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Original Article

The efficacy and safety of microendoscopic discectomy compared with conventional microsurgical discectomy: a meta-analysis of randomised controlled trials

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Abstract: Purpose: The objective of this study was to compare the efficacy and safety of microendoscopicdiscectomy (MED) with conventional microsurgical discectomy (CMSD) for treatment of lumbar disc herniation (LDH). Methods: A comprehensive literature search was performed in PubMed, MEDLINE, EMBASE, Web of Science, Cochrane Library, ClinicalTrials.gov, SinoMed, and CNKI. Randomised controlled trials (RCTs) that compared MED with CMSD for the surgical management of LDH were included. These trials were carefully picked out following the inclusion and exclusion criteria. Two authors independently extracted data and assessed these trials' quality according to the Cochrane Collaboration guidelines. Results: Ten randomized controlled trials (RCTs) with a total of 1953 patients met the inclusion criteria and were included in this meta-analysis. All patients underwent MED or CMSD. Pooled estimates showed that patients treated with microendoscopic discectomy had comparable effects in blood loss (WMD=9.50, 95% CI -5.06 to 24.07, P=0.20), serum levels of CPK (WMD=35.05, 95% CI -214.08 to 284.19, P=0.78), VAS of leg pain (WMD=0.05, 95% CI -0.46 to 0.56, P=0.85), VAS of back pain (WMD=0.27, 95% CI -0.08 to 0.63, P=0.14), ODI (WMD=1.22, 95% CI -0.13 to 2.56, P=0.08), hospital stay (WMD=0.14, 95% CI -0.07 to 0.34, P=0.19) and root injury (RD=0.01, 95% CI -0.00 to 0.02, P=0.23), but had shorter size of incision (WMD=-1.32, 95% CI -1.86 to -0.78, P<0.00001), longer surgical time (WMD=8.77, 95% CI 5.25 to 12.29, P<0.00001), higher risk of total complications (RD=0.06, 95% CI 0.02 to 0.10, P=0.002), higher risk of disc herniation recurrence (RR=1.84, 95% CI 1.05 to 3.23, P=0.03), higher risk of dural tear (RD=0.02, 95% CI 0.01 to 0.04, P=0.001), and more hospital costs (SMD=1.84, 95% CI 0.12 to 3.56, P=0.04), when compared with those treated with conventional microsurgical discectomy. Conclusions: Based on current evidence, microendoscopic discectomy with a small incision significantly increased the surgical time, total complications, disc herniation recurrence, dural tear and hospital costs, but had similar effects on blood loss, serum levels of CPK, clinical effect, root injury and hospital stay, when compared with conventional microsurgical discectomy.

Keywords: Microendoscopic discectomy, microsurgical discectomy, lumbar disc herniation, a meta-analysis

Introduction

Sciatica due to lumbar disc herniation (LDH) affects millions of individuals worldwide. Lumbar disc herniation, with a reported prevalence of 1-3% [1], is generally thought to be the main cause of discogenic low back pain (LBP). Although most of them can restore through various conservative treatment including physiotherapy, hydrotherapy, and analgesia, but still a few patients need surgical intervention. It's reported that 2% to 10% of patients underwent surgery to treat sciatica from lumbar disc herniation [2].

Surgical treatment of lumbar disc herniation was first described in 1934 by Mixter and Barr [3]. Since then, a variety of refined surgical techniques have been developed to reduce muscle trauma and improve vision. Among which, two widely used surgical techniques for the treatment of lumbar disc herniation have been debated over the past decades. One is microsurgical discectomy (MSD), introduced by Caspar [4] and Yasargil [5] in 1977, involving a small incision with minimal paravertebral muscle dissection using magnification. The conventional microsurgical discectomy (CMSD), considered to be the gold standard procedure for the treatment of lumbar disc herniation [6, 7], is still open discectomy performed with a small incision using surgical microscope [8] or magnifying loupe [9]. The other is microendoscopic discectomy, introduced as a minimally invasive procedure by Foley and Smith [10] in 1997. In this minimally invasive technique, tubular retraction systems and endoscopic systems enable simultaneous visualization and less tissue damage.

Both of the two procedures are widely used in clinical practice, but it is still uncertain whether MED is more effective and safer than CMSD for patients with LDH. Microendoscopic discectomy (MED) is thought to cause less tissue damage than standard open microdiscectomy with a marked reduction in postoperative pain and muscle spasm [11, 12]. Inspite of the above advantages, safety of the MED has been questioned due to the small working channel and compromised visualization [13, 14]. Recently, a meta-analysis demonstrates that interlaminar minimally invasive discectomy (ILMI) and microdiscectomy (MD) are both safe and effective surgical procedures for treating LDH [15]. However, this meta-analysis results can't reveal the difference between MED and CMSD. Firstly, due to the limited amount and quality of evidence, MED was combined with other minimally invasive discectomy to compare with MD, and clinical heterogeneity might be caused by the different ILMI technologies. In addition, five prospective comparative studies [16-20] written in Chinese were not included, which may cause statistical bias and publication bias.

Currently, no firm conclusions on effectiveness and safety of MED compared with CMSD can be drawn. A well conducted meta-analysis is needed. Therefore, we conducted this meta-analysis of relative studies to compare the efficacy and safety of MED with CMSD for the treatment of symptomatic LDH.

Materials and methods

Search strategy and study selection

To assemble all of the relevant published studies, PubMed, MEDLINE, EMBASE, Web of Science, Cochrane Library, ClinicalTrials.gov, SinoMed, and CNKI database searches were performed on all randomized controlled trials published until the end of August 2015 with the following search terms: "lumbar disc herniation OR lumbar disc prolapse OR intervertebral disc herniation OR sciatica" AND "micro-endoscopic discectomy OR microendoscopic discectomy OR MED OR tubular diskectomy OR minimally invasive discectomy" AND "microdiscectomy OR microsurgical discectomy OR microlumbar diskectomy OR open discectomy" AND "randomized controlled trial OR controlled clinical trial". References of the retrieved articles were also screened for relevant studies, and reviews were also examined in order to find more eligible studies.

Inclusion and exclusion criteria

Studies were considered eligible for inclusion if they met the following criteria:

Study design: RCT.

Population: Patients with sciatica caused by one level LDH.

Intervention: MED.

Comparator: CMSD (using magnifying loupe or surgical microscope for visual isation).

Outcomes: Reported at least one of the following: size of incision, surgical time, blood loss, serum levels of creatine phosphokinase (CPK), visual analogue scale (VAS) score of leg/back pain, Oswestry Disability Index (ODI), total complications, disc herniation recurrence, dural tear, root injury, hospital stay and hospital costs.

Studies did not meet the above criteria were excluded from selection.

Date extraction and quality assessment

Two authors independently extracted relevant data from the included studies. The data include the following: first author, year of publication, study design, number of patients, age, types of interventions, operative parameters, clinical outcomes, complications, hospital stay and hospital costs.

For the assessment of methodologic quality, two independent researchers evaluated risk of bias in included trials according to the Cochrane risk of bias guidelines [21], which included random sequence generation, allocation conceal-

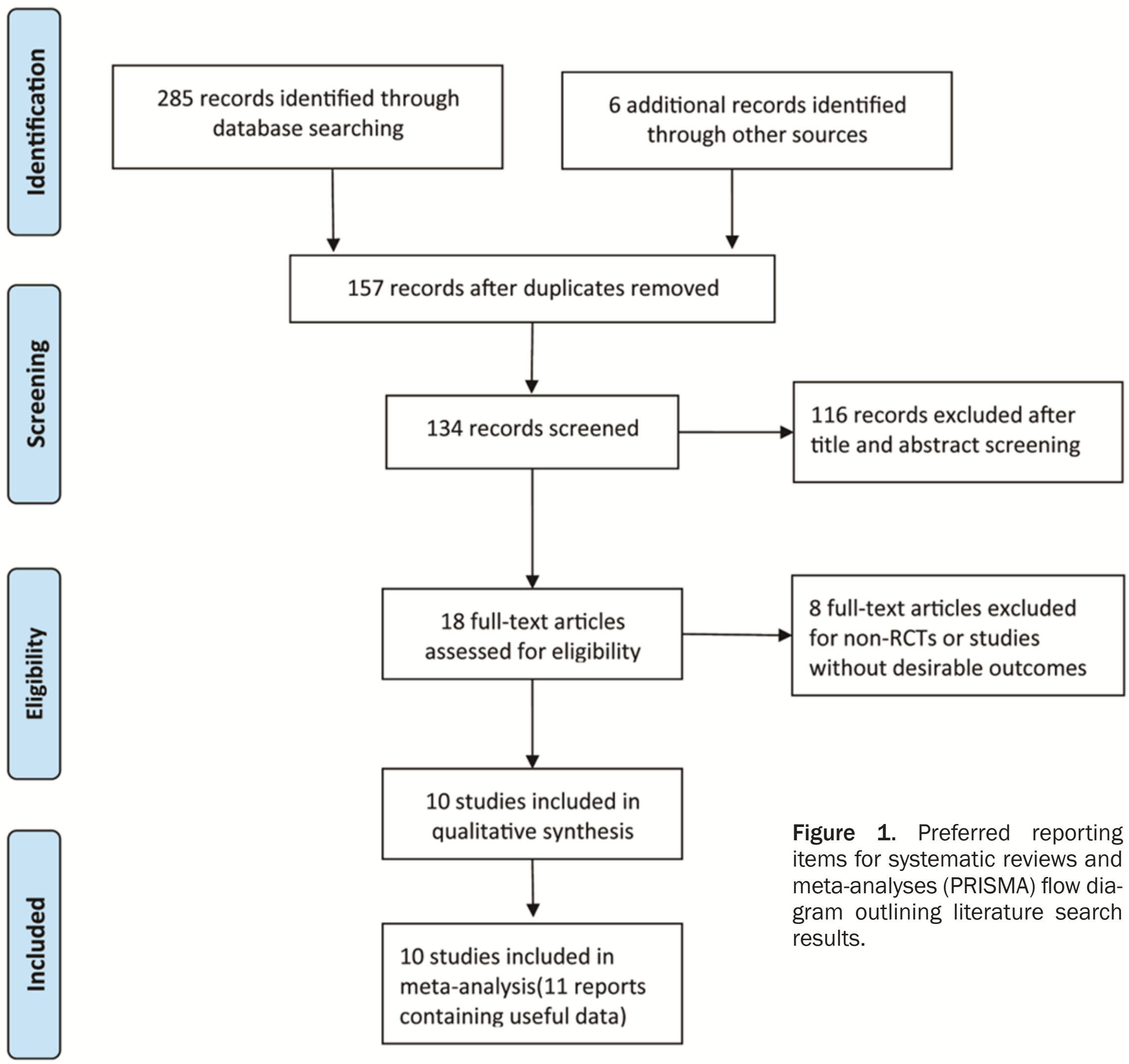

Figure 1. Preferred reporting items for systematic reviews and meta-analyses (PRISMA) flow diagram outlining literature search results.

ment, blinding of participants, personnel and outcome assessors, incomplete outcome data, selective outcome reporting, and other bias.

Statistical analysis

According to the recommendations of the Cochrane Collaboration, RevMan software (version 5.2.0) was used for data analysis. For continuous outcomes, such as size of incision, surgical time, blood loss, serum levels of creatine phosphokinase (CPK), the means and standard deviations were pooled to a weighted mean difference (WMD) and its 95% confidence interval (CI). When the same continuous outcomes were measured in different scales, standardized mean difference (SMD) and 95% CI were calculated. Relative risk (RR) and 95% CI were used to evaluate the dichotomous outcomes, such as the incidence of complications. Moreover, heterogeneity across trials was tested by a chi-square-based Q statistic test [22]. The effect of heterogeneity was quantified by using an I^2 value. If the I^2 value was >50%, RRs were pooled by random effect model, otherwise, the fixed effect model was used. The main results of publication bias were assessed by Stata 12.0 software (Stata Corporation, College Station, TX, USA). A P value less than 0.05 was regarded as significant in this meta-analysis.

Results

Included studies and characteristics

From the selected databases, 291 references were obtained. By screening the titles and abstracts, 116 references were excluded due

Table 1. Characteristics of included studies

Study	Year	Study design	Intervention	Magnifying techniques for CMSD	Total No.	No. of patients (MED:CMSD)	MED Mean age	CMSD Mean age
Righesso [23]	2007	RCT	MED:CMSD	Magnifying loupe	40	21:19	42.0 ± 10.7	46 ± 12.4
Teli [13]	2010	RCT	MED:CMSD	Surgical microscope	142	70:72	39 ± 12	40 ± 12
Shin [24]	2008	RCT	MED:CMSD	Surgical microscope	30	15:15	42.7 ± 17.7	48.1 ± 10.6
Arts [25]	2009	RCT	MED:CMSD	Magnifying loupe or surgical microscope	325	166:159	41.6 ± 9.8	41.3 ± 11.7
Arts [26]	2011	RCT	MED:CMSD	Magnifying loupe or surgical microscope	216	110:106	41.0 ± 10.0	40.8 ± 11.7
Sasaoka [27]	2006	RCT	MED:CMSD	Surgical microscope	26	15:11	36.5	37.7
Ye [17]	2011	RCT	MED:CMSD	Surgical microscope	854	422:432	41.9 ± 5.6	42.6 ± 4.3
Guo [18]	2009	RCT	MED:CMSD	Surgical microscope	278	130:148	35.8	35
Wen [19]	2008	RCT	MED:CMSD	Surgical microscope	69	36:33	43	40
Yang [20]	2008	RCT	MED:CMSD	Surgical microscope	91	46:45	44.9 ± 7.7	46.2 ± 6.7
Yang [16]	2015	RCT	MED:CMSD	Surgical microscope	98	44:54	36.52	41.82

RCT: randomised controlled trial; MED: microendoscopic discectomy; CMSD: conventional microsurgical discectomy.

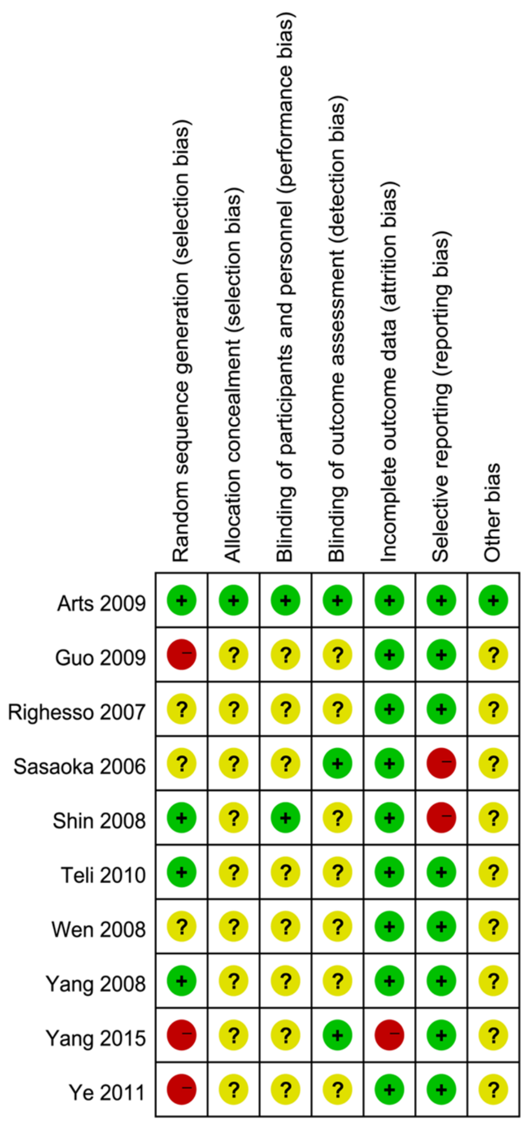

Figure 2. Risk of bias summary: review authors' judgements about each risk of bias item for each included study.

to the irrelevance to this topic. 18 trials were reviewed in full text, and eight trials were excluded because of study design or no desirable outcomes reported. We included 10 RCTs (n=1953) in the meta-analysis (the search strategy were shown in **Figure 1**). The characteristics of all ten included studies are shown in **Table 1**.

Quality assessment

In these studies, the risk of bias was assessed with the help of Cochrane Collaboration tool. For the seven evaluation indicators, when there is a low risk of bias, it was denoted with "+"; otherwise "-" for a high risk of bias, or "?" for unclear risk of bias were listed. The details were showed in **Figures 2** and **3**.

Operative parameters

Four studies [16-18, 23] reported the size of incision, while nine studies [13, 16-20, 23-25] reported detail surgical time. Size of incision was significantly shorter in the MED group than in the CMSD (WMD=-1.32; 95% CI -1.86 to -0.78; P<0.00001) (**Figure 4**). The heterogeneity was significant among the trials (P<0.00001, I^2=97%). Conversely, the statistical results showed the MED required more time for the surgical procedure (WMD=8.77, 95% CI 5.25 to 12.29, P<0.00001) (**Figure 4**), with significant heterogeneity (P<0.00001, I^2=87%). Eight studies [16-20, 23-25] reported blood loss in the surgery. Pooled analysis showed no significant differences between the MED and CMSD groups for blood loss (WMD=9.50, 95% CI -5.06 to 24.07, P=0.20) (**Figure 4**), with significant heterogeneity (P<0.00001, I^2=99%). Three

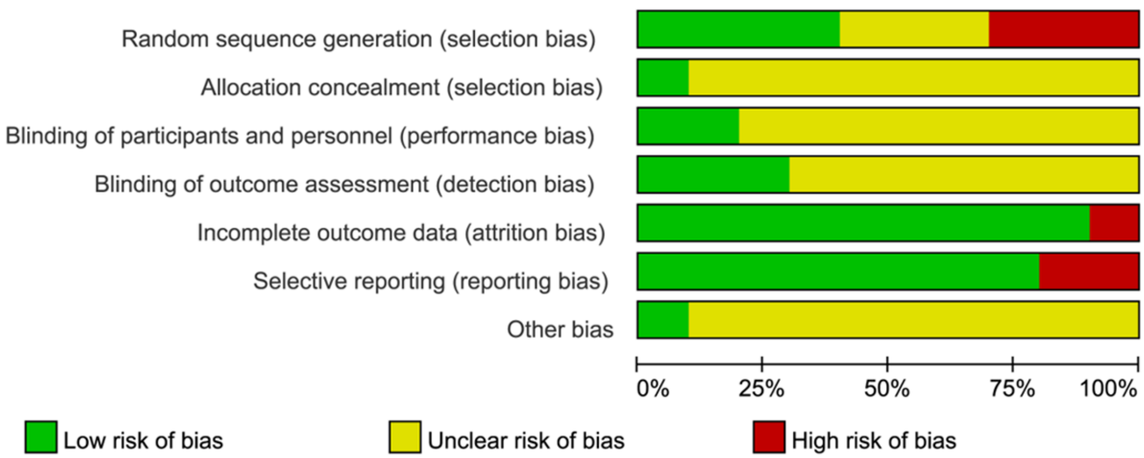

Figure 3. Risk of bias graph: review authors' judgements about each risk of bias item presented as percentages across all included studies.

Study or Subgroup	MED Mean	MED SD	MED Total	CMSD Mean	CMSD SD	CMSD Total	Weight	Mean Difference IV, Random, 95% CI
1.1.1 Size of incision								
Guo 2009	2.1	0.2	21	2.6	0.4	19	25.1%	-0.50 [-0.70, -0.30]
Righesso 2007	2.4	0.7	422	3.8	1.1	432	25.7%	-1.40 [-1.52, -1.28]
Yang 2015	2.51	0.47	44	3.92	0.71	54	24.8%	-1.41 [-1.64, -1.18]
Ye 2011	2.5	0.8	126	4.5	1.5	148	24.3%	-2.00 [-2.28, -1.72]
Subtotal (95% CI)			**613**			**653**	**100.0%**	**-1.32 [-1.86, -0.78]**
Heterogeneity: Tau² = 0.29; Chi² = 89.29, df = 3 (P < 0.00001); I² = 97%								
Test for overall effect: Z = 4.80 (P < 0.00001)								
1.1.2 Surgical time								
Arts 2009	47	22	166	36	16	159	11.6%	11.00 [6.83, 15.17]
Guo 2009	62	16.3	422	51	14.2	432	13.2%	11.00 [8.95, 13.05]
Righesso 2007	82.6	21.9	21	63.7	15.5	19	5.5%	18.90 [7.22, 30.58]
Shin 2008	49	5	15	47	5	15	12.1%	2.00 [-1.58, 5.58]
Teli 2010	56	12	70	43	8	72	12.3%	13.00 [9.64, 16.36]
Wen 2008	46	12	36	41	8	33	11.0%	5.00 [0.22, 9.78]
Yang 2008	53	10.3	46	45.3	6.2	45	12.2%	7.70 [4.22, 11.18]
Yang 2015	59.82	14.31	44	62.56	15.72	54	9.9%	-2.74 [-8.69, 3.21]
Ye 2011	56	15.9	126	40	13.8	148	12.1%	16.00 [12.44, 19.56]
Subtotal (95% CI)			**946**			**977**	**100.0%**	**8.77 [5.25, 12.29]**
Heterogeneity: Tau² = 23.34; Chi² = 59.55, df = 8 (P < 0.00001); I² = 87%								
Test for overall effect: Z = 4.88 (P < 0.00001)								
1.1.3 Blood loss								
Arts 2009	47	21	166	49	23	159	13.0%	-2.00 [-6.79, 2.79]
Guo 2009	111	45	126	96	77	148	11.7%	15.00 [0.32, 29.68]
Righesso 2007	50	39	21	40	33	19	10.1%	10.00 [-12.33, 32.33]
Shin 2008	35	9	15	34	11	15	12.8%	1.00 [-6.19, 8.19]
Wen 2008	29	6	36	20	4	33	13.2%	9.00 [6.61, 11.39]
Yang 2008	80.3	6.5	46	54.5	5.6	45	13.2%	25.80 [23.31, 28.29]
Yang 2015	58.87	12.65	44	87.21	12.47	54	13.0%	-28.34 [-33.34, -23.34]
Ye 2011	106	43	422	60	35	432	13.0%	46.00 [40.73, 51.27]
Subtotal (95% CI)			**876**			**905**	**100.0%**	**9.50 [-5.06, 24.07]**
Heterogeneity: Tau² = 417.33; Chi² = 573.78, df = 7 (P < 0.00001); I² = 99%								
Test for overall effect: Z = 1.28 (P = 0.20)								
1.1.4 Serum levels of CPK								
Arts 2009	255.7	209.8	110	268.1	242.4	106	35.1%	-12.40 [-72.95, 48.15]
Sasaoka 2006	689	108	15	406	71	11	34.9%	283.00 [214.10, 351.90]
Shin 2008	422.7	318.1	15	620.9	178.8	15	30.0%	-198.20 [-382.86, -13.54]
Subtotal (95% CI)			**140**			**132**	**100.0%**	**35.05 [-214.08, 284.19]**
Heterogeneity: Tau² = 45044.43; Chi² = 50.35, df = 2 (P < 0.00001); I² = 96%								
Test for overall effect: Z = 0.28 (P = 0.78)								

Test for subgroup differences: Chi² = 32.90, df = 3 (P < 0.00001), I² = 90.9%

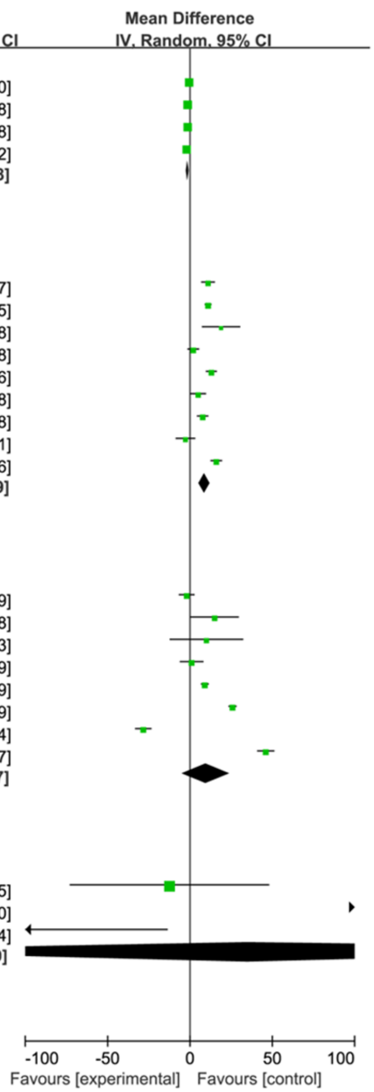

Figure 4. Forest plot illustrating size of incision, surgicaltime, bloodloss, serum levels of creatine phosphokinase (CPK) of meta-analysis comparing MED with CMSD.

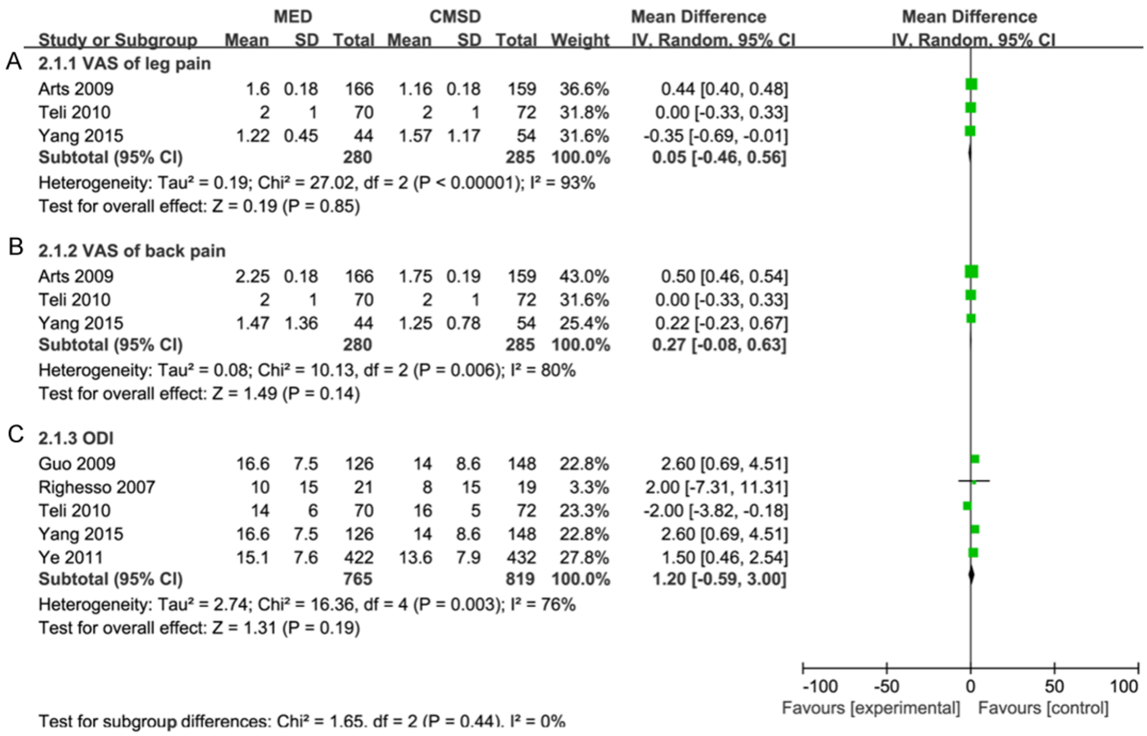

Figure 5. Forest plot showing the meta-analysis of visual analogue scale (VAS) scores of leg pain (A), back pain (B), and Oswestry disability index (C).

studies [23, 24, 26] measured serum levels of creatine phosphokinase (CPK) 24 hours after operation. The data on serum levels of CPK between the 2 groups had no statistical significance (WMD=35.05, 95% CI -214.08 to 284.19, P=0.78) (**Figure 4**). Significant heterogeneity was found between these studies (P<0.00001, I^2=96%).

Clinical outcomes

Three studies [13, 16, 25] reported visual analogue scale (VAS) scores of leg pain and back pain. Pooled analysis showed no significant differences between the MED and CMSD groups for VAS of leg pain (WMD=0.05, 95% CI -0.46 to 0.56, P=0.85) (**Figure 5**) or back pain (WMD=0.27, 95% CI -0.08 to 0.63, P=0.14) (**Figure 5**), with significant heterogeneity (leg pain: P<0.00001, I^2=93%; back pain: P=0.006, I^2=80%). Five studies [13, 16-18, 23] reported the results of the ODI. There was no significant difference in the final follow-up ODI (WMD=1.20, 95% CI -0.59 to 3.00, P=0.19) (**Figure 5**) between the MED and the CMSD group. The heterogeneity was significant among the studies (P=0.003, I^2=76%).

Complications

Both the total complications and dural tear were reported in eight trials [13, 16-20, 23, 25]. The overall pooled analysis showed significant differences between 2 groups (total complications: RD=0.06, 95% CI 0.02 to 0.10, P=0.002; dural tear: RD=0.02; 95% CI 0.01 to 0.04, P=0.001) (**Figure 6A** and **6C**). No significant heterogeneity was found among these studies (total complications: P=0.34, I^2=11%; dural tear: P=0.64, I^2=0%). Seven of the included studies [13, 16-18, 20, 23, 25] reported the outcome of disc herniation recurrence. The overall pooled analysis found that disc herniation recurrence was significant higher in MED group compared with the CMSD group (RR=1.84, 95% CI 1.05 to 3.23, P=0.03) (**Figure**

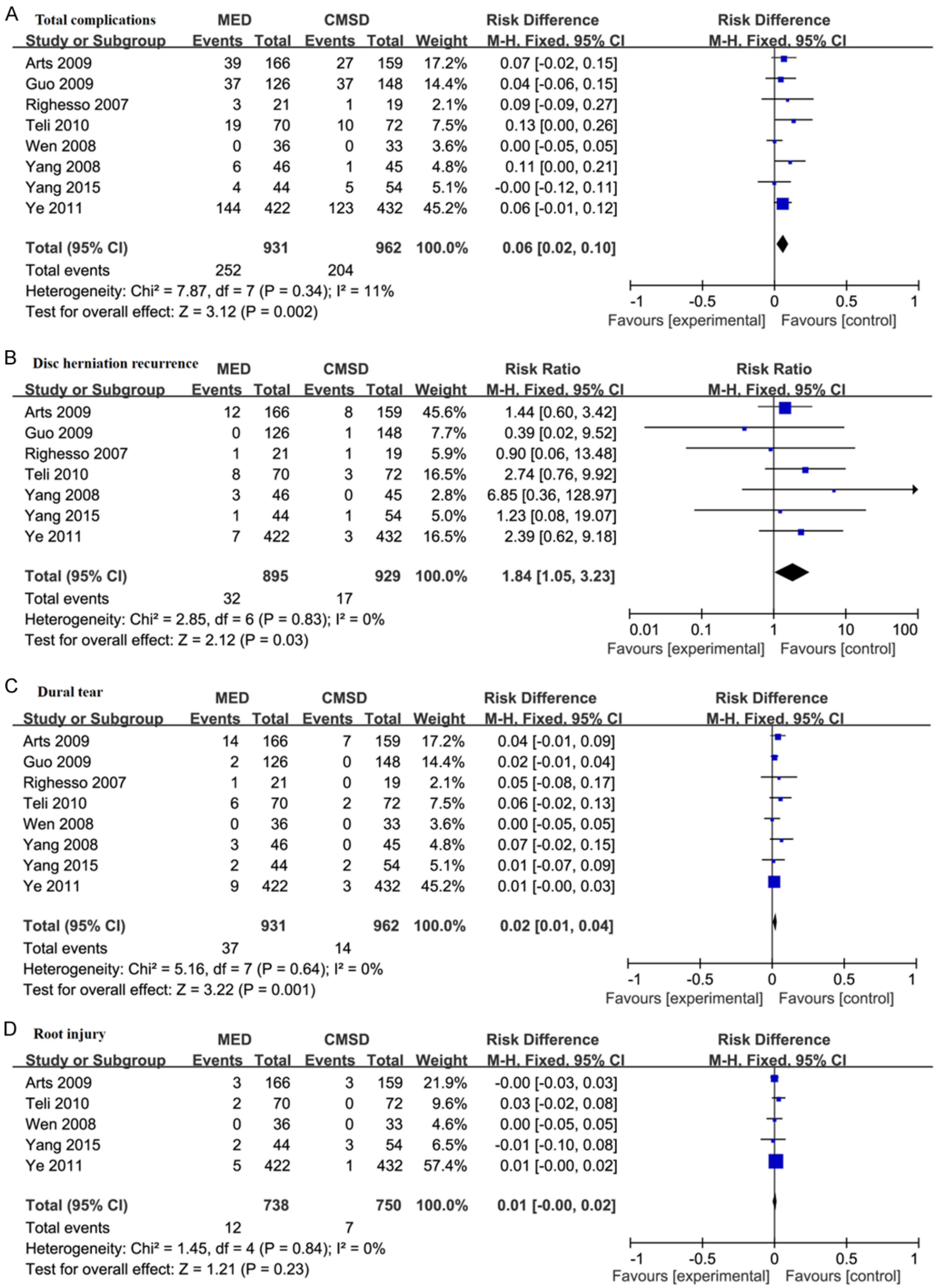

Figure 6. Forest plot illustrating complications of meta-analysis comparing MED with CMSD.

6B), with no significant heterogeneity (*P*=0.83, I^2=0%). Data of root injury was reported in five trials [13, 16, 17, 19, 25]. There was no statistically significant difference in root injury between

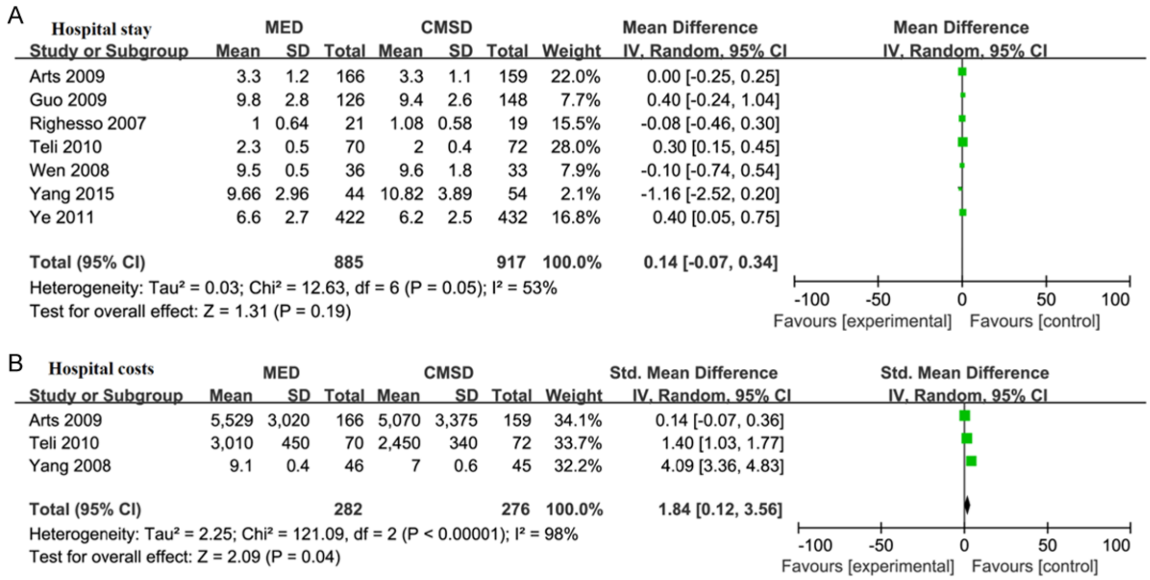

Figure 7. A. Forest plot to assess hospital stay between the 2 treatment strategies; B. Forest plot to assess hospital costs between the 2 groups.

the 2 groups (RD=0.01, 95% CI-0.00 to 0.02, P=0.23) (**Figure 6D**), with no heterogeneity among these trials (P=0.84, I^2=0%).

Hospital stay and hospital costs

Seven studies [13, 16-19, 23, 25] included data on length of hospital stay. The data on hospital stay between the 2 groups had no statistical significance (WMD=0.14, 95% CI -0.07 to 0.34, P=0.19) (**Figure 7A**). The test of heterogeneity found significant differences across the included studies (P=0.05, I^2=53%). The hospital costs were reported in three studies [13, 20, 25]. The hospital costs was significantly lower in the CMSD group (SMD=1.84, 95% CI 0.12 to 3.56, P=0.04) (**Figure 7B**), with a high degree of heterogeneity across the studies (P<0.00001, I^2=98%).

Sensitivity analysis and publication bias

Sensitivity analysis was performed to assess the effect of study quality. All results (operative parameters, clinical outcome, complications, hospital stay and hospital costs) were not significantly altered by omitting any trial in this meta-analysis. On the other hand, reanalysis after changing to random-effects models also did not change the results.

Begg's and Egger's test were performed to analyze their publication bias. The results indicated that there was no statistically significant publication bias existed in the statistics of surgical time (Begg's test, P=0.917; Egger's test, P=0.854) and total complications (Begg's test, P=0.174; Egger's test, P=0.133).

Discussion

Lumbar disc herniation is the most common cause of discogenic low back pain and is effectively treated by surgery. Surgical discectomies are indicated for those patients with persistent low back pain and sciatica after at least 6 weeks of conservative treatment or in those with early or progressive neurological impairment [7, 28, 29]. Traditional open discectomy was shown to be more effective than chemonucleolysis or conservative treatment in selected patients [29]. Previous studies show good outcomes for open discectomy [30], but it requires a larger incision and hypothetically a greater degree of muscle trauma. With the development of surgical technology, advances in lumbar discectomy techniques have concentrated on less soft tissue injury, fewer complications, no effect on the lumbar stability, less postoperative low back pain and faster recovery, while achieving good clinical outcome. Conventional microsurgical discectomy (CMSD) and microendoscopic discectomy (MED) are two widely used surgical procedures for the treatment of lumbar disc herniation. During surgery, excellent illumination and magnification could be achieved by both MED and CMSD, but the main advantage of the surgical microscope or surgical loupe is their ability to maintain three-dimensional vision while endoscopic surgery only allows for a two-dimensional video display [31, 32]. Both of the two procedures are widely used in clinical practice, but it is still uncertain whether MED is more effective and safer than CMSD for patients with LDH. Therefore, we conducted the present meta-analysis.

In this article, VAS and ODI were used to measure the clinical efficacy after the operation. This meta-analysis based on ten trials showed that there was no statistically significant difference in VAS scales of leg pain and back pain between MED and CMSD group. Additionally, the postoperative ODI were not significant difference between these two groups. This study indicated that the effectiveness of MED might be similar to the CMSD procedure.

There were significantly longer operation times in MED group in this meta-analysis, since more time is needed to do sufficient preoperative preparation and precisely insert the working tube [31]. Prolonged surgical time in MED group may increase intraoperative blood loss. Therefore, no statistically significant difference was found in blood loss between the 2 groups in our meta-analysis, even although MED group has smaller size of incision.

The main objective of current minimally invasive techniques for lumbar disc surgery is to reduce paravertebral muscles injury [33]. Several biological and histological studies have tried to measure degree of muscular trauma after lumbar disc surgery. In these studies, muscle damage has been assessed by an increase of creatine phosphokinase (CPK) [24, 27], lacticodehydrogenase-5 (LDH-5) [24, 27]. However, our meta-analysis suggests that no significant difference was detected between the 2 groups in postoperative serum lever of CPK. Prolonged muscular retraction due to longer surgical time in MED group can increase muscle damage. Consequently, the postoperative CPK is similar between the 2 groups, although MED has the advantage of a smaller wound.

With increasing use of endoscopes for spine surgery, the safety of the two-dimensionality of the endoscopic image became become increasingly concerned. Recurrent herniation, dural tears and root injuries are main complications for the treatment of LDH by discectomy. Complications were analyzed to evaluate the safety of two techniques in our meta-analysis. We found that the incidence of total complications, disc herniation recurrence and dural tear in the MED group was slightly higher than that in the CMSD group, but root injury rates were also similar. This difference may be due to the two-dimensional visualization and poor depth perception, and steep learning curve associated with endoscopic techniques [34, 35]. In addition, higher rates of recurrent herniation in the MED group may due to a limited surgical exposure that leads to difficulty in removing the entirety of the herniated disc [36, 37].

This study demonstrated a related lower hospital costs in CMSD group, but there was no significant difference between the 2 groups in hospital stay time. Prolonged postoperative management due to more complications in MED group can increase hospital stay time. Thus, there was no statistically significant difference in hospital stay between the 2 groups, although MED has the merits of earlier recovery.

This meta-analysis has some limitations. First, despite 10 RCTs were included, included patients in three trails [23, 24, 27] are small. Secondly, continuous outcomes were provided in form of only mean values without standard deviation in some studies and couldn't be involved in meta-analysis. Thirdly, the heterogeneity among studies was significant in the operative parameters, clinical outcomes, hospital stay and costs. Heterogeneity was only slightly reduced when trials were analysed in the subgroup of surgeon nationality (non-Chinese vs. Chinese) (data not shown). Although a random-effect model was applied to incorporate heterogeneity in this meta-analysis, the readers still should be cautious with these results.

Conclusions

Based on the meta-analysis of RCTs, we conclude that microendoscopic discectomy has significantly increased the surgical time, total complications, disc herniation recurrence, dural tear and hospital costs, although the minimally invasive approach is associated with the advantage of a small size of incision compared with the conventional microsurgical discectomy. However, there are no statistically differences in blood loss, serum levels of CPK, clinical effect, root injury and hospital stay between 2 groups. Therefore, benefits and safety of microendoscopic discectomy should be carefully considered before surgery. Due to the limitations of this study, future well-designed RCTs are needed to indentify our findings.

Disclosure of conflict of interest

None.

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