

A meta-analysis of endoscopic discectomy versus open discectomy for symptomatic lumbar disk herniation

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Abstract

Purpose The purpose of this study was to systematically compare the effectiveness and safety of endoscopic discectomy (ED) with open discectomy (OD) for the treatment of symptomatic lumbar disc herniation (LDH).

Methods A highly sensitive search strategy was used to identify all published randomized controlled trials up to August 2014. A criteria list taken from Koes et al. was used to evaluate the risk of bias of the included studies. The five questions that were recommended by the Cochrane Back Review Group were used to evaluate the clinical relevance. Cochrane methodology was used for the results of this meta-analysis.

Results Nine relevant RCTs involving 1,092 patients were identified. Compared with OD, ED results in slightly better clinical outcomes which were evaluated by the Macnab criteria without clinical significance (ED group: 95.76 %; OD group: 80 %; OR: 3.72, 95 % CI: [0.76, 18.14], $P = 0.10$), a significantly greater patient satisfaction rate (ED group: 93.21 %; OD group: 86.57 %; OR: 2.19; 95 % CI: [1.09, 4.40]; $P = 0.03$), lower intraoperative blood loss volume (WMD: -123.71 , 95 % CI: $[-173.47, -73.95]$, $P < 0.00001$), and shorter length of hospital stay (WMD: -2144.45 , 95 % CI: $[-239.54, -49.37]$, $P = 0.003$).

Conclusions From the existing outcomes, ED surgery could be viewed as a sufficient and safe supplementation and alternative to standard open discectomy. The cost-

effectiveness analyses still remain unproved from the existing data. More independent high-quality RCTs using sufficiently large sample sizes with cost-effectiveness analyses are needed.

Keywords Meta-analysis · Randomized controlled trial · Open discectomy · Endoscopic discectomy · Symptomatic lumbar disk herniation

Introduction

Sciatica, which is caused by nerve root compression or irritation, describes the symptoms of leg pain and occasionally neurological disturbance in the dermatome of the affected nerve root. Over 90 % of cases are due to symptomatic lumbar disk herniation (LDH) [1, 2]. Symptomatic LDH, with a reported prevalence of 1–3 % [3], is the commonest pathological process leading to spinal surgery.

Surgery for symptomatic LDH can be classified into two broad categories: open versus endoscopic surgery. In 1934, Mixter and Barr were the first authors to treat symptomatic LDH surgically by performing an open laminectomy and discectomy [2]. In 2007, a Cochrane review on surgical interventions for LDH concluded that there was considerable evidence that open discectomy (OD) was effective in reducing symptoms in the short term [4]. But, in the last decades, endoscopic discectomy (ED) techniques which were developed to perform discectomy under direct view and local anesthesia have gained a growing interest. The perceived benefits are minimal muscle and soft tissue damage with excellent visualization. Yeung developed the commercially available Yeung Endoscopic Spine System (YESS) in 1997 [5], and Hoogland developed the Thomas Hoogland Endoscopic Spine System (THESSYS) in 1994.

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With the latter system, it is possible to enlarge the intervertebral foramen near the facet joint with special reamers to reach intracanal extruded and sequestered disk fragments and decompress foraminal stenosis [6]. Microendoscopic discectomy (MED) was first described in 1997 as a minimally invasive transmuscular approach using advanced optics [7]. Currently, OD (e.g., conventional open discectomy and open microdiscectomy) and ED (e.g., transforaminal endoscopic discectomy and MED) are the most widespread procedure among the majority of spine surgeons for surgical decompression of radiculopathy caused by symptomatic LDH.

However, previous studies that compared the clinical effects of ED with OD for treating symptomatic LDH are constituted of ambiguous results. Therefore, it is still uncertain whether ED is more effective and safer than OD. The objective of this study was to systematically compare the effectiveness and safety of ED with OD for the treatment of symptomatic LDH.

Materials and methods

Criteria for selected trials

All randomized controlled clinical trials (RCTs) comparing ED with OD for the treatment of symptomatic LDH were identified in this study. We systematically reviewed published studies according to the following criteria: (1) patients younger than 70 years of age underwent spinal ED or OD for symptomatic LDH were included in the study; (2) the interventions in this study included various types of ED and OD in the lumbar spine; (3) the study reported at least one desirable outcome; (4) all included trials were followed up at least 1 year after surgery; and (5) patients were excluded if they had an acute spinal fracture, infection, tumor, or rheumatoid arthritis. The outcomes obtained in this study were labeled as the primary outcome and the secondary outcome. The primary outcome includes: (1) the clinical outcomes evaluated by the Macnab criteria, (2) patient satisfaction with the treatment, and (3) complications. The secondary outcome includes: (1) length of hospital stay, (2) operation time and blood loss volume, (3) recurrences rate, and (4) reoperation rate.

Search methods for identification of studies

RCTs without language restrictions were identified up to August 2014 by PubMed and China National Knowledge Infrastructure (CNKI); computer searching of Ovid MEDLINE and EMBASE; the Cochrane Central Register of Controlled Trials; hand searching of European Spine Journal, Spine, The Spine Journal and Journal of Bone and

Joint Surgery of abstracts from 1990; and communication with international experts. The following key words were used for search: lumbar disk herniation (protrusion or prolapse), endoscopic, discectomy, open discectomy, and randomized controlled trial. Two investigators independently reviewed all subjects, abstracts, and the full text of articles that were potentially eligible based on abstract review. Then the eligible trials were selected according to the inclusion criteria. Disagreement was resolved by discussion, if necessary, by further discussion with an independent colleague.

Data collection

The data were extracted from included reports independently by two reviewers, and further discussions would be needed to deal with the disagreements. The data extracted include the following categories: the participant characteristics, the number of participants, and the loss to follow-up; study characteristics; the intervention details; the primary and the secondary outcomes; odds ratios (OR) or mean difference (MD); and 95 % confidence limits (95 % CI) of the comparisons.

Assessment of risk of bias

Two reviewers independently assessed the risk of bias of the trials. In a subsequent meeting, the reviewers tried to reach consensus on each criterion that they initially disagreed on. A criteria list taken from Koes et al. [8] was used to evaluate it. To each criterion, a weight was attached. The maximum score was 100 points for each study. The assessments which resulted in higher scores indicate studies of lower risk of bias. The included study which scored more than 50 points was considered as best study according to the criteria [8].

Assessment of clinical relevance

Two reviewers independently assessed the clinical relevance of the included studies referring to the five questions recommended by the Cochrane Back Review Group [9, 10]. Positive (+) would be recorded for the question if the clinical relevance item is met, negative (−) for the irrelevance, and unclear (?) if the data are inadequate for answering the question.

Measures of treatment effect

Attempts were made to statistically pool the data of included studies in order to obtain the primary and the secondary outcomes. The results were expressed in terms of odds ratio (OR) and a 95 % confidence interval (95 %

CI) for dichotomous outcomes, and in terms of mean difference (MD) and 95 % CI for continuous outcomes. When the same continuous outcomes are measured in different scales, standardized mean difference (SMD) and 95 % CI are calculated. If outcomes were shown as dichotomous data in some studies while in the other studies expressed as continuous data, odds ratios would be re-pressed as standardized mean difference to allow dichotomous and continuous data to be pooled together [11]. Collected data were checked and entered into the computer by the two reviewers. RevMan software (vesion5.0) was used for data analysis. We performed the Laird Q test for heterogeneity and also calculated the I^2 statistic for each analysis [12]. If the P value was 0.05 or less, indicating obvious heterogeneity between studies, a random-effects model was used to calculate the pooled OR [13], otherwise, a fixed-effects model was performed [14]. A rating system with five levels of evidence taken from the Cochrane Back Review Group was used to evaluate the level of evidence [9].

Results

Description of studies

The process of identifying eligible studies is shown in Fig. 1. After titles and abstracts evaluation, 143 references were omitted according to conditions listed in Fig. 1. The remaining 15 candidate studies were taken for a comprehensive evaluation. We excluded 6 more studies after evaluating the full article versions of the remaining articles due to unsuitable controls, data replication. Finally, nine studies with a total of 1,092 patients with symptomatic LDH entered this meta-analysis [15–23].

The characteristics of nine included studies are summarized in Table 1. In all included studies, the patients with symptomatic LDH were recruited with sample size ranging from 40 to 240 patients. All the included studies have definite inclusion/exclusion criteria. Frank et al. [17] performed the video-assisted arthroscopic microdiscectomy compared with OD. In four studies [15, 16, 18, 19], the transforaminal endoscopic discectomy (TED) was employed compared with OD (open microsurgical discectomy or standard open discectomy). In addition, in the other four studies [20–23], the MED was employed compared with OD. The clinical outcomes, surgical data, and complications were analyzed in at least 1-year follow-up period.

Risk of bias in included studies

Risk of bias assessment of included studies is presented in Table 2. The 2 reviewers disagreed on 8 of 72 items

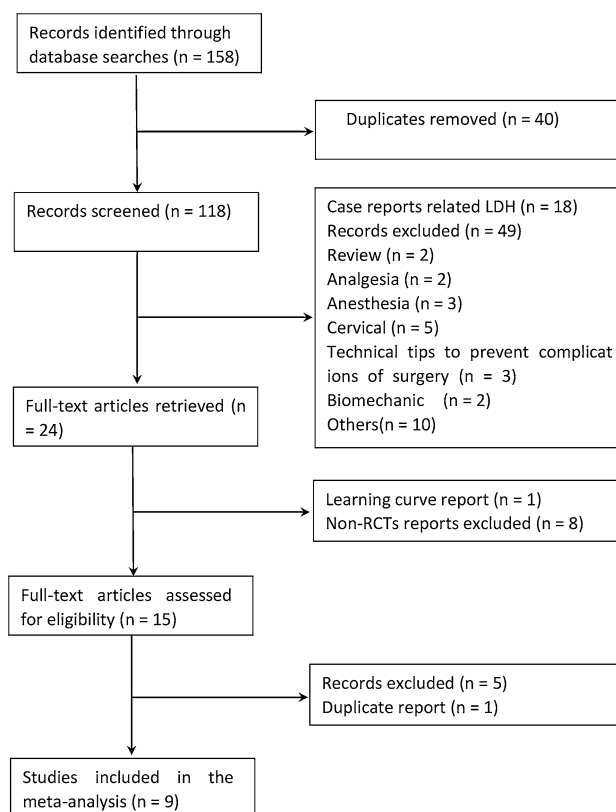


Fig. 1 Study selection process. The flow-chart showed the selection of randomized controlled trials for meta-analysis

(11.1 %) scored. After discussing the results, they reached consensus on the scoring of all items. There were 5 best studies which scored more than 60 points, and the other 4 studies which scored more than 50 points. The median score was 62.8 points, indicating the overall lower risk of bias of the trials. The most prevalent methodologic shortcomings appeared to be (F) the small size of the study populations included, and (M) a lack of clarity regarding the outcome assessor blinded to the intervention. In four studies, there was a clear attempt at concealment of group allocation and method of randomization [15–17, 20]. There were five trials performed an intention-to-treat analysis [17–19, 21, 22]. All of the nine trials had the recommended follow-up for surgical studies of at least 1 year and had a follow-up rate of more than 87 % of each included trials.

Clinical relevance

Clinical relevance of the included studies is presented in Table 3. There was disagreement between the 2 reviewers with regard to the scoring of 2 of 20 (10 %) clinical relevance items. Consensus was reached on all scorings after discussion. All of the included trials described the interventions and treatment settings well enough to enable

Table 1 Characteristics of the included studies

Study	Ruetten [15]	Ruetten [16]	Frank [17]	Lee [18]	Liu [19]	Mohamed [20]	Garg [21]	Righesso [22]	Teli [23]
Methods	R: randomized assignment C: being allocated by nonphysician study staff B: blind surgeon	R: randomized assignment C: being allocated by nonphysician study staff B: blind surgeon	R: randomized assignment C: sealed envelope B: blind surgeon	R: randomized with unclear method C: unclear B: unclear	R: random number table C: being allocated by nonphysician study staff B: blind surgeon	R: randomization with unclear method C: unclear B: unclear	R: randomization with unclear method C: unclear B: unclear	R: randomization with unclear method C: unclear B: unclear	R: computer-generated random list C: being allocated by nonphysician study staff B: unclear
Participants	L: Exp 9/100, Ctl 13/100 (at 2 years) 200 patients; 116 females, 84 males; mean age 43 (20–68); level LDH between L1/L2–L5/S1; good compliance	L: Exp 5/50, Ctl 8/50 (at 2 years) 100 patients; 44 females, 56 males; mean age 39 (23–59); level LDH between L2/L3–L5/S1; good compliance	L: Exp 0/30, Ctl 0/30 (at 31 months) 60 patients; 21 females, 39 males; mean age 39.5 (15–67); level LDH between L2/L3–L5/S1; good compliance	L: Exp 0/30, Ctl 0/30 (at 3 years) 60 patients; 16 females, 44 males; mean age 39.45 (20–67); level LDH between L4/L5–L5/S1; good compliance	L: Exp 0/40, Ctl 0/40 (at 19 months) 80 patients; 35 females, 45 males; mean age 41 (18–67); level LDH between L3/L4–L5/S1; good compliance	L: Exp 5/100, Ctl 10/100 (at 8 years) 200 patients; 88 females, 112 males; mean age 30.9 (18–54); level LDH between L2/L3–L5/S1; good compliance	L: Exp 0/55, Ctl 0/57 (at 1 year) 112 patients; 32 females, 80 males; mean age 37 (26–57); level LDH between L4/L5–L5/S1; good compliance	L: Exp 0/21, Ctl 0/19 (at 2 years) 40 patients; 17 females, 23 males; mean age 43.9; level LDH between L2/L3–L5/S1; good compliance	L: Exp 70/80, Ctl 142/160 (at 2 years) 212 patients; 73 females, 139 males; mean age 39.3 (18–65); level LDH between L3/L4–L5/S1; good compliance
Interventions	Exp: full-endoscopic surgery	Exp: full-endoscopic surgery	Exp: video-assisted arthroscopic microdiscectomy	Exp: percutaneous endoscopic lumbar discectomy	Exp: percutaneous transforaminal endoscopic discectomy	Exp: microendoscopic discectomy	Exp: microendoscopic discectomy	Exp: microendoscopic discectomy	Exp: microendoscopic discectomy
Outcomes	Ctl: microsurgical discectomy Complication, recurrences, mean operating time, blood loss, clinical outcomes, reoperation rate, subjective satisfaction	Ctl: microsurgical operation Complication, recurrences, mean operating time, blood loss, clinical outcomes, reoperation rate, subjective satisfaction	Ctl: open discectomy Satisfied with operative result, complication, resume normal activity time, return to work time, clinical outcomes, reoperation rate, subjective satisfaction	Ctl: open lumbar microdiscectomy MacNab, disk height, foraminal height, operation time, length of hospital stay, reoperation rate	Ctl: fenestration discectomy Complication, recurrences, blood loss, mean operating time, size of incision, return to work time, length of hospital stay, clinical outcomes, MacNab	Ctl: standard open discectomy Operative time, blood loss, length of hospital stay, time to return to work, reoperation rate, recurrences, patient satisfaction index (PSI), MacNab, clinical outcomes	Ctl: open discectomy Clinical outcomes, complications, length of hospital stay, surgical time, blood loss, weight of disk removal, reoperation rate, recurrences, subjective satisfaction	Ctl: open discectomy Clinical outcomes, complications, length of hospital stay, surgical time, blood loss, size of incision, reoperation rate, recurrences	Ctl: open discectomy and micro discectomy Clinical outcomes, complications, mean operating time, length of hospital stay, size of incision, recurrences, costs

R randomization, C concealment of allocation, B blinding, L losses to follow-up, Exp experimental group, Ctl control group, LHD lumbar disk herniation

Table 2 Risk of bias assessment of included studies

Criterion	Weight	Ruetten [15]	Ruetten [16]	Frank [17]	Lee [18]	Liu [19]	Mohamed [20]	Garg [21]	Righesso [22]	Teli [23]
A Homogeneity	2	2	2	2	2	2	2	2	2	2
B Comparability of relevant baseline characteristics	5	3	3	3	3	3	3	3	3	3
C Randomization procedure adequate	4	4	4	4	–	2	4	–	–	2
D Drop-outs described for each study group separately	3	3	3	3	3	3	3	3	3	3
E <20 % loss to follow-up	2	2	2	2	2	2	2	2	2	2
<10 % loss to follow-up	2	–	–	2	2	2	2	2	2	–
F >50 subjects in the smallest group	8	8	–	–	–	–	8	8	–	8
>100 subjects in the smallest group	9	–	–	–	–	–	–	–	–	–
G Interventions included in protocol and described	10	10	10	10	10	10	10	10	10	10
H Pragmatic study	5	5	5	5	5	5	5	5	5	5
I Co-interventions avoided	5	5	5	5	5	5	5	5	5	5
J Placebo-controlled	5	–	–	–	–	–	–	–	–	–
K Patients blinded	5	–	–	3	–	–	–	–	–	3
L Outcome measures relevant	10	10	10	8	6	10	10	8	8	10
M Blinded outcome assessments	10	–	–	10	–	–	–	10	–	10
N Follow-up period adequate	5	5	5	5	5	5	5	5	5	5
O Intention-to-treat analysis	5	–	–	5	5	5	–	5	5	–
P Frequencies of most important outcomes presented for each treatment group	5	5	5	5	5	5	5	5	5	5
Total score	100	62	54	72	53	59	64	73	55	73

Table 3 Clinical relevance

	Ruetten [15]	Ruetten [16]	Frank [17]	Lee [18]	Liu [19]	Mohamed [20]	Garg [21]	Righesso [22]	Teli [23]
1. Are the patients described in detail so that you can decide whether they are comparable to those that you see in your practice?	+	+	+	+	+	+	+	+	+
2. Are the interventions and treatment settings described well enough so that you can provide the same for your patients?	+	+	+	+	+	+	+	+	+
3. Were all clinically relevant outcomes measured and reported?	+	+	+	–	+	+	+	+	+
4. Is the size of the effect clinically important?	+	+	+	+	–	+	+	+	+
5. Are the likely treatment benefits worth the potential harms?	+	+	+	+	+	+	+	+	+

clinicians to replicate the treatment in clinical practice. In one study trial, the relevant outcomes, such as complications, were not reported [18], and in another study trial [19], the size of the effect was not considered to be clinically important. The consistent outcomes of all included studies suggested that the treatment benefits were likely worth the potential harms.

Meta-analysis results

At the end of follow-up point, patient satisfaction status was significantly better in ED group than OD group (OR: 2.19; 95 % CI: [1.09, 4.40]; $P = 0.03$, $I^2 = 0\%$). The patient satisfaction rates of ED group and OD group were 93.21 and 86.57 %, respectively.

Although the complication rate of OD group was slightly higher than ED group (OD: 20.12 %, ED: 16.11 %), no significant difference was found in the complication rate (OR: 0.73, 95 % CI: [0.34, 1.57], $P = 0.41$, $I^2 = 75$ %), which reflects the primary harm outcome. The primary beneficial clinical outcomes which were evaluated by the Macnab criteria of ED group were slightly higher than OD group (ED group: 95.76 %; OD group: 80 %), but no statistical significance was found between ED group and OD group in clinical outcomes evaluated by the Macnab criteria (OR: 3.72, 95 % CI: [0.76, 18.14], $P = 0.10$, $I^2 = 62$ %).

In the secondary outcomes, significant differences were found between ED group and OD group in the length of hospital stay (WMD: -144.45 , 95 % CI: $[-239.54, -49.37]$, $P = 0.003$, $I^2 = 99$ %) and the blood loss volume (WMD: -123.71 , 95 % CI: $[-173.47, -73.95]$, $P < 0.00001$, $I^2 = 99$ %). The length of hospital stay of OD group was significantly longer than ED group, and the blood loss volume of the OD group was significantly higher than ED group. No significant difference was found in the operating time (WMD: 9.27, 95 % CI: $[-6.69, 25.23]$, $P = 0.25$, $I^2 = 95$ %), recurrences rate (OR: 1.62; 95 % CI: [0.84, 3.12]; $P = 0.15$, $I^2 = 0$ %), and the reoperation rate (OR: 0.98; 95 % CI: [0.60, 1.61]; $P = 0.93$, $I^2 = 0$ %). The recurrence rates of ED group and OD group were 5.04 and 3.35 %, respectively. The reoperation rates of ED group and OD group were 6.82 and 6.93 %, respectively. The results of meta-analysis are shown in Fig. 2.

Other results

Mohamed et al. [20] reported that the total success rate of MED group was 96.8 % (1-year postoperative) which remained unchanged till the end of the follow-up period and 71.1 % (1-year postoperative) for OD group which decreased to 55.6 % by 8 years. 98 % of MED group showed complete satisfaction with MED procedure and outcome and would undergo the surgery again for the same condition compared to 40 % of the control group. Teli et al. [23] found that MED was significantly more expensive than OD both as a single and as a repeat procedure when the cost of recurrences was taken into account (MED: $3,010 \pm 450$ Euros per case, OD: $2,310 \pm 260$ – $2,450 \pm 340$ Euros per case). Huang et al. [24] suggested that surgical trauma, as reflected by systemic IL-6 and CRP response, was significantly less following MED than following OD, and the difference in the systemic cytokine response may support that the MED procedure is less traumatic. Lee et al. [18] noted that the successful clinical outcomes were 96.7 % in ED group and 93.3 % in the OD group. Among the various

radiological parameters, changes of disk height (1.41 ± 1.19 mm in ED group and 2.29 ± 2.12 mm in OD group, $P = 0.024$) and foraminal height (1.26 ± 0.91 mm in ED group and 1.85 ± 0.92 mm in OD group, $P = 0.017$) were significantly different between the two groups, and they concluded that although the clinical outcomes were similarly satisfactory in both groups, ED is a less invasive procedure than OD in selected cases. Garg et al. [21] found that both methods were equally effective in relieving radicular pain by reducing the tension on the nerve root caused by the herniated disc.

Discussion

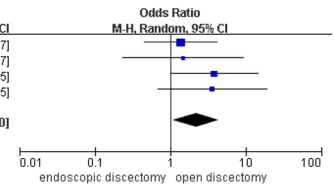
This meta-analysis identified nine RCTs that compared ED with OD for symptomatic LDH. It revealed that ED group resulted in a higher patient satisfaction rate with clinical statistical significance when compared with OD group at the end of follow-up point. There is strong evidence that blood loss volume which reflects harm outcomes of OD group was significantly higher than ED group. Furthermore, the length of hospital stay of OD group was significantly longer than ED group. The cost of discectomy for LDH has rarely been the object of research, despite its need [25]. The topic of cost has been addressed in only one RCT [23], which found that MED was significantly more expensive than OD. But in several countries, the length of hospitalization is also influenced by reimbursement issues. It is supposed that shorter length of hospital stay may lead to lower cost of treatment. To assess the topic of cost, more high-quality RCTs with cost-effectiveness analyses are needed. Additionally, the primary beneficial clinical outcomes which were evaluated by the Macnab criteria of ED group were slightly higher than OD group, but no significant difference was found between them. Mohamed's study [20], which underwent 8 years follow-up, reported that 98 % of MED group showed complete satisfaction with MED procedure and outcome, and would undergo the surgery again for the same condition compared to 40 % of the control group. The follow-up duration of the other eight studies was ranged from 1 to 3 years. Mohamed's study was found to be highly influential to the overall results. Therefore, when analyzing patient satisfaction status, we excluded this study as making a sensitivity analysis. After omitting Mohamed's study [20], there was no statistical statistical heterogeneity found in this meta-analysis combined result about the patient satisfaction rate, and the combined results were similar with the eligible studies. Qualitative analysis reveals that ED technique can significantly relieve the patients' symptom.

The goal of surgical treatment of symptomatic LDH was sufficient decompression with minimization of operation-

Fig. 2 Pooled results of endoscopic discectomy (ED) versus open discectomy (OD). The results of ED versus instrumented OD were shown as follows: the clinical outcomes evaluated by the Macnab criteria, patient satisfaction, complication rate, length of hospital stay, operation time, the blood loss volume, recurrences rate, and reoperation rate

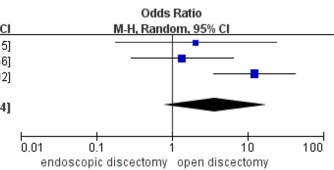
Patient Satisfaction

Study or Subgroup	endoscopic discectomy		open discectomy		Weight	Odds Ratio M-H, Random, 95% CI
	Events	Total	Events	Total		
Frank 1999	22	30	20	30	39.8%	1.38 [0.45, 4.17]
Garg 2011	53	55	54	57	14.6%	1.47 [0.24, 9.17]
Ruetten 2008	88	91	77	87	27.8%	3.81 [1.01, 14.35]
Ruetten 2009	43	45	36	42	17.8%	3.58 [0.68, 18.85]
Total (95% CI)		221		216	100.0%	2.19 [1.09, 4.40]
Total events: 206 (ED), 187 (OD)						
Heterogeneity: Tau ² = 0.00; Chi ² = 1.87, df = 3 (P = 0.60); I ² = 0%						
Test for overall effect: Z = 2.19 (P = 0.03)						



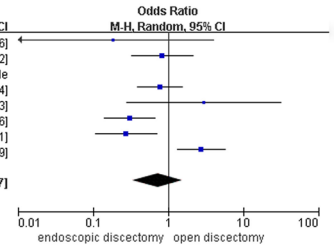
The Clinical Outcomes Evaluated By The Macnab Criteria

Study or Subgroup	endoscopic discectomy		open discectomy		Weight	Odds Ratio M-H, Random, 95% CI
	Events	Total	Events	Total		
Lee 2006	29	30	28	30	23.6%	2.07 [0.18, 24.15]
Liu 2014	37	40	36	40	35.5%	1.37 [0.29, 6.56]
Mohamed 2014	92	95	64	90	40.9%	12.46 [3.62, 42.92]
Total (95% CI)		165		160	100.0%	3.72 [0.76, 18.14]
Total events: 158 (ED), 128 (OD)						
Heterogeneity: Tau ² = 1.20; Chi ² = 5.32, df = 2 (P = 0.07); I ² = 62%						
Test for overall effect: Z = 1.63 (P = 0.10)						



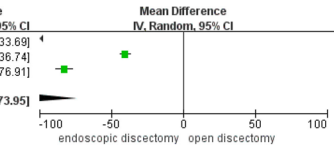
Complication Rate

Study or Subgroup	endoscopic discectomy		open discectomy		Weight	Odds Ratio M-H, Random, 95% CI
	Events	Total	Events	Total		
Frank 1999	0	30	2	30	4.9%	0.19 [0.01, 4.06]
Garg 2011	10	55	12	57	16.6%	0.83 [0.33, 2.12]
Liu 2014	0	40	0	40		Not estimable
Mohamed 2014	20	95	23	90	18.7%	0.78 [0.39, 1.54]
Righesso 2007	3	21	1	19	7.2%	3.00 [0.28, 31.63]
Ruetten 2008	11	91	27	87	17.9%	0.31 [0.14, 0.66]
Ruetten 2009	9	45	20	42	16.5%	0.28 [0.11, 0.71]
Tell 2010	19	70	17	142	18.3%	2.74 [1.32, 5.69]
Total (95% CI)		447		507	100.0%	0.73 [0.34, 1.57]
Total events: 72 (ED), 102 (OD)						
Heterogeneity: Tau ² = 0.70; Chi ² = 23.67, df = 6 (P = 0.0006); I ² = 75%						
Test for overall effect: Z = 0.82 (P = 0.41)						



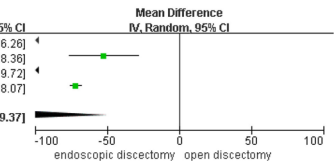
The Blood Loss Volume

Study or Subgroup	endoscopic discectomy		open discectomy		Weight	Mean Difference IV, Random, 95% CI		
	Mean	SD	Mean	SD				
Garg 2011	41	12	55	306	120	57	30.8%	-265.00 [-296.31, -233.69]
Liu 2014	7.2	2.1	40	47.5	11.3	40	34.8%	-40.30 [-43.86, -36.74]
Mohamed 2014	41.6	13.1	95	124.22	24.5	90	34.7%	-82.62 [-88.33, -76.91]
Total (95% CI)			190		187	100.0%	-123.71 [-173.47, -73.95]	
Total events: 190 (ED), 187 (OD)								
Heterogeneity: Tau ² = 1851.63; Chi ² = 327.89, df = 2 (P < 0.00001); I ² = 99%								
Test for overall effect: Z = 4.87 (P < 0.00001)								



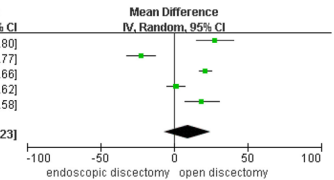
Length Of Hospital Stay

Study or Subgroup	endoscopic discectomy		open discectomy		Weight	Mean Difference IV, Random, 95% CI		
	Mean	SD	Mean	SD				
Garg 2011	72	24	55	288	72	57	25.0%	-216.00 [-235.74, -196.26]
Lee 2006	19.5	30.12	30	71.9	60.05	30	24.8%	-52.40 [-76.44, -28.36]
Liu 2014	84	16.8	40	321.6	55.2	40	25.0%	-237.60 [-255.48, -219.72]
Mohamed 2014	10.46	3.5	95	82.38	18.3	90	25.2%	-71.92 [-75.77, -68.07]
Total (95% CI)			220		217	100.0%	-144.45 [-239.54, -49.37]	
Total events: 220 (ED), 217 (OD)								
Heterogeneity: Tau ² = 9330.46; Chi ² = 499.66, df = 3 (P < 0.00001); I ² = 99%								
Test for overall effect: Z = 2.98 (P = 0.003)								



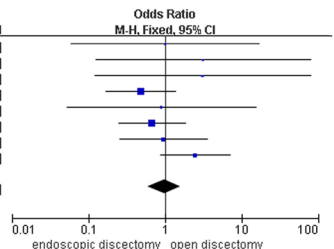
Operation Time

Study or Subgroup	endoscopic discectomy		open discectomy		Weight	Mean Difference IV, Random, 95% CI		
	Mean	SD	Mean	SD				
Garg 2011	84	36	55	56	33	57	18.9%	28.00 [15.20, 40.80]
Lee 2006	42.6	14.21	30	65.1	23.17	30	19.9%	-22.50 [-32.23, -12.77]
Liu 2014	73.7	11.2	40	52.4	8.5	40	21.1%	21.30 [16.94, 25.66]
Mohamed 2014	98.8	26.9	95	97.27	13.5	90	20.8%	1.53 [-4.56, 7.62]
Righesso 2007	82.6	21.9	21	63.7	15.5	19	19.3%	18.90 [7.22, 30.58]
Total (95% CI)			241		236	100.0%	9.27 [-6.69, 25.23]	
Total events: 241 (ED), 236 (OD)								
Heterogeneity: Tau ² = 308.63; Chi ² = 84.54, df = 4 (P < 0.00001); I ² = 95%								
Test for overall effect: Z = 1.14 (P = 0.25)								



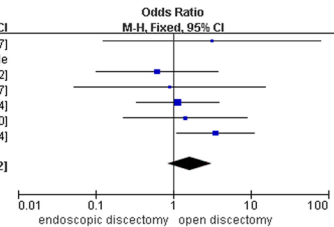
Reoperation Rate

Study or Subgroup	endoscopic discectomy		open discectomy		Weight	Odds Ratio M-H, Fixed, 95% CI
	Events	Total	Events	Total		
Frank 1999	1	30	1	30	3.1%	1.00 [0.06, 16.76]
Garg 2011	1	55	0	57	1.5%	3.17 [0.13, 79.37]
Lee 2006	1	30	0	30	1.5%	3.10 [0.12, 79.23]
Mohamed 2014	6	95	11	90	33.7%	0.48 [0.17, 1.37]
Righesso 2007	1	21	1	19	3.2%	0.90 [0.05, 15.47]
Ruetten 2008	7	92	10	92	29.4%	0.68 [0.25, 1.86]
Ruetten 2009	5	47	5	45	14.5%	0.95 [0.26, 3.54]
Tell 2010	8	70	7	142	13.0%	2.49 [0.86, 7.17]
Total (95% CI)		440		505	100.0%	0.98 [0.60, 1.61]
Total events: 30 (ED), 35 (OD)						
Heterogeneity: Chi ² = 6.27, df = 7 (P = 0.51); I ² = 0%						
Test for overall effect: Z = 0.08 (P = 0.93)						



Recurrences Rate

Study or Subgroup	endoscopic discectomy		open discectomy		Weight	Odds Ratio M-H, Fixed, 95% CI
	Events	Total	Events	Total		
Garg 2011	1	55	0	57	3.4%	3.17 [0.13, 79.37]
Liu 2014	0	40	0	40		Not estimable
Mohamed 2014	2	95	3	90	21.4%	0.62 [0.10, 3.82]
Righesso 2007	1	21	1	19	7.1%	0.90 [0.05, 15.47]
Ruetten 2008	6	91	5	87	33.8%	1.16 [0.34, 3.94]
Ruetten 2009	3	45	2	42	13.7%	1.43 [0.23, 9.00]
Tell 2010	8	70	5	142	20.7%	3.54 [1.11, 11.24]
Total (95% CI)		417		477	100.0%	1.62 [0.84, 3.12]
Total events: 21 (ED), 16 (OD)						
Heterogeneity: Chi ² = 3.45, df = 5 (P = 0.63); I ² = 0%						
Test for overall effect: Z = 1.45 (P = 0.15)						



induced traumatization and its consecutive sequelae. OD has become a “gold” standard procedure in treating symptomatic LDH since Mixter and Barr’s first report in 1934 [2]. However, optimal surgical management of symptomatic LDH remains controversial. OD has been criticized because it can cause muscle scarring, epidural fibrosis, and spinal instability. The demands of modern society create the need for faster recoveries, allowing patients to resume their normal activities sooner. Technical developments in the past decades have made the treatment of LDH safer and less invasive. Using endoscopic approaches through small incisions, nerve root decompression is achieved with minimal risk of complication and preserving normal anatomy [26]. The concept of MED was developed by Smith and Foley in 1997. This procedure allows the disk to be addressed directly through the spinal canal. This system aims to limit intraoperative soft tissue trauma while providing good illumination and visualization [27]. The possible advantages of TED are described in many articles. The procedure can be performed in an outpatient or day-surgery setting. Because of the small incision and minimal internal tissue damage, the rehabilitation period is supposed to be shorter and scar tissue fewer. The procedure can be performed in wakeful patients under local anesthesia and conscious sedation, thereby avoiding the risk of general anesthesia especially for elderly and infirm individuals [28, 29]. Another benefit of local anesthesia is the ability of surgeons to continually communicate with the patient, thus avoiding the risk of nerve damage during insertion of the working sheath [30, 31]. Despite these advantages, potential disadvantages are also reported. The potential problems of MED include a longer operating time that reflects the learning curve inherited to this video-endoscopic technique and the complex hand-eye coordination necessary for the procedure. Problems with intraoperative bleeding control, difficulty in repairing the dura tears, and fencing of instruments owing to limited working space are its disadvantages. TED also has a steep learning curve that requires patience and experience, especially for those unfamiliar with percutaneous techniques. Over all, ED technology is less traumatizing to the soft tissue, results in less blood loss, shorter hospital stay, and greater overall patient satisfaction. The current study seems to suggest that after endoscopic surgery 93.21 % of the patients experience a satisfactory outcome.

In this study, no significant difference was found in operating time. The results regarding operative times are difficult to interpret. There is considerable heterogeneity among operative times in the included studies. This may be explained by the learning curve associated with ED surgery [30], variability in the techniques used, and differences in how operative time was defined, for example, whether or not total time under anesthesia was measured. This study

found no significant differences in reoperation percentages between ED group and OD group (6.82 vs. 6.93 %). Reoperation rate of the two groups is similar with reported for OD (4.0–9.7 %) [32] and ED (4.2–11.0 %) [5, 33]. As in most surgical interventions, adequate patient selection and accurate diagnosis seem very important. Most common cause for reoperations was persistent complaints due to missed lateral bony stenosis and remnant fragments [34]. Although it was reported that, at the beginning of the learning curve, the poor perception of depth with endoscopic surgery is possibly linked to a higher incidence of iatrogenic dural and root injuries compared to OD [22], while the restricted field of work by the tubular retractor might justify a lower chance of identifying and removing free fragments within the disk space, ultimately leading to a higher incidence of LDH recurrences. In our study, complications and recurrences did not differ significantly between the ED group and OD group. Most patients after lumbar discectomy are restricted in their activities for some time by discomfort and medical advice and advised to restrict weight-bearing activities or bending over for several weeks or months [35–37]. However, the optimal time of restrictions and the clinical benefit of such restrictions remain unknown [38].

The purpose of this study was to systematically compare the effectiveness and the safety of ED with OD for the treatment of symptomatic LDH. Gibson et al. [25] have prior reviewed surgical interventions for LDH in 2007, and subsequently Nellensteijn et al. [39] reviewed TED for symptomatic LDH in 2010. Due to the lack of enough relevant RCTs, the statistically pooling results of ED versus OD were not stated in both of their reviews. In our study, nine RCTs which compare ED with OD are included to evaluate a total of 1,092 patients with symptomatic LDH. When the data from nine high-quality included studies were pooled, we found that both treatments are efficacious for symptomatic LDH. The results suggest that the patients with ED had a greater patient satisfaction rate, lower intraoperative blood loss volume, and shorter length of hospital stay. In every included study, the patients were selected carefully by means of employing the similar inclusion and exclusion criteria. These criteria did in fact result in a patient sample which could contribute to good clinical results. The benefit of both interventions may not be repeated when performing them onto every symptomatic LDH patient. Meticulous patient selection is essential to obtain a good clinical result.

Meta-analysis is a statistical analysis of data collected from several different researches and surveys on the same problem, pooling outcomes in order to arrive at a more unbiased and scientific conclusion. Ideally, each of the studies included in meta-analysis should contain large numbers of cases and have a similar validated design. In

this study, only nine published RCTs on ED versus OD were analyzed. The major strength of performing this meta-analysis is that it pools RCTs and all of the included trials have high methodological qualities (score >50), which implies a lower risk of bias. The most prevalent methodological shortcomings appeared to be the small size of populations and the insufficiency regarding the outcome assessor blinding to intervention. To avoid outcomes distorted by language bias, we considered all articles without language restrictions. This study has a number of limitations that should be considered when drawing conclusions regarding the effectiveness of ED versus OD for symptomatic LDH. The small number of included studies limited our ability to assess potential publication bias by the funnel plot, and unpublished researches with negative results cannot be identified. Therefore, publication bias may exist, which could result in the overestimation of the effectiveness of interventions. Moreover, the sample size of each included study is slightly small. Due to these limitations, the combined results of this meta-analysis should be cautiously accepted. In addition, the cost-effectiveness analyses still remain unproved from the existing data. More independent high-quality RCTs using sufficiently large sample sizes with cost-effectiveness analyses are needed.

Conclusion

Compared with OD, ED results in slightly better clinical outcomes evaluated by the Macnab criteria without clinical significance, a significantly greater patient satisfaction rate, lower intraoperative blood loss volume, and shorter length of hospital stay. From the existing outcomes, ED surgery could be viewed as a sufficient and safe supplementation and alternative to standard open discectomy. More independent high-quality RCTs using sufficiently large sample sizes with cost-effectiveness analyses are needed.

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Conflict of interest None.

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