Hernia* 8:127–134
- Koch A, Bringman S, Myrelid P, Smeds S, Kald A (2008) Randomized clinical trial of groin hernia repair with titanium-coated lightweight mesh compared with standard polypropylene mesh. *Br J Surg* 95:1226–1231
- Nikkolo C, Lepner U, Murruste M, Vaasna T, Seepeter H, Tikk T (2010) Randomised clinical trial comparing lightweight mesh with heavyweight mesh for inguinal hernioplasty. *Hernia* 14:253–258
- Sajid MS, Leaver C, Baig MK, Sains P (2012) Systematic review and meta-analysis of lightweight versus heavyweight mesh in open inguinal hernia repair. *Br J Surg* 99:29–37
- Abdelhamid MS (2011) Transabdominal pre-peritoneal inguinal hernia repair with external fixation. *Hernia* 15:185–188
- Anadol AZ, Akin M, Kurukahvecioglu O, Tezel E, Ersoy E (2011) A prospective comparative study of the efficacy of conventional Lichtenstein versus self-adhesive mesh repair for inguinal hernia. *Surg Today* 41:1498–1503
- Negro P, Basile F, Brescia A, Buonanno GM, Campanelli G, Canonico S, Cavalli M, Corrado G, Coscarella G, Di Lorenzo N, Falletto E, Fei L, Francucci M, Fronticelli Baldelli C, Gaspari AL, Gianetta E, Marvaso A, Palumbo P, Pellegrino N, Piazzai R, Salvi PF, Stabilini C, Zanghi G (2011) Open tension-free Lichtenstein repair of inguinal hernia: use of fibrin glue versus sutures for mesh fixation. *Hernia* 15:7–14
- Novik B, Nordin P, Skullman S, Dalenbäck J, Enochsson L (2011) More recurrences after hernia mesh fixation with short-term absorbable sutures: a registry study of 82 015 Lichtenstein repairs. *Arch Surg* 146:12–17
- Paajanen H, Kössi J, Silvasti S, Hulmi T, Hakala T (2011) Randomized clinical trial of tissue glue versus absorbable sutures for mesh fixation in local anaesthetic Lichtenstein hernia repair. *Br J Surg* 98:1245–1251
- Wong JU, Leung TH, Huang CC, Huang CS (2011) Comparing chronic pain between fibrin sealant and suture fixation for bilayer polypropylene mesh inguinal hernioplasty: a randomized clinical trial. *Am J Surg* 202:34–38
- Higgins JPT, Green S (eds). *Cochrane handbook for systematic reviews of interventions* version 5.0.0 (updated February 2008). <http://www.cochrane-handbook.org>. Accessed on 27 June 2014
- Review Manager (RevMan) [Computer program]. Version 5.3]. The Nordic Cochrane Centre, The Cochrane Collaboration: Copenhagen, 2008. Accessed on 27 June 2014
- DerSimonian R, Laird N (1986) Meta-analysis in clinical trials. *Control Clin Trials* 7:177–188
- DeMets DL (1987) Methods for combining randomized clinical trials: strengths and limitations. *Stat Med* 6:341–350
- Higgins JP, Thompson SG (2002) Quantifying heterogeneity in a meta-analysis. *Stat Med* 21:1539–1558
- Egger M, Smith GD, Altman DG (2006) *Systematic reviews in healthcare*. BMJ Publishing, London
- Deeks JJ, Altman DG, Bradburn MJ (2001) Statistical methods for examining heterogeneity and combining results from several studies in meta-analysis. In: Matthias E, George Davey S, Altman DG (eds) *Systemic reviews in health care: meta-analysis in context*, 2nd edn. BMJ Publication group, London, pp 285–312
- Jadad AR, Moore RA, Carroll D, Jenkinson C, Reynolds DJ, Gavaghan DJ (1996) Assessing the quality of reports of randomized clinical trials: is blinding necessary? *Control Clin Trials* 17:1–12
- Chalmers TC, Smith H Jr, Blackburn B, Silverman B, Schroeder B, Reitman D (1981) A method for assessing the quality of a randomized control trial. *Control Clin Trials* 2:31–49
- Cochrane IMS <http://ims.cochrane.org/revman/otherresources/gradepr/download>. Accessed on 27 June 2014
- Aitola P, Airo I, Matikainen M (1998) Laparoscopic versus open preperitoneal inguinal hernia repair: a prospective randomised trial. *Ann Chir Gynaecol* 87:22–25
- Bostanci BE, Tetik C, Özer S, Özden A (1998) Posterior approaches in groin hernia repair with prosthesis: open or closed. *Acta Chir Belg* 98:241–244
- Günel O, Ozer S, Gürleyik E, Bahçebaşı T (2007) Does the approach to the groin make a difference in hernia repair? *Hernia* 11: 429–434

35. Hamza Y, Gabr E, Hammadi H, Khalil R (2010) Four-arm randomized trial comparing laparoscopic and open hernia repairs. *Int J Surg* 8:25–28
36. Johansson B, Hallerbäck B, Glise H, Anesten B, Smedberg S, Román J (1999) Laparoscopic mesh versus open preperitoneal mesh versus conventional technique for inguinal hernia repair: a randomized multicenter trial (SCUR Hernia Repair Study). *Ann Surg* 230:225–231
37. Kawji R, Feichter A, Fuchsjager N, Kux M (1999) Postoperative pain and return to activity after five different types of inguinal herniorrhaphy. *Hernia* 3:31–35
38. Ozmen MM, Ozalp N, Zulfikaroglu B, Soyuncu P, Ziranman I, Hengirmen S (2004) The evaluation of the peak flow velocity and cross-sectional area of the femoral artery and vein following totally extraperitoneal vs preperitoneal open repair of inguinal hernias. *Hernia* 8:332–335
39. Simmermacher RKJ, van Duyn EB, Clevers GJ, de Vries LS, van Vroonhoven TJMV (2000) Preperitoneal mesh in groin hernia surgery. A randomized clinical trial emphasizing the surgical aspects of preperitoneal placement via a laparoscopic (TEP) or grid-iron (Ugahary) approach. *Hernia* 4: 296–298
40. Sinha R, Sharma N, Dhobal D, Joshi M (2006) Laparoscopic total extraperitoneal repair versus anterior preperitoneal repair for inguinal hernia. *Hernia* 10:187–191
41. Vatansev C, Belviranlı M, Aksoy F, Tuncer S, Sahin M, Karahan O (2002) The effects of different hernia repair methods on postoperative pain medication and CRP levels. *Surg Laparosc Endosc Percutan Tech* 12:243–246
42. Willaert W, De Bacquer D, Rogiers X, Troisi R, Berrevoet F (2012) Open preperitoneal techniques versus Lichtenstein repair for elective inguinal hernias. *Cochrane Database Syst Rev* 7, CD008034
43. Liem MS, Halsema JA, van der Graaf Y, Schrijvers AJ, van Vroonhoven TJ (1997) Cost-effectiveness of extraperitoneal laparoscopic inguinal hernia repair: a randomized comparison with conventional herniorrhaphy. *Coala trial group. Ann Surg* 226:668–675
44. Lawrence K, McWhinnie D, Goodwin A, Doll H, Gordon A, Gray A, Britton J, Collin J (1995) Randomised controlled trial of laparoscopic versus open repair of inguinal hernia: early results. *BMJ* 311:981–985
45. Wellwood J, Sculpher MJ, Stoker D (1998) Randomised controlled trial of laparoscopic versus open mesh repair for inguinal hernia: outcome and cost. *BMJ* 317:103–110
46. Li J, Ji Z, Li Y (2012) Comparison of mesh-plug and Lichtenstein for inguinal hernia repair: a meta-analysis of randomized controlled trials. *Hernia* 16:541–548
47. Bansal VK, Misra MC, Babu D, Victor J, Kumar S, Sagar R, Rajeshwari S, Krishna A, Rewari V (2013) A prospective, randomized comparison of long-term outcomes: chronic groin pain and quality of life following totally extraperitoneal (TEP) and transabdominal preperitoneal (TAPP) laparoscopic inguinal hernia repair. *Surg Endosc* 27:2373–2382
48. McCormack K, Wake BL, Fraser VL, Perez J, Grant A (2005) Transabdominal pre-peritoneal (TAPP) versus totally extraperitoneal (TEP) laparoscopic techniques for inguinal hernia repair: a systematic review. *Hernia* 9:109–114