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ORIGINAL ARTICLE

Male Fertility

Comparison of surgical effect and postoperative patient experience between laparoendoscopic single-site and conventional laparoscopic varicocelectomy: a systematic review and meta-analysis

Zheng Zhang*, Shu-Juan Zheng*, Wen Yu, You-Feng Han, Hai Chen, Yun Chen, Yu-Tian Dai

The present meta-analysis was conducted to compare the clinical effect and patient experience of laparoendoscopic single-site varicocelectomy (LESSV) and conventional laparoscopic varicocelectomy. The candidate studies were included after literature search of database Cochrane Library, PubMed, EMBASE, and MEDLINE. Related information on essential data and outcome measures was extracted from the eligible studies by two independent authors, and a meta-analysis was conducted using STATA 12.0 software. Subgroup analyses were conducted by study design (RCT and non-RCT). The odds ratio (OR) or standardized mean difference (SMD) and their 95% confidence intervals (95% CIs) were used to estimate the outcome measures. Seven articles were included in our meta-analysis. The results indicated that patient who had undergone LESSV had a shorter duration of back to work (overall: SMD = −1.454, 95% CI: −2.502–−0.405, *P* = 0.007; non-RCT: SMD = −2.906, 95% CI: −3.796–−2.017, *P* = 0.000; and RCT: SMD = −0.841, 95% CI: −1.393–−0.289, *P* = 0.003) and less pain experience at 3 h or 6 h (SMD = −0.447, 95% CI: −0.754–−0.139, *P* = 0.004), day 1 (SMD = −0.477, 95% CI: −0.905–−0.05, *P* = 0.029), and day 2 (SMD = −0.612, 95% CI: −1.099–−0.125, *P* = 0.014) postoperatively based on RCT studies. However, the meta-analyses based on operation time, clinical effect (improvement of semen quality and scrotal pain relief), and complications (hydrocele and recurrence) yielded nonsignificant results. In conclusion, LESSV had a rapid recovery and less pain experience over conventional laparoscopic varicocelectomy. However, there was no statistically significant difference between the two varicocelectomy techniques in terms of the clinical effect and the incidence of hydrocele and varicocele recurrence. More high-quality studies are warranted for a comprehensive conclusion.
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Keywords: complications; conventional laparoscopic varicocelectomy; laparoendoscopic single-site varicocelectomy; meta-analysis; pain score; semen quality

INTRODUCTION

Varicocele, defined as dilated and tortuous veins of the pampiniform plexus of scrotal veins, is relatively prevalent among males. Varicocele occurs in approximately 15% of the male population.[1] Notably, it was observed in 21%–39% of infertile men.[2] Varicoceles are indicated in the cause of male infertility by increasing scrotal region temperature or promoting oxidative stress in the seminiferous tubules spermatogenic environment.[3,4] Except for subfertility, the main complaints of varicocele include scrotal pain or discomfort and ill-defined scrotal mass.

Although several surgical approaches have been applied for varicocele treatment, including open surgical spermatic vein ligation, microsurgical and laparoscopic varicocelectomy, and retrograde or antegrade sclerotherapy, the ideal method is still a matter of controversy. Notably, various clinical studies and systematic reviews and meta-analyses have confirmed a positive role of laparoscopic approach in the treatment of varicocele. Its advantages over standard open surgeries attributed to its relatively rapid recovery.[5–7] It was also associated with shorter operation time, less training and lower patient costs when compared to microscopic varicocelectomy.[5–9]

In an attempt to reduce the number of incisions and ports in laparoscopic surgeries, laparoendoscopic single-site surgery was introduced and further obtained a popular application.[10–13] Since the first report of laparoendoscopic single-site varicocelectomy (LESSV) by Kaouk and Palmer in 2008,[14] several studies have been published to evaluate its clinical effect and its potential application alternative to the conventional laparoscopic procedures. However, there was discrepancy among these studies.[15–24] Therefore, we applied systematic evaluation

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and meta-analysis of the limited data together to provide a more precise and comprehensive estimation on the advantages and disadvantages of LESSV over conventional laparoscopic approaches while focusing on its surgical effect and patient experience postoperatively.

MATERIALS AND METHODS

The preferred reporting items for systematic reviews and meta-analysis (PRISMA) were used to conduct this present meta-analysis.[25]

Literature search

We conducted electronic searches in the database Cochrane Library, PubMed, EMBASE, and MEDLINE up to August 1, 2015, using the MeSH terms "varicocele," "varicocelectomy," "Laparoendoscopic single-site," "single incision," and "laparoscopic" (alone or in combination). All retrieved articles were screened for potential inclusion according to the predefined inclusion and exclusion criteria by two independent reviewers (Zheng Zhang, Shu-Juan Zheng).

Inclusion criteria

Study design

Randomized controlled trials (RCT) and nonrandomized controlled trials, prospective or retrospective cohort, and case–control studies (non-RCT) comparing laparoendoscopic single-site approach and conventional laparoscopic approach for varicocele repair were included in our meta-analysis with quantitative data available on related outcome measures.

Type of participants

Patients (adults or adolescents) who underwent varicocelectomy (laparoendoscopic single-site or conventional laparoscopic approach) were included in the present study.

Type of interventions

Laparoendoscopic single-site versus conventional laparoscopic approach for the treatment of varicocele.

Type of outcome measures

Operative time, postoperative pain score, hospital stay and time to return to normal activity after the surgery, patients who had scrotal pain relief or improved semen quality postoperatively, postoperative complications: hydrocele formation and varicocele recurrence, and patient satisfaction rate of wound cosmetic appearance were measured in the meta-analyses.

Exclusion criteria

(1) Incomplete data; (2) reviews, animal experiments, case reports, comments, editorials, letters, and congress; (3) data not available; and (4) non-English published articles.

Bias assessment

The bias assessment of each included study was analyzed using the Cochrane Collaboration bias appraisal tool, which including the following items: (1) adequate sequence generation, (2) allocation concealment, (3) blinding, (4) incomplete outcome data addressed, (5) free of selective addressed, and (6) free of other bias. Each item was answered with "yes," "no," or "unclear" by two investigators (Zheng Zhang, Shu-Juan Zheng). Any disagreement was dissolved by open discussion.

Evidence quality assessment

Two reviewers (Zheng Zhang, Shu-Juan Zheng) independently used the Newcastle-Ottawa Scale (NOS) (nonrandomized studies)[26] and Jadad scale (randomized controlled studies) to assess the quality of the included studies. Studies with overall quality scores of more than 5 in NOS 9-scale system or more than 3 in Jadad system were considered high-quality.

Study enrollment and data extraction

Two investigators (Zheng Zhang, Shu-Juan Zheng) independently assessed articles for possible enrollment according to the inclusion and exclusion criteria and extracted related information, which includes study characteristics, the first author's name, year of publication, and related data in the two approaches on outcome measures. Any discrepancy was consulted by discussion between the two investigators.

Statistical analysis

This systematic review and meta-analysis was performed using STATA software (version 12.0; Stata Corporation, College Station, TX, USA). Heterogeneity among the articles was measured using Q-test or I^2 value. The heterogeneity was considered significant if $P < 0.1$ or $I^2 > 40\%$. The random effect model was adopted if there was heterogeneity among the studies. Otherwise, we selected the fixed-effects model. Odds Ratio (OR) or standardized mean difference (SMD) and their corresponding 95% confidence intervals (95% CIs) were calculated for outcomes. Subgroup analysis was performed by study design. Publication bias was estimated using Begg's funnel plots and Egger's test. A value of "$Pr > |z|$" above 0.05 for Begg's funnel plots or a value of "$P > |t|$" above 0.05 for Egger's test was considered negative publication bias. Sensitivity analyses were conducted to determine the effect of each study on the summary meta-analysis estimate.

RESULTS

Characteristics of the included studies and evidence quality assessment

We obtained 145 articles based on the search strategy. However, after the screening process, 124 articles were excluded. Of the remaining 21 articles, 14 were excluded and seven studies[15–19,22,24] including three RCTs[15,16,19] and four non-RCTs[17,18,22,24] were indentified for our meta-analysis. According to the established evidence quality assessment criteria, three studies were of moderate quality[17,18,24] while the other four were high-quality evidence.[15,16,19,22] The flowchart of the process for the identification of the studies is shown in **Figure 1**. The characteristics of the selected studies and quality assessment results are summarized in **Table 1**.

Bias assessment

The risk of bias assessment is indicated in **Table 2**. Of the seven studies included, three studies showed the method of allocation concealment and

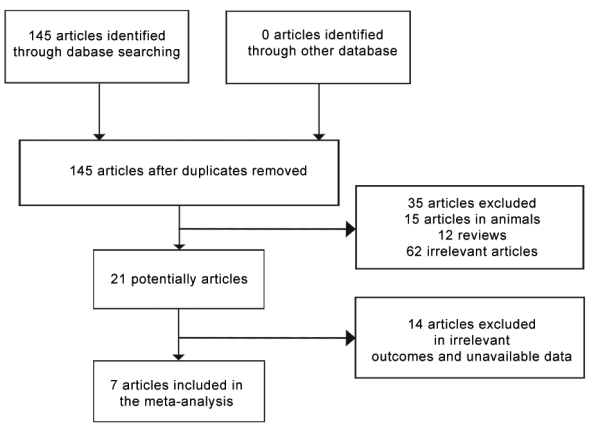

Figure 1: The flowgram of the identification and selection of the studies.

Table 1: The essential information of selected studies

First author (publication year)	*Study design*	*Country or region*	*Patients*	*Indications for varicocelectomy*	*Varicocelectomy side*	*Sample size (LESS/ conventional laparoscopic approach)*	*Outcome reported*	*Quality score/ total score*
Bansal (2014)	Retrospective cohort study	America	Adolescents	Scrotal pain, testicular hypotrophy, grade increase, patient decision	Left and bilateral	11/32	Operative time; scrotal pain relief; hydrocele formation; varicocele recurrence	5/9
Friedersdorff (2013)	Retrospective case-control study	Germany	Adolescents and adults	Scrotal pain, subfertility	unilateral	20/79	Operative time; postoperative pain score; hospital stay; time to return to normal activity; patients had scrotal pain relief; improved semen quality; hydrocele formation; satisfaction rate of wound cosmetic appearance	6/9
Lee (2011)	Randomized controlled study	Korea	Adults	Scrotal pain, subfertility, testicular hypotrophy	Left and bilateral	39/43	Operative time; postoperative pain score; hospital stay; time to return to normal activity; patients had scrotal pain relief; hydrocele formation; varicocele recurrence; satisfaction rate of wound cosmetic appearance	5/5
Micali (2014)	Retrospective cohort study	Italy	Adults	Scrotal pain, subfertility	Bilateral	10/14	Operative time; hospital stay; time to return to normal activity; improved semen quality; hydrocele formation; varicocele recurrence; satisfaction rate of wound cosmetic appearance	5/9
Wang (2014)	Randomized controlled study	China	Adults	Scrotal pain, subfertility	unilateral	44/43	Operative time; postoperative pain score; hospital stay; time to return to normal activity; patients had scrotal pain relief; hydrocele formation; varicocele recurrence	5/5
Youssef (2015)	Randomized controlled study	Egypt	Adults	Scrotal pain, subfertility	Unilateral and bilateral	41/39	Operative time; postoperative pain score; hospital stay; time to return to normal activity; patients had scrotal pain relief; improved semen quality; hydrocele formation; varicocele recurrence; satisfaction rate of wound cosmetic appearance	4/5
Marte (2015)	Retrospective cohort study	Italy	Adolescents	Grades II-III varicocele, testicular hypotrophy	Not available	44/25	Operative time; postoperative pain score; patients had hydrocele formation; varicocele recurrence	5/9

LESS: laparoendoscopic single-site

Table 2: Bias assessment

First author (publication year)	*Allocation concealment*	*Adequate sequence generation*	*Blinding*	*Incomplete outcome data addressed*	*Free of selective addressed*	*Free of other bias*
Bansal (2014)	No	Yes	No	Yes	Unclear	No
Friedersdorff (2013)	No	Yes	No	Yes	No	No
Lee (2011)	Yes	Yes	Yes	Yes	No	Yes
Micali (2014)	Unclear	No	No	Yes	No	No
Wang (2014)	Yes	Yes	Yes	Yes	Unclear	Unclear
Youssef (2015)	Yes	Yes	Yes	Yes	Unclear	Yes
Marte (2015)	Unclear	Yes	Unclear	Yes	Yes	No

randomization methods.[15,16,22] All seven studies addressed incomplete outcome data while only one study was free of selective reporting.[18]

The results of meta-analysis

Operation time and postoperative patient experience

All seven studies reporting operation time were included in the meta-analysis.[15–19,22,24] The pooled SMD demonstrated that there was no significant difference between the LESSV and conventional laparoscopic varicocelectomy (laparoendoscopic *vs* conventional, SMD = −0.065, 95% CI: −0.533–0.402, P = 0.784). Subgroup analysis by study design showed a similar trend with the overall analysis (non-RCT: SMD = −0.436, 95% CI: −1.443–0.72, P = 0.397; RCT: SMD = 0.201, 95% CI: −0.073–0.475, P = 0.151) (**Figure 2a** and **Table 3**).

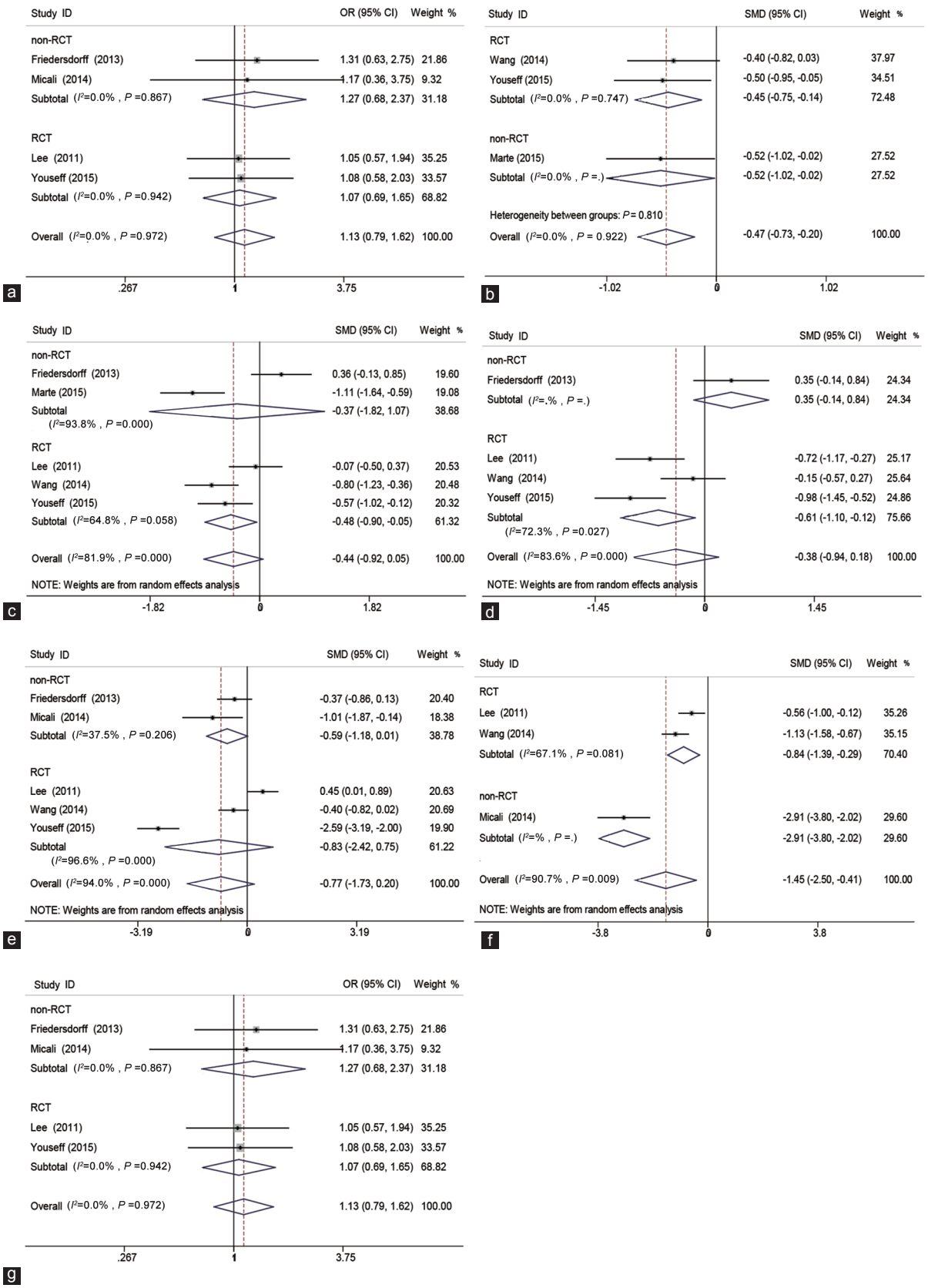

Figure 2: Forest plots for the comparison of operation time and postoperative patient experience. (**a**) operation time; (**b**) postoperative pain score at 3 h or 6 h; (**c**) postoperative pain score at day 1; (**d**) postoperative pain score at day 2; (**e**) hospital stay; (**f**) time to return to work; and (**g**) patient satisfaction rate of cosmetic appearance.

Table 3: Main results of the meta-analysis

Group	*I^2 (%)*	*SMD (95% CI)*	*P*	*Begg's (Pr > |Z|)*	*Egger (P > |t|)*
Operation time					
Non-RCT	89.9	–0.436 (–1.443–0.72)	0.397	0.548	0.015
RCT	16.9	0.201 (–0.073–0.475)	0.151		
Overall	81.7	–0.065 (–0.533–0.402)	0.784		
Hospital stay					
Non-RCT	37.5	–0.586 (–1.183–0.011)	0.054	0.462	0.332
RCT	96.9	–0.834 (–2.418–0.75)	0.302		
Overall	94.0	–0.766 (–1.732–0.200)	0.120		
Time to return to work					
Non-RCT	67.1	–2.906 (–3.796–-2.017)	0.000	0.296	0.222
RCT	-	–0.841 (–1.393–-0.289)	0.003		
Overall	90.7	–1.454 (–2.502–-0.405)	0.007		
Postoperative pain score at 3 h or 6 h					
Non-RCT	-	–0.519 (–1.017–-0.20)	0.042	0.296	0.402
RCT	0.0	–0.447 (–0.754–-0.139)	0.004		
Overall	0.0	–0.467 (–0.728–-0.205)	0.000		
Postoperative pain score at day 1					
Non-RCT	93.8	–0.374 (–1.186–1.068)	0.611	0.806	0.830
RCT	64.8	–0.477 (–0.905–-0.05)	0.029		
Overall	81.9	–0.435 (–0.924–0.054)	0.081		
Postoperative pain score at day 2					
Non-RCT	-	0.351 (–0.142–0.844)	0.163	1.000	0.776
RCT	72.3	–0.612 (–1.099–-0.125)	0.014		
Overall	83.6	–0.380 (–0.942–0.182)	0.185		
		OR (95% CI)			
Improvement of semen parameters					
Non-RCT	0.0	0.962 (0.377–2.450)	0.935	1.000	0.693
RCT	-	1.029 (0.505–2.099)	0.937		
Overall	0.0	1.004 (0.570–1.769)	0.989		
Resolution of testicular pain					
Non-RCT	0.0	1.056 (0.435–2.566)	0.904	1.000	0.709
RCT	0.0	0.991 (0.501–1.958)	0.979		
Overall	0.0	1.015 (0.591–1.741)	0.958		
Hydrocele					
Non-RCT	0.0	1.265 (0.278–5.766)	0.761	1.000	0.486
RCT	0.0	0.784 (0.188–3.258)	0.737		
Overall	0.0	0.977 (0.345–2.764)	0.965		
Recurrence					
Non-RCT	-	0.568 (0.034–9.484)	0.694	0.308	0.055
RCT	0.0	1.008 (0.200–5.092)	0.992		
Overall	0.0	0.877 (0.216–3.569)	0.855		
Patient satisfaction					
Non-RCT	0.0	1.269 (0.680–2.369)	0.454	0.308	0.580
RCT	0.0	1.066 (0.687–1.654)	0.777		
Overall	0.0	1.129 (0.788–1.617)	0.508		

CI: confidence interval; RCT: randomized controlled trial; OR: odds ratio; SMD: standardized mean difference

Several studies included made a comparison of the patient pain experience evaluated by the visual analog scale postoperatively of the two approaches. In the analysis of the included three articles,[15,16,18] with the assessment of pain score at 3 h or 6 h postoperatively, the overall and subgroup SMD indicated that patients underwent LESSV had lower pain scores than that of conventional laparoscopic approaches (overall: SMD = −0.467, 95% CI: −0.728–−0.205, P = 0.000; RCT: SMD = −0.447, 95% CI: −0.754–−0.139, P = 0.004; and non-RCT: SMD = −0.519, 95% CI: −1.017–−0.20, P = 0.042) (**Figure 2b** and **Table 3**), with no heterogeneity existed (I^2 = 0%). Pooled analyses were also performed in the enrolled articles with an evaluation of postoperative pain score at day 1 and day 2. Five studies compared the pain score at day 1[15,16,18,19,22] while four at day 2[15,16,19,22] after the surgery were included. The results indicated that patient who had undergone LESSV had less pain experience over those in conventional laparoscopic procedures in RCT studies (day 1: SMD = −0.477, 95% CI: −0.905–−0.05, P = 0.029 (**Figure 2c** and **Table 3**); day 2: SMD = −0.612, 95%

CI: −1.099–−0.125, P = 0.014 (**Figure 2d** and **Table 3**)), yet it was not confirmed in the overall and non-RCT studies.

In addition, there was no significant difference between LESSV and conventional laparoscopic varicocelectomy in terms of hospital stay (overall: SMD = −0.766, 95% CI: −1.732–0.200, P = 0.120; non-RCT: SMD = −0.586, 95% CI: (1.183–0.011, P = 0.054; and RCT: SMD = −0.834, 95% CI: −2.418–0.75, P = 0.302)[15–17,19,22] (**Figure 2e** and **Table 3**). However, the time to return to work was significantly shorter after the LESSV than that of conventional laparoscopic varicocelectomy (overall: SMD = −1.454, 95% CI: −2.502–−0.405, P = 0.007; non-RCT: SMD = −2.906, 95% CI: −3.796–−2.017, P = 0.000; and RCT: SMD = −0.841, 95% CI: −1.393–−0.289, P = 0.003)[16,17,19] (**Figure 2f** and **Table 3**).

Furthermore, pooled analyses concerning the patient satisfaction rate of wound cosmetic appearance were also conducted.[15,17,19,22] The satisfaction rate was comparable of the two varicocelectomy approaches in the overall and subgroup analyses (overall: OR = 1.129, 95% CI: 0.788–1.617, P = 0.508; non-RCT: OR = 1.269, 95% CI: 0.680–2.369, P = 0.454; and RCT: OR = 1.066, 95% CI: 0.687–1.654, P = 0.777) (**Figure 2g** and **Table 3**).

Surgical effect: improvement of semen parameters and resolution of testicular pain

Patients would like to perform varicocelectomy for different indications: subfertility or testicular pain. In the present meta-analyses, pooled analyses were conducted in terms of the proportions of patients having improvement of semen parameters or resolution of scrotal pain. Concerning patients having improvement of sperm quality, the results did not favor LESSV over conventional procedures (overall: OR = 1.004, 95% CI: 0.570–1.769, P = 0.989; non-RCT: OR = 0.962, 95% CI: 0.377–2.450, P = 0.935; and RCT: OR = 1.029, 95% CI: 0.505–2.099, P = 0.937)[15,17,22] (**Figure 3a** and **Table 3**). Similar results were obtained in terms of the percentage of patients having resolution of testicular pain (overall: OR = 1.015, 95% CI: 0.591–1.741, P = 0.958; non-RCT: OR = 1.056, 95% CI: 0.435–2.566, P = 0.904; and RCT: OR = 0.991, 95% CI: 0.501–1.958, P = 0.979)[15,16,19,22,24] (**Figure 3b** and **Table 3**).

Complications: hydrocele formation and recurrence

The main complications postoperatively with respect to hydrocele formation and varicocele occurrence were also analyzed. There was no significant difference between the two varicocelectomy approaches in incidence of hydrocele formation (overall: OR = 0.977, 95% CI: 0.345–2.764, P = 0.965; non-RCT: OR = 1.265, 95% CI: 0.278–5.766, P = 0.761; and RCT: OR = 0.784, 95% CI: 0.188–3.258, P = 0.737) (**Figure 4a** and **Table 3**) and recurrence (overall: OR = 0.877, 95% CI: 0.216–3.569, P = 0.855; non-RCT: OR = 0.568, 95% CI: 0.034–9.484, P = 0.694; and RCT: OR = 1.008, 95% CI: 0.200–5.092, P = 0.992) (**Figure 4b** and **Table 3**).

Assessment of publication bias and sensitivity analyses

Sensitivity analyses were also conducted to determine the effect of each study on the summary meta-analysis and no substantial changes occurred for the corresponding ORs or SMDs. To assess the publication bias between the studies, Begg's funnel plots and Egger's test were conducted. The main results of the tests are shown in **Table 3**. In the analysis of "operation time" items, Begg's test indicated no publication bias ($Pr > |z|$ = 0.548), but Egger's test found publication bias ($P > |t|$ = 0.015). Publication bias was not found in the remaining results of the meta-analysis.

DISCUSSION

LESS surgery is introduced to comply with the minimally invasive principle in surgical procedures. It has been performed in a variety of surgeries, including nephrectomies, cholecystectomies, and appendectomies.[10–12] LESS surgery has been proven to be applicable in the clinical field, being feasible and effective, with high patients' satisfaction rates of the cosmetic appearance.[27,28] Several systematic reviews and meta-analyses have confirmed that LESS surgery offers comparable surgical outcome and feasible alternative to its conventional laparoscopic counterpart.[29–36] Its significant advantage over conventional laparoscopic surgery is also noted in terms of postoperative patient experience, evaluated with postoperative pain score or analgesic requirement in several evidence-based studies,[30,33,34,36] yet not confirmed in some other studies.[29,31] Patients who had undergone LESS nephrectomy also benefit from shorter hospital stay and shorter recovery time[34] while LESS cholecystectomy patients show a lesser physical quality of life.[29] These results were consistent with the present meta-analyses that LESSV patients had a shorter duration of back to work.

LESS surgery is introduced over conventional laparoscopy surgery for an effort to improve the wound cosmetic outcome. Some patients would otherwise prefer the open surgery with only one wound. Although Fan *et al*. concluded in a systematic review with 25 studies and 1094 cases identified that patient who had undergone LESS nephrectomy had better cosmetic outcome over conventional laparoscopic nephrectomy,[34] it was not confirmed in some other[30,31] and the current meta-analyses. The possible explanation for this could be the limited source of studies and data included or varied criteria established to self-define "cosmetic

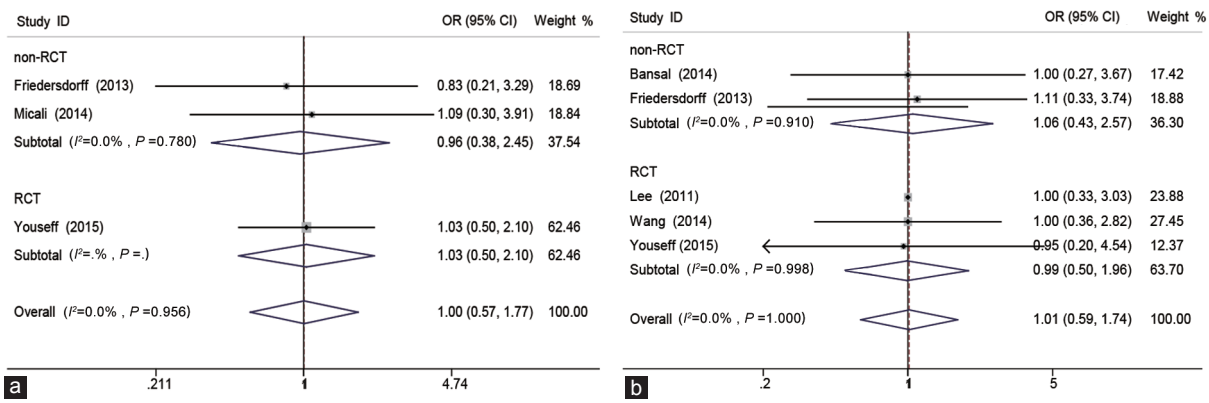

Figure 3: Forest plots for the comparison of surgical effect. (**a**) improvement of semen parameters; (**b**) resolution of testicular pain.

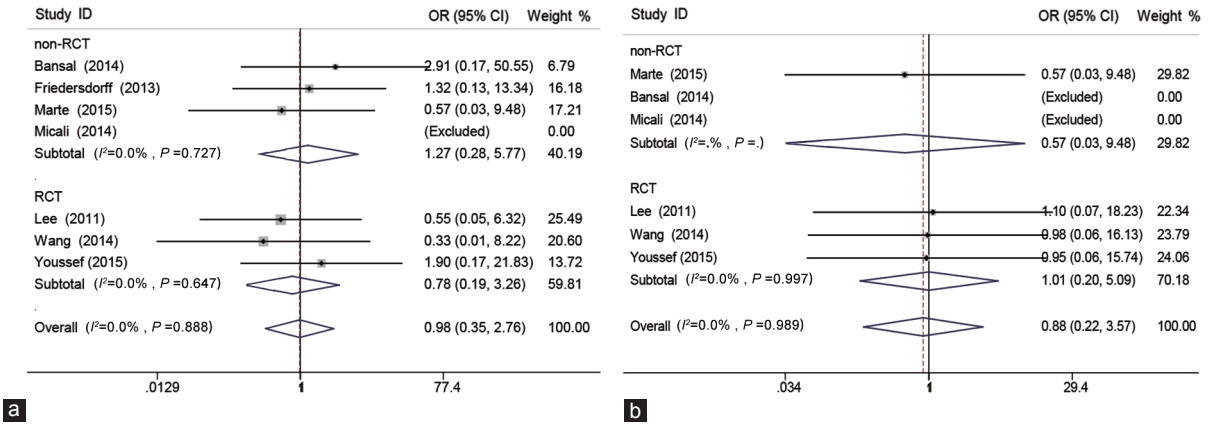

Figure 4: Forest plots for the comparison of postoperative complications. (**a**) hydrocele formation; (**b**) recurrence.

satisfaction." Therefore, further larger studies with scientific definition assessing "patient satisfaction" are needed to strengthen the evidence.

In the current meta-analysis, the operation time of two surgical methods of varicocelectomy was similar, which was consistent with some previous studies.[30,33,36] Some evidence studies even reported a longer operation time in LESS procedures.[30,33,36] Notably, in spite of these controversy findings, there were no studies reporting a less operation time in LESS surgeries. This may represent a challenge against its acceptance by surgeons.

Blood loss in surgeries is a pivotal parameter to evaluate advantages and disadvantages of surgical methods. In the enrolled seven articles for the meta-analysis, a total of three studies reported the blood loss outcome.[17,22,24] Although pooled analysis was not conducted because of the limited data, these studies described an "insignificant" estimated blood loss and it was comparable between the two varicocelectomy methods. However, future studies with more important outcome measures involved are needed for a better and more comprehensive estimation.

Notably, whether the surgical effect of a specific varicocelectomy procedure, mostly regarding semen quality improvement and scrotal pain relief, was associated with the laterality of varicocelectomy has been controversial. Libman *et al*.[37] and Baazeem *et al*.[38] reported that males underwent bilateral microsurgical varicocelectomy had greater increase in sperm percent motility than that of unilateral varicocelectomy while it was not confirmed in Fujisawa's study.[39] On the other hand, Maghraby reported that 46 of 51 patients underwent left laparoscopic varicocelectomy while three of seven patients in bilateral laparoscopic varicocelectomy procedures had scrotal pain relief, which indicated statistical significance.[40] However, Kachrilas *et al*. failed to identify this result in another observation.[41] In the current experiment, three studies analyzed semen quality improvement,[15,17,22] of which one study included patients of unilateral varicocele,[22] one bilateral,[17] and one unilateral and bilateral.[15] The rate of patients with unilateral varicocelectomy having improved semen quality was similar between LESS and conventional laparoscopic approaches (single-site *vs* conventional, 5/6 *vs* 16/16, Friedersdorff *et al*. 2013). Similar results were obtained in Micali's study based on bilateral varicocelectomy (single-site versus conventional, 7/10 versus 9/14) and Youssef's study with left and bilateral varicocelectomy included (single-site *vs* conventional, 28/37 *vs* 25/34). Single-site and conventional laparoscopic varicocelectomy resulted in comparable incidence of patients having scrotal pain relief in the current study. Accordingly, we further analyzed that this surgical effect of these two varicocelectomy methods could possibly be varicocele side-related using meta-analytical method. In the current study, two studies were based on unilateral varicocelectomy[16,22] while the other three unilateral and bilateral.[15,19,24] Both "unilateral" varicocelectomy subgroup and "unilateral and bilateral" varicocelectomy subgroup yielded similar rate of patients having scrotal pain relief between single-site and conventional laparoscopic procedures (unilateral: OR = 1.007, 95% CI: 0.688–1.517, $P = 0.914$; unilateral and bilateral: OR = 0.994, 95% CI: 0.682–1.451, $P = 0.977$) and indicated that the side of variococelectomy was not associated with the surgical outcome of these two surgical choices. However, due to the limited data and some other possible factors may affect surgical effect, such as grade of varicocele, definite conclusion cannot be reached and more high-quality studies are needed to better illustrate the possible relationship between laterality of varicocelectomy and surgical effect of specific varicocelectomy choices.

Several limitations should pay attention to our meta-analysis. First, the number of studies and subjects included in the present meta-analysis is relatively small, which resulted in limited statistical power. We enrolled seven studies with only three RCTs, and the subject number varied from 11 to 79. Second, some heterogeneity existed in the present meta-analysis and 5/7 of the included studies cannot exclude existence of other bias, which lowered the value of the interpretation of results of the present meta-analysis. These findings remind us that the results of this meta-analysis should be interpreted with caution and better designed studies and high-quality studies, like RCTs, with larger sample size involved are warranted for a more precise estimation. Third, because of the limited data, the current meta-analysis was conducted to describe a favorable surgical method between LESSV and conventional laparoscopic varicocelectomy. However, since there were various surgical varicocelectomy techniques, more high-quality studies concerning the comparison of LESS approaches and other varicocelectomy surgical methods or systematic reviews and meta-analyses, like network meta-analyses, are needed for an overall estimation to determine the best method for varicocele treatment, which should provide qualified surgical outcomes and low incidence of complications, while offering favorable patient experience at the same time.

Despite these limitations, there are some advantages of our meta-analysis that should be taken consideration. First, this was the first systematic review and meta-analysis to assess the surgical outcomes and patient experience of LESSV in comparison with conventional laparoscopic varicocelectomy. Second, we performed stratified analyses by study design (RCT and non-RCT). This partially explains the source of

this heterogeneity existed among the studies. Third, we further performed Begg's funnel plots and Egger's test to assess the publication bias, which offers a better understanding of the present status of studies in this field. Thus, we consider the results of the present meta-analyses reliable.

In summary, the present meta-analysis suggests that when compared to conventional laparoscopic varicocelectomy, LESS procedure was associated with less pain experience and shorter duration of back to work. Its advantages regarding operation time, clinical effect concerning semen quality improvement and scrotal pain relief, postoperative hydrocele, varicocele recurrence rate, and postoperative satisfaction rate of wound appearance were not confirmed in the present meta-analysis. However, more studies concerning this topic are needed to further illustrate the issue.

AUTHOR CONTRIBUTIONS

ZZ and SJZ carried out the literature search and data extraction, participated in the data analysis and drafted the manuscript. WY and YFH participated in the study design and performed the statistical analysis. HC and YC participated in the data extraction and statistical analysis. YTD conceived of the study and participated in its design and coordination and helped draft the manuscript. All authors read and approved the final manuscript.

COMPETING INTERESTS

All authors declared no competing financial interests.

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