Systematic Review and Meta-Analysis

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Tubular microscopes discectomy versus conventional microdiscectomy for treating lumbar disk herniation

Systematic review and meta-analysis

Xianbo Li, MD[a], Hengrui Chang, MD[b], Xianzhong Meng, MD[a,*]

Abstract

Background: The application of tubular microscopes discectomy (TMD) was supposed to have similar or better results than conventional microdiscectomy (CMD). However, this conclusion had not been verified by sufficient evidence. Therefore, the focus of this meta-analysis was to assess the efficiency, safety, and clinical outcome of these 2 surgical procedures for treating lumbar disk herniation (LDH).

Methods: PubMed, Embase, and Cochrane Collaboration Central databases were searched for studies which compared the results of TMD and CMD for the treatment of LDH up to July 2017. Data analysis was conducted using RevMan 5.3. A standardized electronic form of 17 predefined criteria from the Consort statement was used for the quality assessment.

Results: Eight randomized controlled trials (RCT) and 2 retrospective studies were included in this review, including 804 patients. The pooled analysis showed that there was no significant difference in operative time ($P = .38$), blood loss ($P = .14$), the length of hospital stay ($P = .47$), the rate of intraoperative complications ($P = .79$), postoperative complications ($P = .16$), dural tear ($P = .87$), the reoperation ($P = .20$), the short-term back visual analog scale (VAS) scores ($P = .76$), the long-term back VAS scores ($P = .64$), the short-term leg VAS scores ($P = .09$), the long-term leg VAS scores ($P = .35$), and the Oswestry disability index (ODI) scores ($P = .41$).

Conclusion: The results of this meta-analysis demonstrate that TMD and CMD are both safe and effective surgical procedures which can be recommended for treating LDH. Additionally, the conclusion should be cautiously treated, because it was reached in the context of limited amount of studies and relatively small sample size. Therefore, future studies with good design and more large samples are required to validate this conclusion.

Abbreviations: CMD = conventional microdiscectomy, LDH = lumbar disk herniation, MED = microendoscopic discectomy, ODI = Oswestry disability index, OR = odds ratio, RCTs = randomized controlled trials, SMD = standardized mean difference, TMD = tubular microscopes discectomy, VAS = visual analog scale.

Keywords: conventional microdiscectomy, lumbar disk herniation, meta-analysis, tubular microscopes discectomy

1. Introduction

Lumbar disc herniation (LDH) is among the most common causes of lower-back pain and sciatica, which affects millions of people throughout the world. Surgery is a recommended practice for patients with stubborn radicular symptoms to conservative management. Since microsurgery for LDH was introduced, new surgical techniques for the treatment of LDH were constantly evolving. Conventional microdiscectomy (CMD), which relies on the operating microscope for visualization, was first described in the late 1970s.[1–3] This operation is considered the gold standard procedure for patients who require surgery for symptomatic LDH.[4] However, this open and subperiosteal approach required the incision of midline ligamentous structures and detachment of tendinous insertions of the paraspinal muscles from the spinous process. The intraoperative injury of the posterior supporting structures of the lumbar spine could lead to postoperative back pain, spinal instability, and even the failed back surgery syndrome.[5,6] Presently, there has been a trend towards minimally invasive procedures. Advances in surgical technique and technology have seen an increase in minimally invasive procedures where by access to the disc is gained by a tube, using a microscope or endoscope for visualization. As the alternative to CMD, minimally invasive procedures have been introduced for less postoperative pain, a shorter hospital stay, and more rapid return to work.[4,7] In the 1999, the microendoscopic discectomy (MED) was introduced by Foley and Smith. It was the original technique that challenged the conventional microdiscectomy.[8] However, with the increasing use of endoscopes for spine surgery, a main limitation of this technique was found by researchers: a small operation field visualized through a cylindrical tubular

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retractor—the two-dimensionality of the endoscopic image. To overcome the limited working field and get better visualization, the tubular retractors systems recently were combined with the use of the microscope.[9] The advent and application of tubular microscopes discectomy (TMD) was supposed to have similar or better results than conventional microdiscectomy, but this conclusion had not been verified by sufficient evidence.[10–13] And as far as we know, there was no meta-analysis comparing TMD to CMD at present.[14,15] Given that, we conducted this meta-analysis to determine whether TMD or CMD was more safe and efficacious for patients sustained LDH.

2. Materials and methods

2.1. Ethics statement

There was no need to seek consent from patients, as in this study all the data were collected from the published data and analyzed anonymously without any potential harm to the patients; this study was approved by the Ethics Committee of our hospital.

2.2. Search strategy

An extensive search of literature was performed in PubMed, Embase, and the Cochrane library published from July 2007 to July 2017. The search was conducted with the use of the following search terms: "Minimally invasive" or "Tubular microscopes discectomy," AND "Microdiscectomy" AND "Sciatica" or "Lumbar disk herniation." Language was restricted to English.

2.3. Inclusion criteria

Studies were included if they met the following criteria: published original studies which were randomized controlled trials (RCTs), cohort studies, prospective or retrospective comparative studies; included patients with Sciatica, Lumbar disk herniation; tubular microscopes discectomy and conventional microdiscectomy were compared; reported at least one of the following: operation time, blood loss, the length of hospital stay, Oswestry disability index (ODI), visual analog scale (VAS) score, incidence of complications.

2.4. Exclusion criteria

Studies were excluded if they met the following criteria: the treatment of MED for lumbar disc herniation; patients with spinal deformity, trauma, spinal tumor, or with previous lumbar operation, spondylolisthesis, spinal stenosis, severe somatic, or psychiatric diseases; case reports, reviews, and conference reports; biomechanical or cadaveric researches.

2.5. Study selection

Two coauthors (XL and HC) independently reviewed all subjects, abstracts, and the full text of articles. Then the eligible trials were selected according to the inclusion criteria. When consensus could not be reached, a third reviewer (XM) was consulted to resolve the disagreement.

2.6. Data extraction and management

Two reviewers (XL and HC) extracted data independently. The data extracted included the following categories: basic characteristics of studies; general characteristics of participants; blood loss, operation time, the length of hospital stay, complications, and ODI, VAS score. In addition, we defined the short-term time point as no >1 month and the long-term time point as >3 years. We used the time point closest to the time for pooling, if there was no report at the same time point.

2.7. Quality assessment

Because both RCTs and non-RCTS were included, we did not apply the Jadad scoring system, which is designed only for RCTs. We used a standardized electronic form of 17 predefined criteria from the Consort statement,[16] Table 1 which was used in

Table 1

Quality assessment tool and number (%) of studies achieving each criteria.

Criteria	N (%) of studies achieving criteria
1. How participants were allocated to interventions (e.g., "case–control" and "cohort")	10 (100)
2. Scientific background	10 (100)
3. Eligibility criteria for participants and the settings and locations where the data were collected	10 (100)
4. Clearly defined primary and secondary outcome measures and, when applicable, any methods used to enhance the quality of measurements (e.g., multiple observations, training of assessors, etc.)	8 (80)
5. The total number of case >100	4 (40)
6. Positive if follow-up period is >24 wk	7 (70)
7. Positive if total number of dropouts and loss to follow-up is <15%	8 (80)
8. Whether there is an inverse group	10 (100)
9. Statistical methods used to compare groups for primary outcome(s); methods for additional analyses, such as subgroup analyses and adjusted analyses	8 (80)
10. Baseline demographic and clinical characteristics of each group	9 (90)
11. Specific characteristics of positive participants	9 (90)
12. Number of participants (denominator) in each group included in each analysis. State the results in absolute numbers when feasible (e.g., 10/20, not 50%)	9 (90)
13. For each primary and secondary outcome, a summary of results for each group, and the estimated effect size and its precision (e.g., 95% CI)	8 (80)
14. Address multiplicity by reporting any other analyses performed, including subgroup analyses and adjusted analyses, indicating those prespecified and those exploratory	3 (30)
15. Interpretation of the results, taking into account study hypotheses, sources of potential bias or imprecision and the dangers associated with multiplicity of analyses and outcomes	8 (80)
16. Generalizability (external validity) of the trial findings	10 (100)
17. General interpretation of the results in the context of current evidence	10 (100)

CI = confidence interval.

previous reviews or meta-analyses[17,18] to solve similar problems. Two reviewers (XL and HC) independently graded each article, adding 1 point when 1 criterion was met; otherwise, no score was awarded. Finally, the total points of each paper were calculated and controversial scores were solved by a third reviewer (XM) was consulted to resolve the disagreement.

2.8. Statistical analysis

All data analyses were performed using RevMan 5.3; The Nodic Cochrane Center, The Cochrane Collaboration, Copenhagen, Denmark. For dichotomous variables, we analyzed using odds ratio (OR), and for continuous variables, the standardized mean difference (SMD) was used. Both were reported with 95% confidence intervals, and the heterogeneity test was considered statistically significant when $P < .05$. We used I^2 statistic to assess heterogeneity. $I^2 > 50\%$ implied substantial heterogeneity among the included studies, random-effect model was used to analysis. If $I^2 \leq 50\%$, which were considered to represent no significant heterogeneity, we chose fixed-effect model. The results were summarized graphically using a forest plot.

2.9. Test for risk of publication bias

Funnel plot was performed to evaluate the risk of publication bias. If the funnel plot was asymmetric, there is publication bias and symmetric indicated no publication bias. The funnel plot asymmetry was measured by Begg and Egger tests. P values $<.05$ were regarded as a significance level.

3. Results

3.1. Study search, selection, and quality assessment

Through the application of search strategy, a total of 523 studies in Pubmed, Embase, and the Cochrane library were initially included. As a result, a total of 10 studies were identified for this meta-analysis. The flowchart which indicated the progress of literature selection was presented in Fig. 1. Eight studies were designed as RCTs and 2 as retrospective comparative studies. Among these studies, Arts et al[10,11] and Overdevest et al[12] were follow-up studies, Ryang et al[19] and Gempt et al[13] were follow-up studies. There were 422 participants in the TMD group and 382 in the CMD group, and 44.02% of them were women. Four studies were in Germany, 3 in the Netherlands, 2 in USA, and 1 in

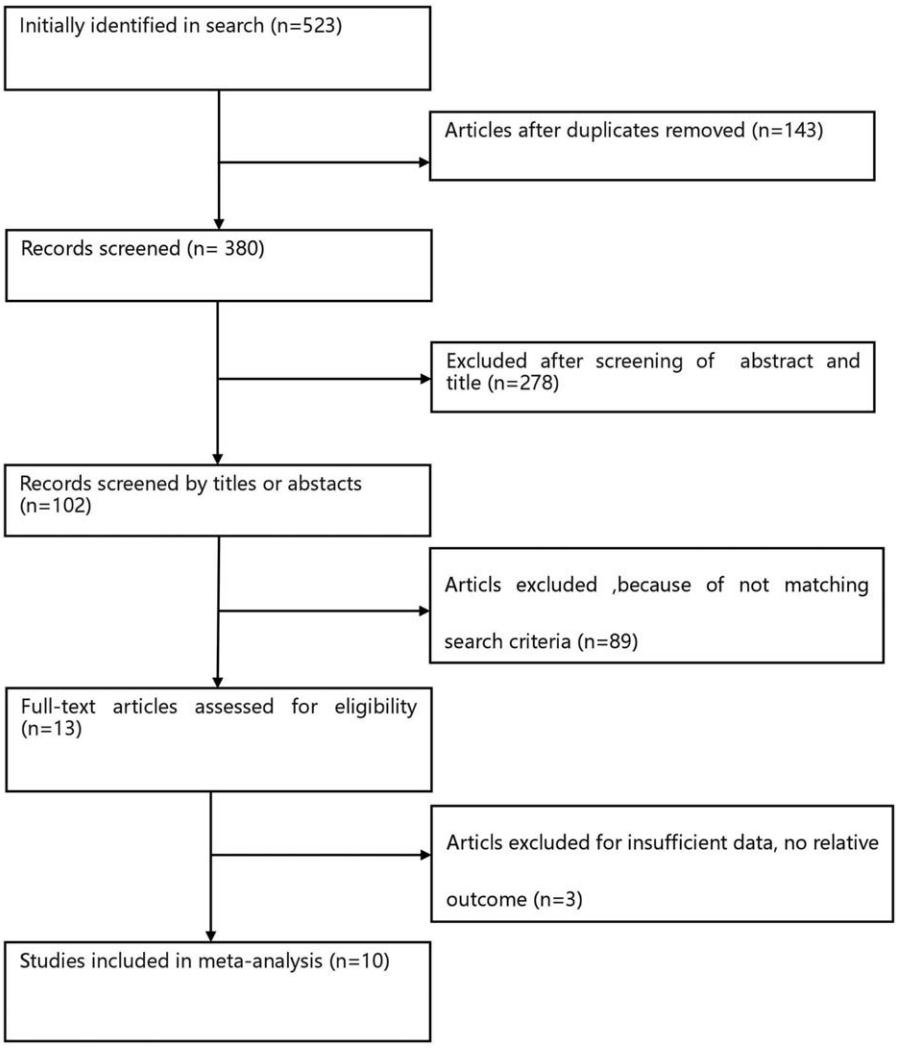

Figure 1. Flow chart for study selection references.

Table 2

Characteristics of the included studies.

Author	Year	Study design	Country	Number of patients		Age (y)		Gender (M/F)		Follow UP	Surgical instruments	
				TMD	CMD	TMD	CMD	TMD	CMD		TMD	CMD
Lau et al	2011	Retrospect	USA	20	25	45	42	10/10	12/13	8.2mo	NA	NA
Overdevest et al	2017	RCT	Netherlands	166	159	41.6	41.3	84/82	88/71	5 y	METRx	NA
Franke et al (index)	2009	RCT	Germany	25	25	40	40	30/20		12 mo	NA	Caspar
Franke et al (tranfer)	2009	RCT	Germany	27	23	40	40	30/20		12 mo	NA	Caspar
Harrington et al	2008	Retrospect	USA	31	35	42.1	41.2	21/10	22/13	3 mo	Flexposure	Williams
Gempt et al	2013	RCT	Germany	30	30	38	39	13/17	19/11	33 mo	NA	Caspar
Arts et al	2009	RCT	Netherlands	166	159	41.6	41.3	84/82	88/71	1 y	METRx	NA
Arts et al	2011	RCT	Netherlands	166	159	41.6	41.3	84/82	88/71	2 y	METRx	NA
Brock et al	2008	RCT	Germany	66	59	51	51	40/26	36/23	6 d	Microdisc-XS	Caspar
Bennis et al	2009	RCT	France	57	26	42	43	28/29	17/9	3 mo	METRx	Caspar
Ryang et al	2008	RCT	Germany	30	30	38	39	13/17	19/11	16 mo	NA	Caspar

CMD = conventional microdiscectomy, F = female, M = male, NA = not available, RCT = randomized controlled trial, TMD = tubular microscopes discectomy.

France. Detailed information about these studies and participants is shown in Table 2.

The score for quality assessment was 14.1 ± 2.13 (range, 11–17). The detailed outcomes of quality assessment for these studies were as follows: 11 points in 1 studies,[20] 12 in 2,[21,22] 13 in 1,[23] 14 in 2,[13,24] 15 in 1,[19] 16 in 1,[12] and 17 in 2 studies.[10,11]

3.2. Outcome analyses

3.2.1. Operative time. The operative time data were performed in 5 of the studies.[12,13,21,23,24] The pooled analysis demonstrated no significantly different operative time between the TMD and CMD groups ($P = .38$, SMD = −0.26 [−0.83, 0.32] heterogeneity: $P < .00001$, $I^2 = 90\%$, random-effect model, Fig. 2).

3.2.2. Blood loss. Two studies[13,21] reported blood loss in the surgery. The result showed no significant difference between 2 groups ($P = .14$, SMD = −1.66 [−3.85, 0.52] heterogeneity: $P < .00001$, $I^2 = 95\%$, random-effect model, Fig. 3).

3.2.3. The length of hospital stay. Four studies[12,13,21,24] reported the number of days stay in hospital after surgery. The analysis found that no significant difference between 2 groups ($P = .47$, SMD = −0.06 [−0.24, 0.11] heterogeneity: $P = .65$, $I^2 = 0\%$, fixed-effects model, Fig. 4).

3.2.4. Complications. Six studies[12,13,20,21,23,24] reported the intraoperative complications after TMD or CMD surgery. The overall pooled analysis found no significant difference between 2 groups ($P = .79$, OR = 1.08 [0.62, 1.87] heterogeneity: $P = .59$, $I^2 = 0\%$, fixed-effects model, Fig. 5). And 6 studies[12,13,20,21,23,24] reported the postoperative complications after TMD or CMD surgery ($P = .16$, OR = 1.35 [0.89, 2.05] heterogeneity: $P = .32$, $I^2 = 14\%$, fixed-effects model, Fig. 6). About the dural tear, which was performed in 5 studies,[12,13,21,23,24] the pooled analysis demonstrated no significantly different between the TMD and CMD groups ($P = .87$, OR = 1.05 [0.56, 1.98] heterogeneity: $P = .41$, $I^2 = 0\%$, fixed-effects model, Fig. 7). The reoperation data were performed in

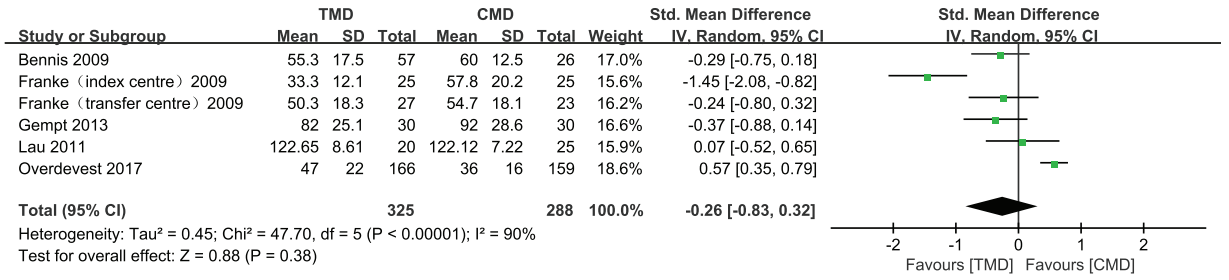

Figure 2. Forest plot to illustrate standardized mean difference (SMD) in operation time between TMD and CMD procedures. CMD = conventional microdiscectomy, TMD = tubular microscopes discectomy.

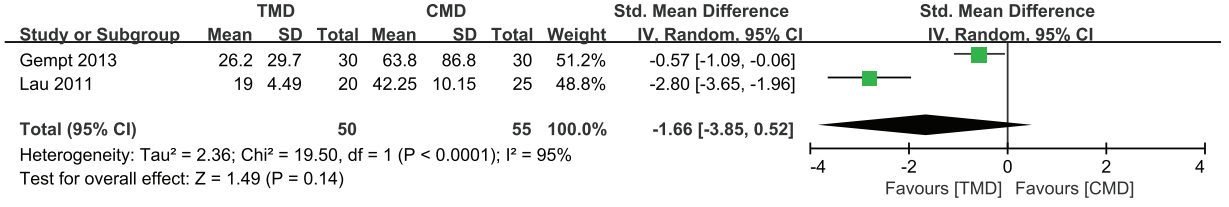

Figure 3. Forest plot to illustrate standardized mean difference (SMD) in blood loss between TMD and CMD procedures. CMD = conventional microdiscectomy, TMD = tubular microscopes discectomy.

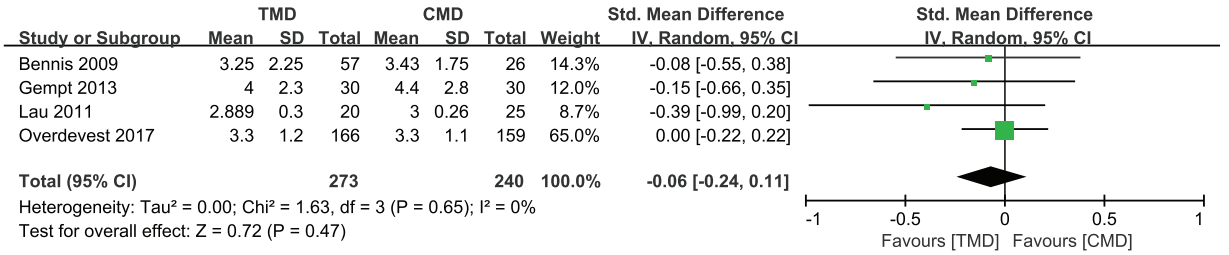

Figure 4. Forest plot to illustrate standardized mean difference (SMD) in the length of hospital stay between TMD and CMD procedures. CMD = conventional microdiscectomy, TMD = tubular microscopes discectomy.

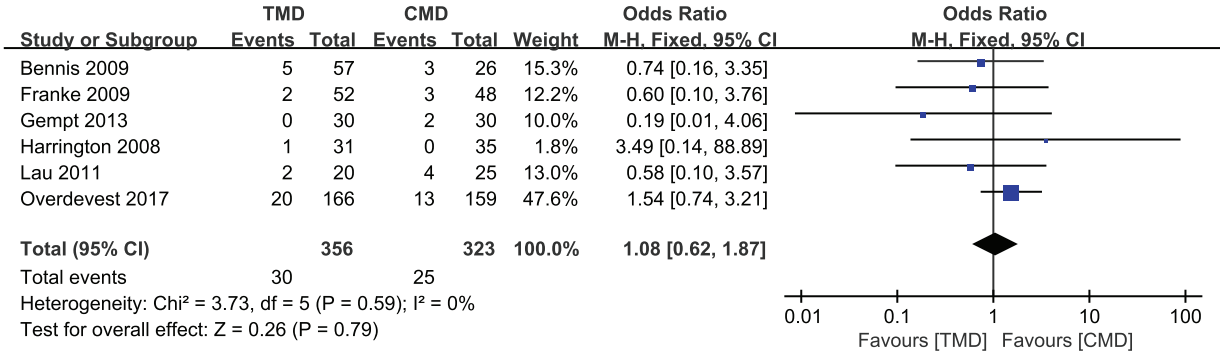

Figure 5. Forest plot to illustrate odds ratio (OR) in intraoperative complications between TMD and CMD procedures. CMD = conventional microdiscectomy, TMD = tubular microscopes discectomy.

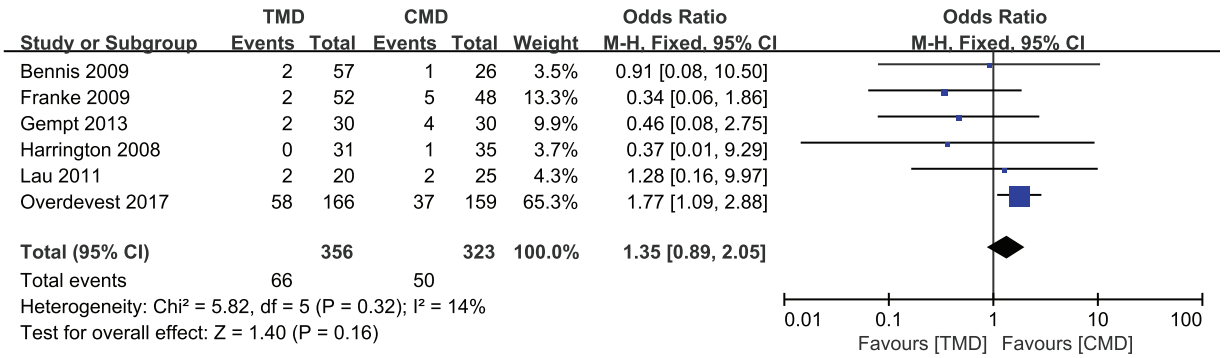

Figure 6. Forest plot to illustrate odds ratio (OR) in postoperative complications betweenTMD and CMD procedures. CMD = conventional microdiscectomy, TMD = tubular microscopes discectomy.

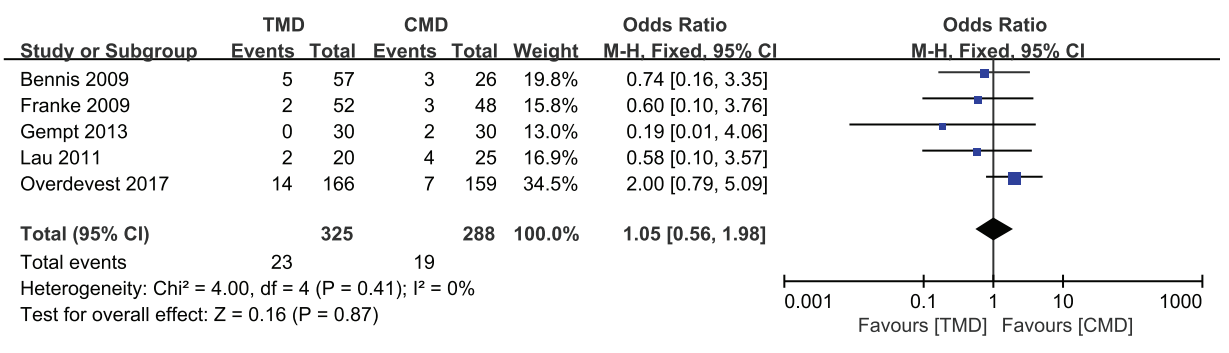

Figure 7. Forest plot to illustrate odds ratio (OR) in dural tear between TMD and CMD procedures. CMD = conventional microdiscectomy, TMD = tubular microscopes discectomy.

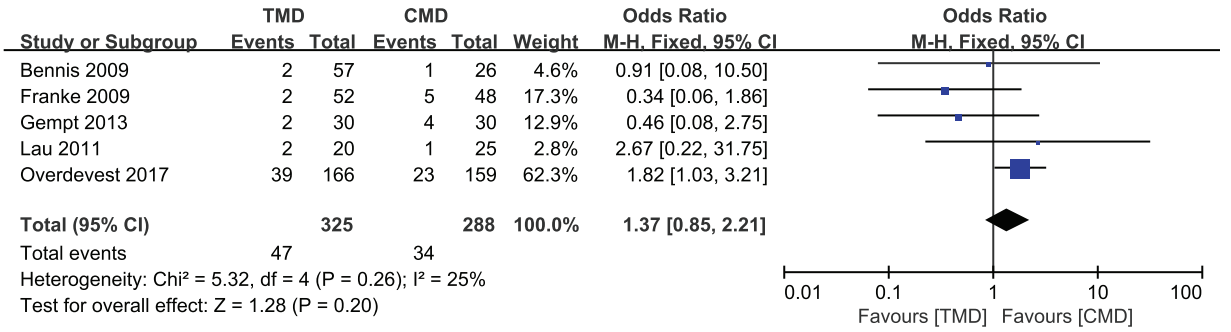

Figure 8. Forest plot to illustrate odds ratio (OR) in reoperation between TMD and CMD procedures. CMD = conventional microdiscectomy, TMD = tubular microscopes discectomy.

5 of the studies.[12,13,21,23,24] The overall pooled analysis found no significant difference between 2 groups ($P = .20$, OR = 1.37 [0.85, 2.21] heterogeneity: $P = .26$, $I^2 = 25\%$, fixed-effects model, Fig. 8).

3.2.5. Back pain. Back pain was measured using a VAS and was classified by the length of the follow-up period, that is, short-term or long-term. Two studies[10,22] reported short-term VAS score. The meta-analysis did not find a significant difference between the TMD and CMD groups ($P = .76$, SMD = −0.07 [−0.51, 0.37] heterogeneity: $P = .03$, $I^2 = 78\%$, random-effect model, Fig. 9). Long-term VAS scores were available in 2 of the studies.[12,13] The study found no significant differences between the TMD and CMD groups ($P = .64$, SMD = −0.05 [−0.25, 0.15] heterogeneity: $P = .84$, $I^2 = 0\%$, fixed-effect model, Fig. 10).

3.2.6. Leg pain. Leg pain analyses were also performed for the short- and long-term VAS scores. Two studies[10,22] reported short-term VAS scores. The TMD and CMD patients did not

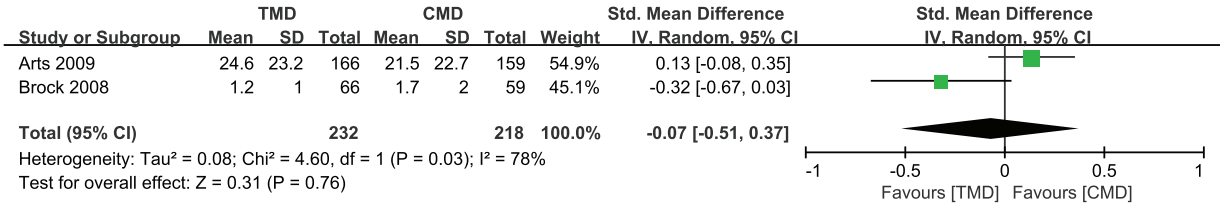

Figure 9. Forest plot to illustrate standardized mean difference (SMD) in short-term back VAS score between TMD and CMD procedures. CMD = conventional microdiscectomy, TMD = tubular microscopes discectomy, VAS = visual analog scale.

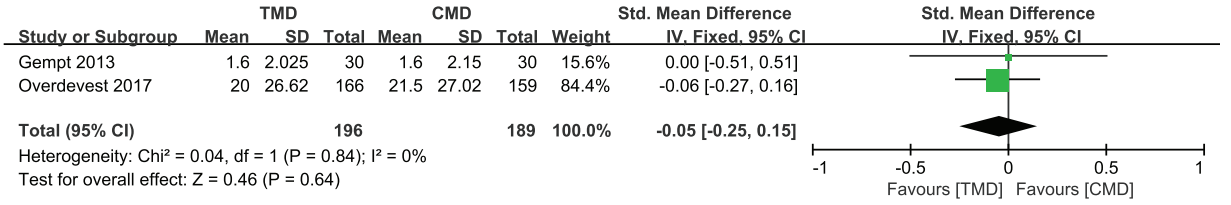

Figure 10. Forest plot to illustrate standardized mean difference (SMD) in long-term back VAS score between TMD and CMD procedures. CMD = conventional microdiscectomy, TMD = tubular microscopes discectomy, VAS = visual analog scale.

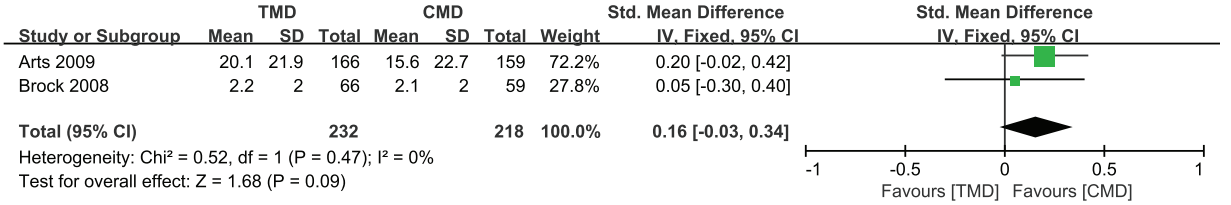

Figure 11. Forest plot to illustrate standardized mean difference (SMD) in short-term leg VAS score between TMD and CMD procedures. CMD = conventional microdiscectomy, TMD = tubular microscopes discectomy, VAS = visual analog scale.

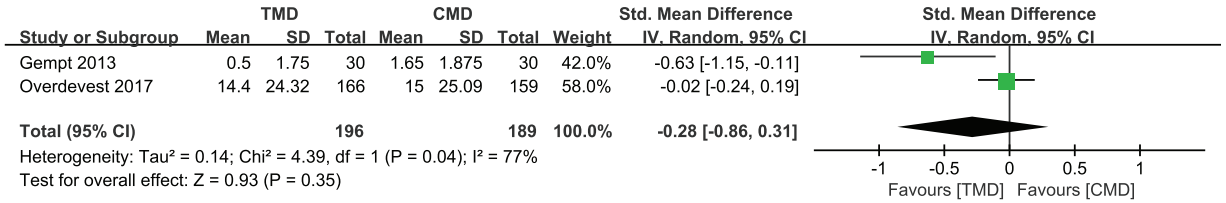

Figure 12. Forest plot to illustrate standardized mean difference (SMD) in long-term leg VAS score between TMD and CMD procedures. CMD = conventional microdiscectomy, TMD = tubular microscopes discectomy, VAS = visual analog scale.

differ significantly ($P = .09$, SMD = 0.16 [−0.03, 0.34] heterogeneity: $P = .47$, $I^2 = 0\%$, fixed-effect model, Fig. 11). Long-term VAS scores were available in 2 of the studies.[12,13] There was no significant difference between the 2 groups ($P = .35$, SMD = −0.28 [−0.86, 0.31] heterogeneity: $P = .04$, $I^2 = 77\%$, random-effect model, Fig. 12).

3.2.7. Oswestry disability index. Function was measured using the ODI. Two studies reported ODI scores.[19,23] There was no significant difference between the 2 groups ($P = .41$, SMD = −0.13 [−0.44, 0.18] heterogeneity: $P = .46$, $I^2 = 0\%$, fixed-effect model, Fig. 13).

3.3. Publication bias

Among these included studies, Arts et al[10,11] and Overdevest et al[12] were follow-up studies, Ryang et al[19] and Gempt et al[13] were follow-up studies. Most of data extractions are just from 7 studies. We did not test for risk of publication bias because funnel plots can be used for reviews with sufficient numbers of included studies.

4. Discussion

CMD, which has gained widespread use, is the gold standard in management of LDH. The advent and application of TMD was supposed to have similar or better results than CMD, but this conclusion has not been verified by sufficient evidence. In previous studies, Wang et al[14] and Kamper et al[15] respectively conducted a meta-analysis comparing the clinical outcomes between minimally invasive discectomy and CMD. However, most of the included studies focused the clinical outcomes between MED and CMD. Up to now, there is no meta-analysis individually comparing TMD to CMD. Therefore, in order to help surgeons make clinical decisions and develop optimal treatments for LDH, we conducted this meta-analysis to analyze the data of the TMD and CMD. In this study, we reviewed 523 potential researches from the commonly used large databases to evaluate blood loss, operation time the length of hospital stay, rate of complications, and ODI, VAS score between the TMD with CMD for treatment of LDH.

Surgical trauma was always assessed by operation time and blood loss. Although there is no significant difference in operative time between the 2 groups, the results are difficult to interpret, because the heterogeneity is considerable. The main reason may be explained by the variability in the techniques used, the differences in how operative time was defined, and the learning curve associated with minimally invasive procedures surgery.[25] As far as we know, TMD was minimally invasive intervention and blunt muscle splitting approach, and blood loss of TMD was expected to have results in the reduction during the surgery. But in our study, blood loss is no significant difference between the 2 groups, the main reason may be explained by the methods of calculation for blood loss, the limited surgical exposure and small surgery manipulation space which make bleeding difficult to stanch.

Although TMD were expected to have reduced intraoperative complications, in this meta-analysis, the overall pooled analysis found no significant difference between 2 groups in intraoperative complications. This may be interpreted that minimally invasive procedures are associated with a significant learning curve and restricted operating space. Furthermore, the intraoperative complication rates may be affected by differential experience of surgeons with TMD.[25] As one of the most important complications of posterior procedures, reoperation was also selected for analysis. Patients treated with TMD were expected to have higher rates of reoperation because of limited surgical exposure with consequent reduced disk removal. However, our study showed that there was no significantly different between 2 procedures. The possible cause was that the CMD, which required the incision of midline ligamentous structures and detachment of tendinous insertions of the paraspinal muscles from the spinous process, was more likely to cause instability in the spine. Equally, differential experience of

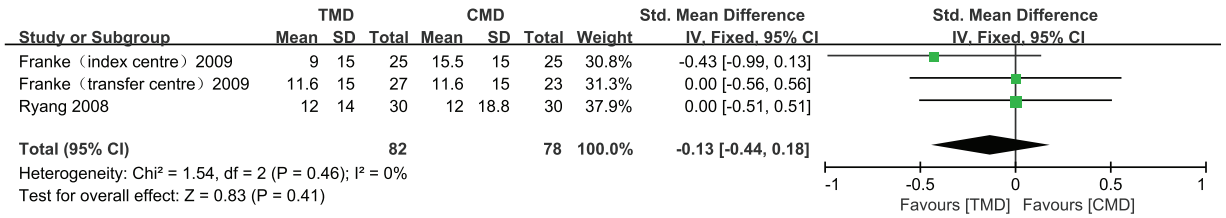

Figure 13. Forest plot to illustrate standardized mean difference (SMD) in ODI score between TMD and CMD procedures. CMD = conventional microdiscectomy, ODI = Oswestry disability index, TMD = tubular microscopes discectomy.

surgeons with TMD and the learning curve associated with TMD were also the reasons possibly.

ODI scores, VAS scores are often used to evaluate the improvement of function. As far as we know, the muscle splitting technique of TMD system is less invasive than subperiosteal detachment of the muscle from the spinous process, and postoperative low back pain and leg pain were expected to be lower after TMD than after CMD, but, in previous studies, the results were different. Gempt et al[13] we reported not statistically significant better clinical results in the TMD when compared with the CMD. Arts et al[10,11] and Overdevest et al[12] reported that patients treated with TMD have more leg pain and low-back pain in 1 year and 2 years of follow-up, in 5 years of follow-up, low back pain was reported equally between TMD and CMD. However, in our study, the pooled data showed that there was no significant difference between TMD and CMD. Meanwhile, postoperative long-term of VAS scores for leg pain and short-term of back pain had considerable heterogeneity. The major causes may be explained that the follow-up time was inconsistent in the studies, and some studies could not provide the detailed standard deviation value, so we could not pool the data completely.[22,23]

There are still some limitations in our paper. Not all the studies included in this meta-analysis were RCTs, which might reduce the test power. Some studies were follow-up studies, the identified studies and most of data extractions were lack. The types of TMD and CMD applied in studies were varied and the follow-up periods in the studies ranged largely from 1 week to several years. Patients' age and sex distribution, various indications for surgeries, the experience level of the orthopedic surgeons, severity of LDH were not consistent with each other in the original studies. We only included the studies in English, and some relevant studies reported in other languages were not included due to a language limitation.

5. Conclusion

From this meta-analysis, we did not find a significant difference between tubular microscopes discectomy and conventional microdiscectomy for treating lumbar disc herniation in outcomes with regards to blood loss, operation time, and length of stay in hospital, complication rate, and functional scores. This conclusion should be treated cautiously, because of the limited number of studies and relatively small sample size. More well-designed, prospective studies with large samples are required to confirm this conclusion.

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