Meta-analysis

A Comparison of Minimally Invasive Surgical Techniques and Standard Open Discectomy for Lumbar Disc Herniation: A Network Meta-analysis

Lu Qin, PhD[1,2], Xiaoqian Jiang, MM[1], Shishun Zhao, PhD[2], Wenlai Guo, MD[3], and Di You, MD[1]

From: [1]Department of Anesthesiology, China-Japan Union Hospital of Jilin University, Changchun, Jilin Province, People's Republic of China; [2]Center for Applied Statistical Research and College of Mathematics, Jilin University, Changchun, Jilin Province, People's Republic of China; [3]Department of Hand Surgery, the Second Hospital of Jilin University, Changchun, Jilin Province, People's Republic of China

Address Correspondence:
Di You, MD
Department of Anesthesiology
China-Japan Union Hospital of Jilin University
Changchun, Jilin Province, People's Republic of China
E-mail: youdi1118@jlu.edu.cn

Disclaimer: There was no external funding in the preparation of this manuscript.

Conflict of interest: Each author certifies that he or she, or a member of his or her immediate family, has no commercial association (i.e., consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted manuscript.

Manuscript received: 08-09-2023
Revised manuscript received: 10-06-2023
Accepted for publication: 10-24-2023

Free full manuscript: www.painphysicianjournal.com

Background: Lumbar disc herniation is a common spinal disease that causes low back pain; surgery is required when conservative treatment is ineffective. There is a growing demand for minimally invasive surgery in younger patient populations due to their fear of significant damage and a long recovery period following standard open discectomy. The development history of minimally invasive surgery is relatively short, and no gold standard has been established.

Objectives: We aimed to find, via a network meta-analysis, the best treatment for low back pain in younger patient populations.

Study Design: Network meta-analysis

Methods: The PubMed, Embase, Cochrane Library, and Web of Science databases were searched. Data quality was evaluated using RevMan 5.3 (The Nordic Cochrane Centre for The Cochrane Collaboration), while STATA 14.0 (StataCorp LLC) was used for the network meta-analysis and to merge data on the Visual Analog Scale (VAS) score, Oswestry Disability Index (ODI) score, complication, blood loss, reoperation rate, and function score.

Results: We included 50 randomized controlled trials, involving 7 interventions; heterogeneity and inconsistency were acceptable. Comparatively, microendoscopic discectomy and percutaneous endoscopic lumbar discectomy were the best surgical procedures from the aspects of VAS score and ODI score, while standard open discectomy was the worst one from the aspect of ODI score. Regarding complications, tubular discectomy was preferred with the fewest complications. Additionally, microendoscopic discectomy outperformed other surgical procedures in reducing blood loss and reoperation rate.

Limitations: First, follow-up data were not reported in all included studies, and the follow-up time varied from several months to 8 years, which affected the results accuracy of our study to some extent. Second, there were some nonsurgical factors that also affected the self-reported outcomes, such as rehabilitation and pain management, which also brought a certain bias in our study results.

Conclusions: Compared to standard open discectomy, minimally invasive surgical procedures not only achieve satisfactory efficacy, but also microendoscopic discectomy and percutaneous endoscopic lumbar discectomy can obtain a more satisfactory short-term VAS score and ODI score. Microendoscopic discectomy has significant advantages in blood loss and reoperation rate, and tubular discectomy has fewer postoperative complications.

Key words: Lumbar disc herniation, minimally invasive surgery, standard open discectomy, Visual Analog Scale, Oswestry Disability Index, complication, blood loss, reoperation rate, function score, network meta-analysis

Pain Physician 2024: 27:E305-E316

Lumbar disc herniation (LDH) is a common cause of low back pain and sciatica (1). It has recurrent symptoms and is difficult to cure completely. If severe, it can lead to lower-limb paralysis. Thus, treatment that can relieve clinical symptoms and improve a patient's prognosis is important.

Conservative treatment, including drug therapy, physical therapy, and traction, is the most common approach for treating LDH, and usually, this can obtain favorable clinical results. However, it is not sufficient for some patients, especially young people. In this context, surgery is required (2), but the related complications are of great concern. Traditional open discectomy is considered as the standard procedure for LDH (3,4), but the inevitable accompanying scarring and adhesions (5,6) generally result in decreased lumbar activity, blood loss, and an extended hospital stay (7).

Minimally invasive surgery, a new approach that can help patients escape from long-term pain, is less costly and requires only a short recovery period. With the wide application of surgical microscopes, microdiscectomy (MD) began in 1976 and is regarded as the "gold standard" for treating patients who are symptomatic who suffer from LDH-induced radiculopathy and who have responded poorly to conservative treatment (8). According to some reports, such treatment predisposes the patient to dural tears, nerve root compromise, and recurrent herniation, compared with the standard open discectomy (SOD) (9).

Microendoscopic discectomy (MED), which was introduced in 1997, uses a tubular retractor system and a microendoscopy that cause less damage to soft tissues and muscle (10). However, it may lead to postoperative low back pain and lumbar spine instability due to the inevitable disruption of the tension band of the spinal column and the bone architecture of the lamina (11).

As endoscopic techniques have developed, multiple other minimally invasive surgical procedures have emerged, such as percutaneous endoscopic lumbar discectomy (PELD) and percutaneous laser disc decompression (PLDD). Both procedures are less invasive than traditional open discectomy and can be performed under local anesthesia; PLLD vaporizes the nucleus pulposus by using laser energy (12,13). Tubular discectomy (TD) was first implemented in 1997. It is a muscle-splitting approach that allows surgeons to perform in a small diameter area with both hands (14). Notably, it can speed up patient recovery, but it also presents more complications (15). Since micromanipulation methods are complicated and have several limitations, chemonucleolysis (CN), a method that induces nucleus pulposus depolymerization by injecting proteolytic enzymes to reduce intradiscal pressure and then relieve pain, was proposed by Smith, et al (16).

Inevitably, technical innovations also have resulted in some new complications. In addition, their treatment effectiveness, safety, and reoperation rate have an effect on the clinical choice of treatment procedures. A traditional meta-analysis compares the efficacy and safety between only 2 interventions; it is not able to perform comparisons among 3 or more interventions. Therefore, we used a network meta-analysis to comprehensively compare the efficacy of 7 surgical interventions: SOD, MD, MED, PELD, PLDD, TD and CN, for LDH treatment from 6 aspects: the Visual Analog Scale (VAS) score, Oswestry Disability Index (ODI) score, complications, blood loss, reoperation rate, and function score. We propose that our study will provide clinically useful and convincing conclusions and guide treatment choice in clinical practice.

Methods

Literature Retrieval

This study was registered in the International Prospective Register of Systematic Reviews (CRD42022314017) on April 1, 2022. We followed the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines, performing an electronic search of PubMed, Embase, Cochrane Library, and Web of Science to obtain all relevant studies that were published through October 2022. In addition, handsearching was performed to include related articles. The search strategy was made up of key words and related synonyms: "lumbar disc herniation," "minimally invasive surgical procedures," "open discectomy," "micro-endoscopic discectomy," and "tubular Diskectomy." Boolean logical operators were applied to combine the search terms (the full search strategy of PubMed as representative is shown in Supplementary File 1).

Eligibility Criteria

Inclusion Criteria

The inclusion criteria were as follows: 1) study patients had LDH, with no restrictions on race or nationality; 2) a randomized controlled trial in all languages; 3) surgical interventions were any 2 of the 7 procedures (SOD, MD, MED, PELD, PLDD, TD, and CN); 4) articles were complete, and outcome measures included at least one of the following indexes: 1) VAS score for back pain

and leg pain at one month, 3 months, and 6 months postsurgery; 2) ODI score at one month, 3 months, 6 months, and 12 months postsurgery; 3) complications; 4) blood loss; 5) reoperation rate; 6) function score (Short Form-36 Bodily Pain [SF36-BP] or Short Form-36 Physical Function [SF36-PF]); or 7) literature data were true and plausible, and each index was shown as, or could be converted to, a binary or continuous variables.

Exclusion Criteria

Exclusion criteria were as follows: 1) study patients had recurrent LDH, spinal stenosis, lumbar spinal degenerative disease, lumbar fracture, lumbar malignancy, or chronic infectious disease; 2) studies involving animals or cadavers; 3) case reports, cohort studies, literature reviews, retrospective studies, and conference papers where the full text could not be obtained; 4) studies whose data could not be extracted, were incomplete, or could not be converted into valid data.

Outcome Measures

Primary Outcome Measures

The primary outcome measures were as follows: 1) VAS score: one of the indicators of clinical effectiveness. We assessed the VAS score for back pain and leg pain at one month, 3 months, and 6 months postoperatively; 2) ODI score: one of the indicators of clinical effectiveness. ODI scores were collected and analyzed at one month, 3 months, 6 months, and 12 months postoperatively—a higher ODI score indicated more severe cognitive dysfunction; 3) complications: a very important factor used to assess the safety of surgery. Because of data limitations, the complications mentioned in studies (wound infection, dural tear, wound hematoma, cerebrospinal fluid leak, damage to nerve roots, deep venous thrombosis in the leg, nerve root injury, etc. (2,17-19) were only subjected to an analysis which was more general.

Secondary Outcome Measures

The secondary outcome measures were as follows: 1) blood loss: an indicator used to evaluate surgical trauma; 2) reoperation rate; 3) function score: analyzed from the SF36-BP and SF36-PF scale scores at 6 and 12 months postoperatively.

Literature Screening and Data Extraction

Assessment of Methodological Quality

Methodological quality assessment on the included studies was done independently by 2 researchers (LQ and XQJ), using the Cochrane Risk-of-Bias tool (20). Any disagreement was resolved by discussion between the 2 researchers or with a third researcher (DY).

Data Collection

The relevant data were independently extracted by the 2 researchers (LQ and XQJ) according to a predesigned uniform data extraction form. Any discrepancy was resolved as described previously.

An attempt was made to contact the corresponding author by email in cases of incomplete data, but we did not receive any responses. Additionally, when the standard deviation was missing and the authors could not be contacted, it was estimated by range or medians (20), or calculated from a confidence interval using the method described in The Cochrane Handbook for Systematic Reviews of Interventions as described in the study of Wan, et al (21).

Statistical Analysis

Stata 14.0 (StataCorp LLC) and RevMan 5.4 (The Nordic Cochrane Centre for The Cochrane Collaboration) were used for pooled analysis and quality assessment. Network meta-analysis was carried out under a frequentist framework using a random-effects model. Dichotomous variables were reported as odds ratios. Continuous variables were calculated as the mean difference and their corresponding 95% CI values were calculated (22). The quality of included studies was assessed using Cochrane RoB RevMan 5.4 and a risk-of-bias plot was generated. A network diagram of evidence, forest plot, rank probabilities graph, and funnel plot were generated with Stata 14.0 software, and corresponding statistical analysis was performed (23).

For outcome indicators with a closed loop in the network diagram of evidence, an inconsistency model was first used to test the inconsistency globally (24,25), and then the node-splitting method was applied to test the inconsistency locally. If the difference was not statistically significant ($P > 0.05$) and the results of direct and indirect comparisons were consistent (26), then pooled analysis could be performed; otherwise, the sources of inconsistency were sought and culled, followed by a pooled analysis. A surface under the cumulative ranking (SUCRA) curve was applied to obtain the ranking probabilities of each treatment; larger SUCRA value indicated better efficacy for the procedure. Publication bias was assessed using a funnel plot when no less than 10 studies were included.

Network Meta-analysis Results

Search Results and Characteristics of Selected Studies

Utilizing our search strategy, 2,786 articles were obtained by electronic search, including 564 from PubMed, 349 from Embase, 1,321 from the Cochrane Library, and 552 from Web of Science. Seventeen articles were obtained by hand searching. After removing duplicates using EndnoteX9 software (Clarivate Analytics and the screening of titles, abstracts, and full texts, 50 randomized controlled trials that included 5,702 patients were deemed eligible and included in our study (Fig. 1 and Supplementary File 2). The basic characteristics of included studies are listed in Table 1.

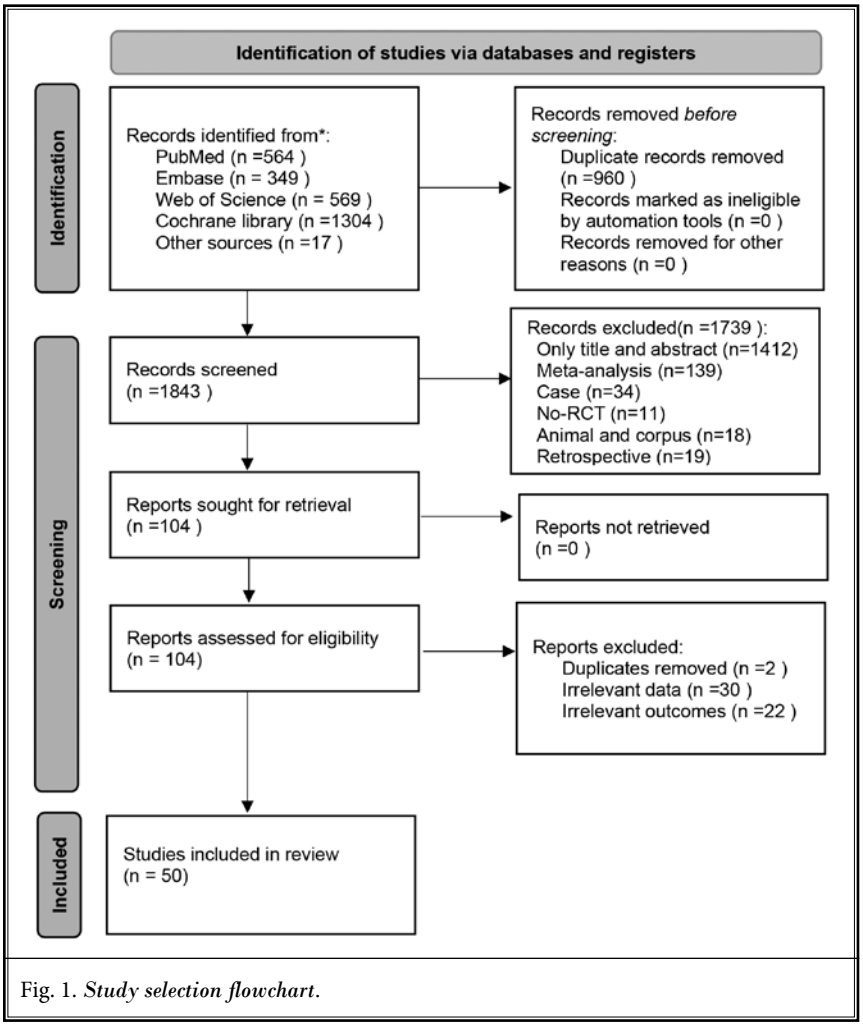


Fig. 1. *Study selection flowchart.*

Risk-of-Bias Evaluation

The risk-of-bias assessment of the 50 randomized controlled trials is shown in Fig. 2.

Results Merging

The network diagram of all interventions included is shown in Fig. 3.

Primary Outcome Measures

For each outcome measure, the network diagram of all interventions included is shown in Supplementary Fig. 1. The forest plot of each pairwise comparison and the SUCRA curve plot of each included intervention are shown in Supplementary Fig. 2 and Fig. 3, respectively. The correction funnel plot is shown in Supplementary Fig. 4, suggesting no remarkable publication bias. The global consistency test results are acceptable for most outcome measures ($P > 0.05$). The node-splitting results of each direct and indirect comparison showed good consistency ($P > 0.05$) for all primary and secondary outcomes in Supplementary Table 1. The league table of each pairwise comparison and the ranking results of interventions for each outcome are shown in Supplementary Table 2 and Table 3, respectively.

VAS Score

A VAS score was reported in 20 studies, in which 7 surgical interventions (SOD, MD, MED, PELD, PLDD, TD, and CN) were involved. We assessed the VAS score for back pain and leg pain at one month, 3 months, and 6 months postsurgery.

VAS Score for Back Pain

VAS score for back pain was reported in 19 studies, in which 7 surgical interventions (SOD, MD, MED, PELD, PLDD, TD, and CN) were involved.

At One Month Postsurgery

The VAS score for back pain at one month postsurgery was

Table 1. *Basic characteristics of the included studies (also see bibliographic list of randomized controlled trials used in our network meta-analysis).*

	Study	Year	Country	Total	Age	Gender(M/W)	Follow-up	Intervention	Outcomes
1	Abrishamkar S, et al	2015	Iran	200	39.7 ± 9.2 vs 40.2 ± 8.8	82/18 vs 78/22	One year	(1) (5)	[1] [3] [5]
2	Arts MP, et al	2011	The Netherlands	325	41.6 ± 9.8 vs 41.3 ± 11.7	84/82 vs 88/71	2 years	(2) (4)	[1] [3] [5] [6]
3	Brouwer PA, et al	2015	The Netherlands	115	43.2 ± 11.8 vs 43.7 ± 9.7	38/19 vs 34/24	One year	(2) (5)	[1] [6]
4	Brouwer PA, et al	2017	Sweden	112	43.2 ± 11.8 vs 43.7 ± 9.7	36/19 vs 33/24	104 weeks	(2) (5)	[1] [6]
5	Crawshaw C, et al	1984	United Kingdom	116	35.6 vs 40.7	NA	One year	(1) (7)	[3] [5]
6	Ding ZM, et al	2017	People's Republic of China	100	41.32 ± 11.53 vs 43.90 ± 11.8	30/20 vs 27/23	8-19 months	(1) (3)	[2]
7	Hussein M, et al	2016	Egypt	73	30.5 vs 31.9	20/17 vs 21/15	25.5 vs 26.2 months	(1) (6)	[1] [2] [3] [4] [5]
8	Hussein M, et al	2014	Egypt	200	30.2 vs 31.5	58/42 vs 54/46	2 years	(1) (6)	[1] [2] [4]
9	Lau D, et al	2011	United States	45	44.55 ± 3.60 vs 42.24 ± 3.18	10/10 vs 12/13	3 years	(1) (2)	[3] [4]
10	Mojaz FM, et al	2019	Germany	121	54 ± 16.83 vs 55.89 ± 15.56	32/28 vs 24/37	6 years	(2) (4)	[3]
11	Elkatatny AAAM, et al	2019	Egypt	10	44	5 vs 5	One year	(1) (2)	[3]
12	Muralikuttan KP, et al	1992	Ireland	92	36 vs 39	27/19 vs 28/18	One year	(1) (7)	[3]
13	Overdevest GM, et al	2017	The Netherlands	325	41.6 ± 9.8 vs 41.3 ± 11.7	84/82 vs 88/71	2 years	(2) (4)	[3] [5]
14	Ran B, et al	2021	People's Republic of China	68	48.7 ± 10.1 vs 46.6 ± 10.2	24/11 vs 18/15	4 years	(1) (3)	[1] [3]
15	Righesso O, et al	2007	Brazil	40	46.0 ± 12.4 vs 42.0 ± 10.7	13/6 vs 10/11	2 years	(1) (6)	[2] [3] [4] [5]
16	Ruetten S, et al	2008	Germany	200	43 (20 - 68)	84 vs 116	2 years	(2) (3)	[3] [5]
17	Ryang YM, et al	2008	Germany	60	39.1± 11.3 vs 38.2 ± 9.3	19/11vs 13/17	6 - 16 months	(2) (4)	[3] [4] [5] [6]
18	van Alphen Ham, et al	1989	The Netherlands	151	NA	99/52	One year	(1) (7)	[3] [5]
19	Yu Dongli, et al	2017	People's Republic of China	97	61.5 ± 1.7 vs 61.5 ± 1.6	22/21 vs 18/21	6 months	(1) (6)	[4] [5]
20	Arts MP, et al	2009	The Netherlands	325	41.6 ± 9.8 vs 41.3 ± 11.7	84/82 vs 88/71	One year	(2) (4)	[1] [3] [5] [6]
21	Chen Z, et al	2018	People's Republic of China	153	40.2 ± 11.4 vs 40.7 ± 11.1	52/28 vs 37/36	One year	(3) (6)	[1] [2] [3] [5] [6]
22	Cristante AF, et al	2016	Brazil	40	41.2 ± 9.3 vs 44.9 ± 9.4	10/10 vs 10/10	One year	(2) (3)	[1] [2]
23	Garg B, et al	2011	India	112	37 ± 8 vs 38 ± 6	36/19 vs 44/13	One year	(1) (6)	[1] [2] [4]
24	Hamawandi SA, et al	2020	Iraq	60	29 - 50	NA	4 years	(1) (2)	[1] [5]
25	Kelekis A, et al	2022	Greece	47	39.5 ± 10.5 vs 41.1 ± 12.9	17/7 vs 14/9	4 years	(2) (7)	[4]
26	Meyer G, et al	2020	Brazil	47	47.2 ± 10.6 vs 45.2 ± 10.6	NA	One year	(2) (3)	[1] [3]

Table 1 cont. *Basic characteristics of the included studies (also see bibliographic list of randomized controlled trials used in our network meta-analysis).*

	Study	Year	Country	Total	Age	Gender(M/W)	Follow-up	Intervention	Outcomes
27	Pan Z, et al	2016	Republic of Korea	106	39.5 (22 - 58) vs 42.8 (27 -61)	26/22 vs 31/27	12-25 months	(1) (3)	[1] [2] [3] [4]
28	Sasaoka R, et al	2006	Japan	33	36.5 (25 - 60) vs 37.7 (20 - 58) vs 59.6 (49 - 72)	6/9 vs 8/3 vs 5/2	One year	(1) (2) (6)	[4]
29	van den Akker ME, et al	2011	The Netherlands	325	18 - 70	NA	One year	(2) (4)	[5]
30	Wang F ,et al	2019	People's Republic of China	90	47.54 ± 3.29 vs 48.52 ± 2.65	26/19 vs 27/18	6 months	(3) (6)	[1] [2] [4]
31	Yadav, et al	2019	People's Republic of China	60	57.5 ± 17.63 vs 58.27 ± 11.44	15/15 vs 14/16	6 months	(1) (6)	[2] [4]
32	Chen Z, et al	2020	People's Republic of China	241	40.9 ± 11.9 vs 41 ± 10.8	73/46 vs 70/52	2 years	(3) (6)	[1] [2] [3] [5] [6]
33	Chang F, et al	2018	People's Republic of China	110	52.54 ± 4.12 vs 3.67 ± 4.28	40/20 vs 30/20	One year	(1) (3)	[2] [4]
34	Pan L, et al	2014	People's Republic of China	20	NA	NA	One year	(1) (3)	[4]
35	Wardlaw D, et al	2013	United Kingdom	100	NA	27/21 vs 33/19	3 years	(1) (7)	[3]
36	Thome C, et al	2005	Germany	84	42 ± 9 vs 40 ± 10	24/18 vs 23/19	One year	(1) (2)	[1] [5] [6]
37	Kong L, et al	2019	People's Republic of China	39	34.6 vs 31.9	16/3 vs 11/9	More than one year	(2) (3)	[4]
38	Huang TJ, et al	2005	People's Republic of China	22	39.2 ± 10.8 vs 39.8 ± 11	6/4 vs 9/3	One year	(1) (6)	[4]
39	Teli M, et al	2010	Italy	212	39 ± 12 vs 40 ± 12 vs 39 ± 12	45/25 vs 48/24 vs 46/24	2 years	(1) (2) (6)	[1] [2] [3] [6]
40	Burton AK, et al	2000	United Kingdom	40	41.9 ± 10.6	19/21	One year	(1) (7)	[1] [5]
41	Ejeskar A, et al	1983	Sweden	29	42.14 ± 14.69 vs 36.6 ± 10.77	NA	One year	(1) (7)	[5]
42	Franke J, et al	2009	Germany	100	44 ± 11.7	60/40	One year	(2) (3)	[5]
43	Hermantin Fu, et al	1999	United States	60	40 (18 - 67) vs 39 (15 - 66)	17/13 vs 22/8	2 years	(1) (3)	[3] [5]
44	Belykh E, et al	2016	Russia	131	39.5 (37 - 49) vs 41 (32- 49) vs 39 (36 - 48)	27/21 vs 28/16 vs 27/12	One year	(2)(3) (4)	[3] [4]
45	Gibson JNA, et al	2017	United Kingdom	140	42 ± 9 vs 39 ± 9	30/40 vs 40/30	2 years	(2) (3)	[1] [2] [3] [5] [6]
46	Ruetten S, et al	2009	Germany	87	39 (23 - 59)	56/44	2 years	(2) (3)	[3] [5]
47	Jing Z, et al	2021	People's Republic of China	62	51.32 ± 8.99 vs 50.75 ± 9.36	17/14 vs 16/15	2 years	(3) (6)	[3] [4] [5]
48	Li Z, et al	2020	People's Republic of China	42	49:8 ± 17:9 vs 49:5 ± 12:6	13/8 vs 15/6	3 years	(1) (3)	[2]
49	He J, et al	2022	People's Republic of China	94	50.23 ± 2.67 vs 50.15 ± 2.6	28/19 vs 30/17	One year	(1) (3)	[2]
50	Chen Z, et al	2023	People's Republic of China	241	40.9 ± 11.9 vs 41.0 ± 10.8	73/46 vs 70/52	5 years	(3) (6)	[2]

Interventions:
(1)SOD (2)MD (3)PELD (4)TD (5)PLDD (6)MED (7)CN
Outcome measures:
[1] VAS Score [2] ODI Score [3] Complications [4] Blood Loss [5] Reoperation Rate [6] Function Score
vs, versus; NA, not available; M, men; W, women
The order of vs before and after comparison is the same as the order of intervention.

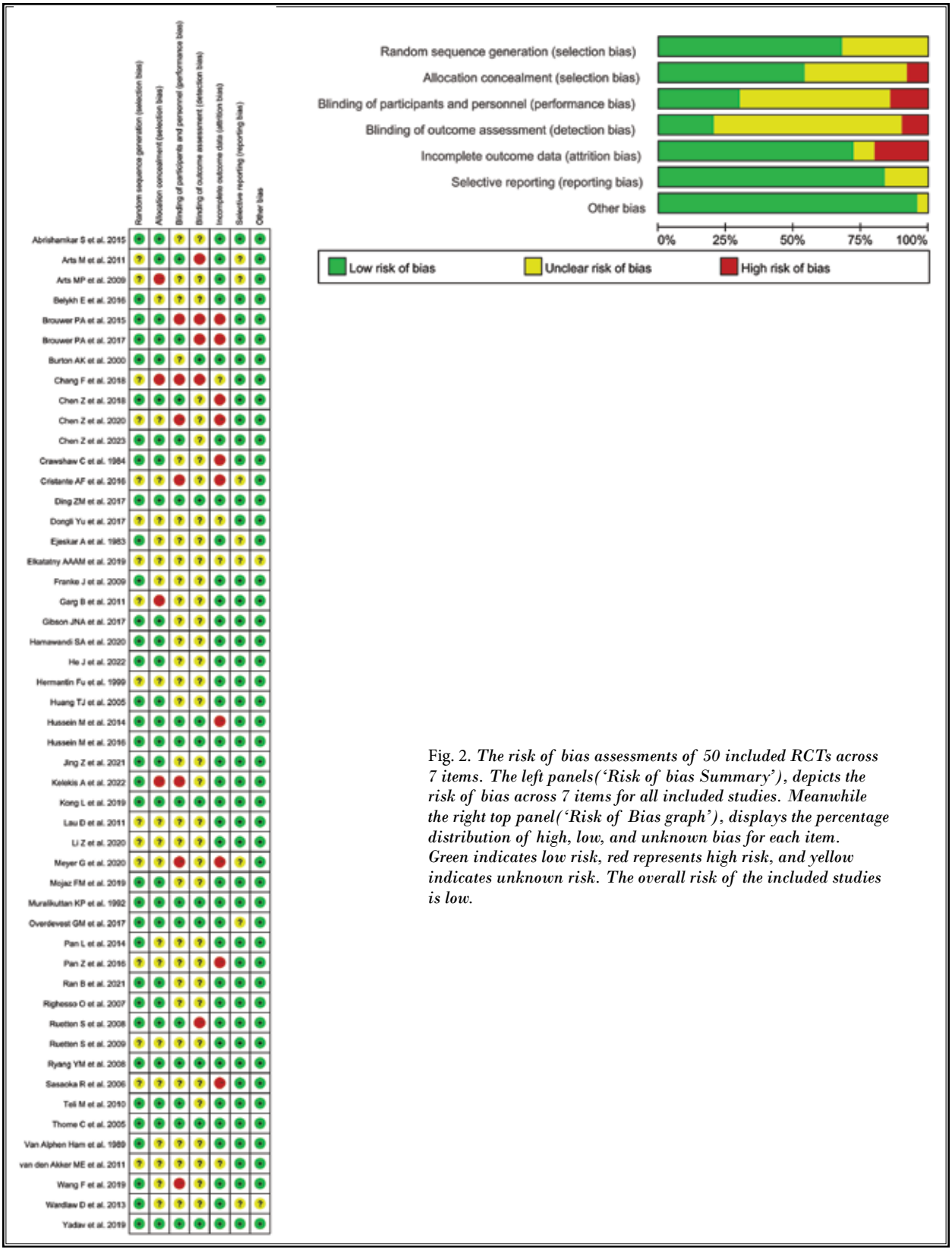


Fig. 2. *The risk of bias assessments of 50 included RCTs across 7 items. The left panels('Risk of bias Summary'), depicts the risk of bias across 7 items for all included studies. Meanwhile the right top panel('Risk of Bias graph'), displays the percentage distribution of high, low, and unknown bias for each item. Green indicates low risk, red represents high risk, and yellow indicates unknown risk. The overall risk of the included studies is low.*

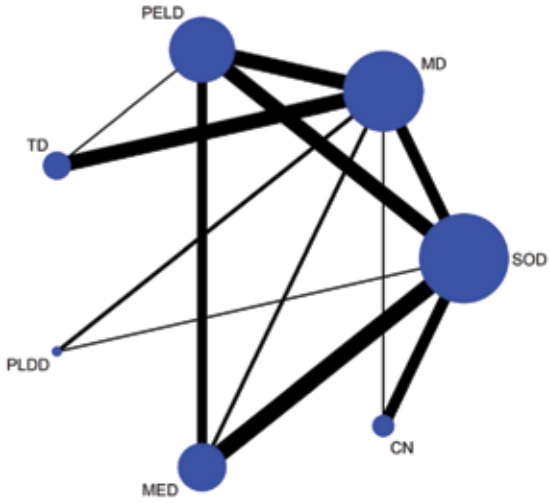


Fig. 3. *Risk-of-bias summary.*

reported in 12 studies, in which 7 surgical interventions (SOD, MD, MED, PELD, PLDD, TD, and CN) were involved. Global consistency was first tested (P = 0.001; < 0.05), followed by using the node-splitting method to search for the source of inconsistency (Supplementary Table 1). It was found that this inconsistency was likely due to SOD vs CN and PELD vs CN. Thus, data fitting was done using an inconsistency model. Comparing results with MD, MD was significantly better than PELD, TD, PLDD, and CN, while MED was significantly better than MD. The ranking result of the interventions is MED > MD > TD > PELD > PLDD > SOD > CN.

At 3 Months Postsurgery

The VAS score for back pain at 3 months postsurgery was reported in 9 studies, in which 5 surgical interventions (SOD, MD, PELD, PLDD, and MED) were involved. Comparing results with SOD , there was no significant difference between PLDD and SOD. However, MD, PELD, and MED were significantly better than SOD. The ranking result of the interventions is MD > MED > PELD > SOD > PLDD.

At 6 Months Postsurgery

The VAS score for back pain at 6 months postsurgery was reported in 15 studies, in which 6 surgical interventions (SOD, MD, PELD, TD, PLDD, and MED) were involved. Global consistency was first tested (P = 0.000; < 0.05), followed by using the node-splitting method to search for the source of inconsistency (Table S1). It was found that this inconsistency was likely due to the SOD vs MD. Thus, data fitting was done using an inconsistency model. Comparing results with MD, there was no significant difference between MD and PELD. However, MD was significantly better than TD, PLDD, and MED. The ranking result of the interventions is MED > PELD > SOD > MD > TD > PLDD.

VAS Score for Leg Pain

The VAS score for leg pain was reported in 19 studies, in which 7 surgical interventions (SOD, MD, PELD, TD, PLDD, MED, and CN) were involved.

At One Month Postsurgery

The VAS score for leg pain at one month postsurgery was reported in 11 studies, in which 7 surgical interventions (SOD, MD, PELD, TD, PLDD, MED, and CN) were involved. The efficacy of MD, TD, and PLDD was in the order of MD > TD > PLDD. Additionally, no distinct differences were reported in other pairwise comparisons. The ranking result of the interventions is MD > TD > MED > PELD > CN > PLDD > SOD.

At 3 Months Postsurgery

The VAS score for leg pain at 3 months postsurgery was reported in 8 studies, in which 4 surgical interventions (SOD, MD, PELD, and MED) were involved. MED was significantly better than SOD, while there were no significant differences in other pairwise comparisons. The ranking result of the interventions is MED > PELD > MD > SOD.

At 6 Months Postsurgery

The VAS score for leg pain at 6 months postsurgery was reported in 14 studies, in which 6 surgical interventions (SOD, MD, PELD, TD, PLDD, and MED) were involved. Comparing results with PELD, PELD was significantly better than TD and PLDD, while there was no significant difference between PELD and MED. The ranking result of the interventions is MED > PELD > MD > SOD > TD > PLDD.

ODI Score

The ODI score was reported in 16 studies, in which 4 surgical interventions (SOD, MD, PELD, and MED) were involved. We reported ODI scores at one month, 3 months, 6 months, and 12 months postsurgery.

At One Month Postsurgery

The ODI score at one month postsurgery was reported in 9 studies, in which 4 surgical interventions

(SOD, MD, PELD, and MED) were involved. No significant differences were reported in all pairwise comparisons. The ranking result of the interventions is MED > PELD > SOD > MD.

At 3 Months Postsurgery

The ODI score at 3 months postsurgery was reported in 11 studies, in which 4 surgical interventions (SOD, MD, PELD, and MED) were involved. There were no significant differences in all pairwise comparisons. The ranking result of the interventions is PELD > MD > MED > SOD.

At 6 Months Postsurgery

The ODI score at 6 months postsurgery was reported in 13 studies, in which 4 surgical interventions (SOD, MD, PELD, and MED) were involved. MED was significantly better than SOD, while there was no significant difference in other pairwise comparisons. The ranking result of the interventions is MED > PELD > MD > SOD.

At 12 Months Postsurgery

The ODI score at 12 months postsurgery was reported in 11 studies, in which 4 surgical interventions (SOD, MD, PELD, and MED) were involved. PELD and MED were significantly better than SOD, while there was no significant difference in other pairwise comparisons. The ranking result of the interventions is PELD > MED > MD > SOD.

Complications

Complications were reported in 25 studies, in which 7 surgical interventions (SOD, MD, PELD, TD, PLDD, MED, and CN) were involved. MD, PELD, and TD were significantly better than MD, while there was no significant difference in other pairwise comparisons. The ranking result of the interventions is TD > PELD > MD > SOD > CN > PLDD > MED.

Secondary Outcome Measures

Blood Loss

Blood loss was reported in 18 studies, in which 6 surgical interventions (SOD, MD, PELD, TD, MED and CN) were involved. MED was significantly better than SOD in reducing blood loss, while there was no significant difference in other pairwise comparisons. The ranking result of the interventions is MED > CN > PELD > MD > TD > SOD.

Reoperation Rate

The reoperation rate was reported in 24 studies, in which 7 surgical interventions (SOD, MD, PELD, TD, PLDD, MED and CN) were involved. There were no significant differences when SOD was compared with TD and CN, while MD, PELD, PLDD and MED were significantly better than SOD. The ranking result of the interventions is MED > PELD > MD > PLDD > SOD > TD > CN.

Function Score

The function score was reported in 10 studies, in which 6 surgical interventions (SOD, MD, PELD, TD, PLDD and MED) were involved. We reported the SF36-BP and SF36-PF at 6 months and 12 months postsurgery.

SF36-BP

At 6 Months Postsurgery

The SF36-BP at 6 months postsurgery was reported in 8 studies, in which 6 surgical interventions (SOD, MD, PELD, TD, PLDD and MED) were involved. SOD was significantly better than TD, PLDD, and MED. The ranking result of the interventions is SOD > MD > MED > PELD > TD > PLDD.

At 12 Months Postsurgery

The SF36-BP at 12 months postsurgery was reported in 8 studies, in which 6 surgical interventions (SOD, MD, PELD, TD, PLDD and MED) were involved. SOD was significantly better than MD, TD, PLDD, and MED, while there was no significant difference between SOD and PELD. The ranking result of the interventions is SOD > MED> MD > PELD > PLDD > TD.

SF36-PF

At 6 Months Postsurgery

The SF36-PF at 6 months postsurgery was reported in 8 studies, in which 6 surgical interventions (SOD, MD, PELD, TD, PLDD and MED) were involved. SOD was significantly better than TD and PLDD. The ranking result of the interventions is SOD > MED > PELD > MD > PLDD > TD.

At 12 Months Postsurgery

The SF36-PF at 12 months postsurgery was reported in 9 studies, in which 6 surgical interventions (SOD, MD, PELD, TD, PLDD and MED) were involved. SOD was significantly better than TD and PLDD. The ranking result of the interventions is SOD > MD > MED > PELD > PLDD > TD.

Discussion

LDH predominantly occurs in patients aged 24 to 45 years (27). Many symptoms can be complicated by LDH, such as back pain, lower-limb pain and numbness, etc. Mild cases will present with mobility problems; if severe, patients can be incapacitated, affecting their physical health and resulting in both economic and psychological burdens for the patients and their family. Thus, it is crucial to identify effective treatment for patients with LDH (28,29).

We performed a network meta-analysis for the 7 surgical interventions for LDH, including one traditional procedure and 6 minimally invasive surgical techniques: SOD, MD, MED, PELD, PLLD, TD, and CN. , We looked at their relationship to VAS scores, ODI scores, complications, blood loss, reoperation rates, and function scores.

Our results show that MED is the best surgical intervention regarding the VAS score for both back pain and leg pain. Minimally invasive surgical techniques outperformed the traditional procedure (SOD) at one month postsurgery, but the difference at 6 months postsurgery was not significant. This result was consistent with the study by Kim, et al (30). However, other studies (31-34) concluded that there was no significant difference in the postoperative VAS score between minimally invasive surgical methods (PELD and MED) and traditional surgical methods. This may be due to their different follow-up times in each meta-analysis study, and the small number and sample size of the included literature in the studies (32,33), resulting in a lack of persuasiveness in the conclusions drawn.

For the ODI score, we found that minimally invasive surgery is superior to traditional surgery, which is consistent with the conclusions of other studies (30,32,35). Two studies (30,32) concluded that PELD is superior to SOD. Wei, et al (35) concluded that TD has the best efficacy, while SOD has the highest score and the worst efficacy.

In terms of complications, we report that TD has the smallest complication rate, which is consistent with other studies (35,36); however, other studies (37,38) have come to a different conclusion. They (37,38) concluded that for overall complications, PELD was the most optimal with minimal incidences. Li, et al (39) suggested that the low complication rate of TD may be related to extraoperative factors, such as patient selection and postoperative care, rather than the technique itself. One of the big reasons why different studies produced different results is that different studies classified complications differently. Alvi, et al (31) concluded that TD had the highest complication rate, possibly due to the inclusion of retrospective studies in its analysis, while our study only included randomized controlled trials (40). Our research shows that MED has the worst efficacy and the highest rates of complication, which was also found in previous studies (9,41). The possible reason is that a surgeon's depth perception is limited during MED surgery (9,41,42). It may also be because one difficulty of MED surgery is entering from the rear and getting through the ligamentum flavum. Therefore, if adhesion of the ligamentum flavum is a problem, that must be addressed. When serious adhesions have occur and no attention is paid during the operation, if the action is rough, it will easily lead to a dura mater tear, spinal venous plexus bleeding, cerebrospinal fluid leakage, and other complications.

In terms of blood loss, MED has the least blood loss, which is consistent with the conclusion of Wei, et al (36); TD, MED, and PELD have less blood loss than SOD. In terms of trauma, minimally invasive surgery is superior to traditional surgery (43-45). In terms of reoperation rate, MED has a lower rate, followed by PELD; CN has the highest rate. The same conclusion was reached by Wei, et al (36). The possible explanation is that CN dissolves, absorbs, or decomposes the nucleus pulposus tissue through chemical methods, so that it no longer compresses or stimulates the nerves, and achieves local decompression, achieving a therapeutic effect. However, CN cannot accurately control the slowing down of the dissolution rate of the nucleus pulposus tissue, resulting in poor therapeutic effects and a high recurrence rate (46). SOD, MD ,and MED have better efficacy on functional scores SF36-BP and SF36-PF; SOD performed the best, which is consistent with Rasouli, et al (47).

Limitations

Our study has several limitations. First, follow-up data were not reported in every included study, and the follow-up time varied from several months to 8 years, which affected the accuracy of the study to some extent. Second, the different surgical procedures led to different complications; there was no consensus on the definition and classification of what entailed a complication. Thus, heterogeneity existed, and certain bias was produced. Third, there were some nonsurgical factors that also affected the self-reported outcomes, such as rehabilitation and pain management, which also caused a certain bias in our study results.

Conclusions

As patients with LDH have become younger, minimally invasive surgical techniques have been increasingly accepted owing to the advantages of less intraoperative blood loss, a shorter hospital stay, and no need of large-area lumbar spine fusion. Among them, MED performs the best in alleviating early postoperative pain. However, it often leads to various complications, and the MED procedure is difficult to perform. In addition, PELD, a minimally invasive surgery that is performed under local anesthesia and uses transforaminal endoscopy for manipulations, has fewer complications and is related to a higher postoperative ODI score. Thus, PELD is the most prevalent surgical technique in clinical.

Authors' Contributions

Conceptualization: LQ, DY.
Data collection: LQ, XQJ, WLG.
Investigation: LQ, SSZ.
Resources: WLG, DY.
Software: LQ,DY, SSZ.
Writing-original draft: LQ, XQJ, WLG
Writing-review and editing: LQ, SSZ, DY.

All authors agree to be accountable for all aspects of the work, thereby ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All authors approved the final version of the manuscript.

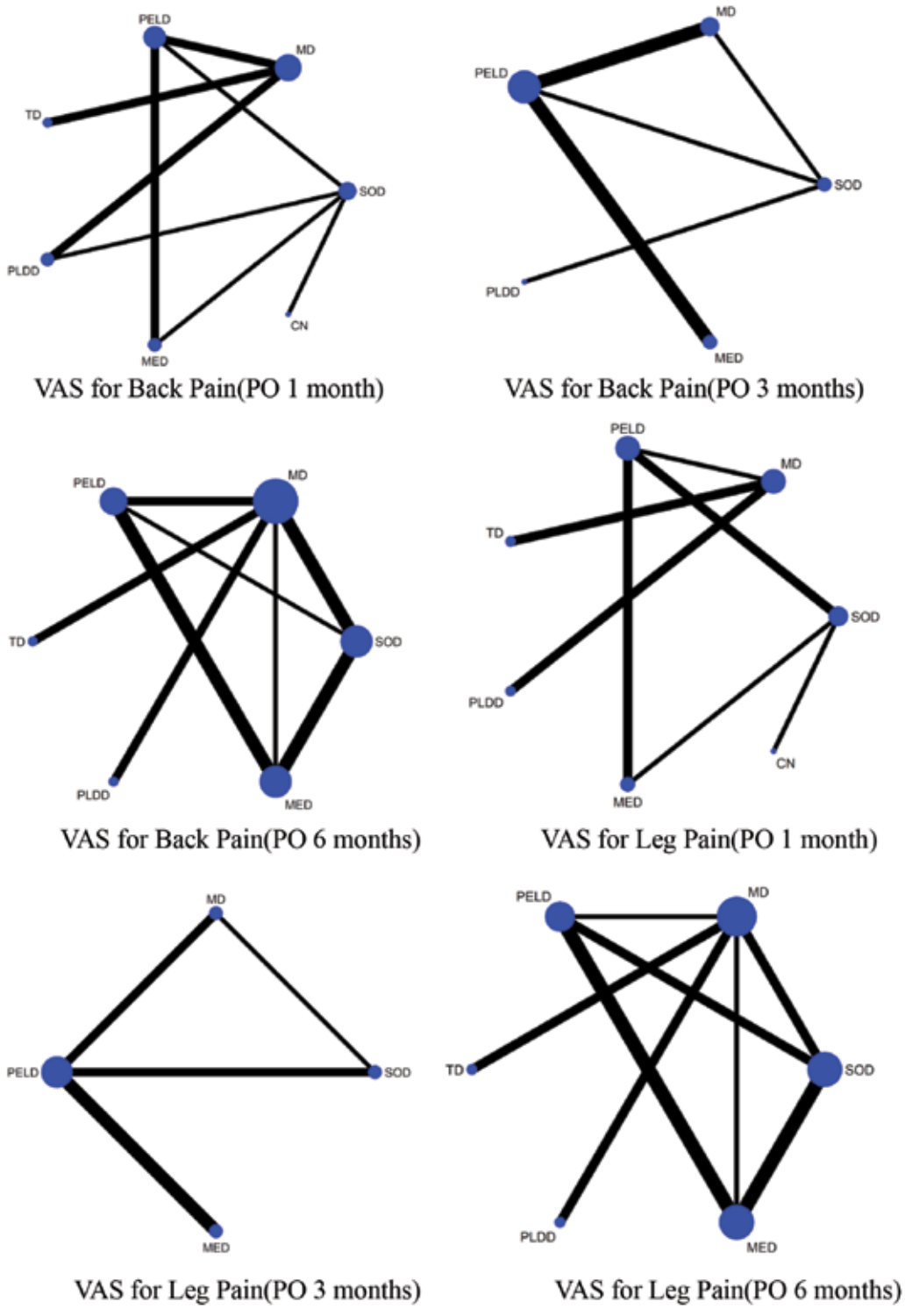
References

1. Takahashi H, Aoki Y, Inoue M, et al. Characteristics of relief and residual low back pain after discectomy in patients with lumbar disc herniation: Analysis using a detailed visual analog scale. *BMC Musculoskel Dis* 2021; 22:1-9.
2. Roiha M, Marjamaa J, Siironen J, et al. Favorable long-term health-related quality of life after surgery for lumbar disc herniation in young adult patients. *Acta Neurochir* 2023; 165:797-805.
3. Blamoutier A. Surgical discectomy for lumbar disc herniation: Surgical techniques. *Orthop Traumatol Surg Res* 2013; 99:S187-S196.
4. Li, Q, Zhou, Y. Comparison of conventional fenestration discectomy with transforaminal endoscopic lumbar discectomy for treating lumbar disc herniation: Minimum 2-year long-term follow-up in 1100 patients. *BMC Musculoskel Dis* 2020; 21:1-6.
5. Hamawandi SA, Sulaiman II, Al-Humairi AK. Open fenestration discectomy versus microscopic fenestration discectomy for lumbar disc herniation: A randomized controlled trial. *BMC Musculoskel Dis* 2020; 21:384.
6. Nordberg CL, Boesen M, Fournier GL, Bliddal H, Hansen P, Hansen BB. Positional changes in lumbar disc herniation during standing or lumbar extension: A cross-sectional weight-bearing MRI study. *Eur Radiol* 2021; 31:804-812.
7. Cong L, Zhu Y, Tu G. A meta-analysis of endoscopic discectomy versus open discectomy for symptomatic lumbar disk herniation. *Eur Spine J* 2016; 25:134-143.
8. Kreiner DS, Hwang SW, Easa JE, et al. An evidence-based clinical guideline for the diagnosis and treatment of lumbar disc herniation with radiculopathy. *Spine J* 2014; 14:180-191.
9. Righesso O, Falavigna A, Avanzi O. Comparison of open discectomy with microendoscopic discectomy in lumbar disc herniations: Results of a randomized controlled trial. *Neurosurgery* 2007; 61:545-549.
10. Riesenburger RI, David CA. Lumbar microdiscectomy and microendoscopic discectomy. *Minim Invasive Ther Allied Technol* 2006; 15:267-270.
11. Shi R, Wang F, Hong X, et al. Comparison of percutaneous endoscopic lumbar discectomy versus microendoscopic discectomy for the treatment of lumbar disc herniation: A meta-analysis. *Int Orthop* 2019; 43:923-937.
12. Xie TH, Zeng JC, Li ZH, et al. Complications of lumbar disc herniation following full-endoscopic interlaminar lumbar discectomy: A large, single-center, retrospective study. *Pain Physician* 2017; 20:E379-E387.
13. Schenk B, Brouwer PA, Peul WC, van Buchem MA. Percutaneous laser disk decompression: A review of the literature. *Am J Neuroradiol* 2006; 27:232-235.
14. Clark AJ, Safaee MM, Khan NR, Brown MT, Foley KT. Tubular microdiscectomy: Techniques, complication avoidance, and review of the literature. *Neurosurg Focus* 2017; 43:E7.
15. Bhatia PS, Chhabra HS, Mohapatra B, Nanda A, Sangodimath G, Kaul R. Microdiscectomy or tubular discectomy: Is any of them a better option for management of lumbar disc prolapse. *J Craniovertebr Junction Spine* 2016; 7:146-152.
16. Simmons JW, Nordby EJ, Hadjipavlou AG. Chemonucleolysis: The state of the art. *Eur Spine J* 2001; 10:192-202.
17. Bombieri FF, Shafafy R, Elsayed S. Complications associated with lumbar discectomy surgical techniques: A systematic review. *J Spine Surg* 2022; 8:377-389.
18. Yang CC, Chen CM, Lin MHC, et al. Complications of full-endoscopic lumbar discectomy versus open lumbar microdiscectomy: A systematic review and meta-analysis. *World Neurosurg* 2022; 168:333-348.
19. Lee JS, Kim HS, Pee YH, Jang JS, Jang IT. Comparison of percutaneous endoscopic lumbar diskectomy and open lumbar microdiskectomy for recurrent lumbar disk herniation. *J Neurol Surg A Cent Eur Neurosurg* 2018; 79:447-452.
20. Higgins JP, Altman DG, Gøtzsche PC, et al. The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. *BMJ* 2011; 343:d5928.
21. Wan X, Wang W, Liu J, Tong T. Estimating the sample mean and standard deviation from the sample size, median, range and/or interquartile range. *BMC Med Res Methodol* 2014;

14:135.

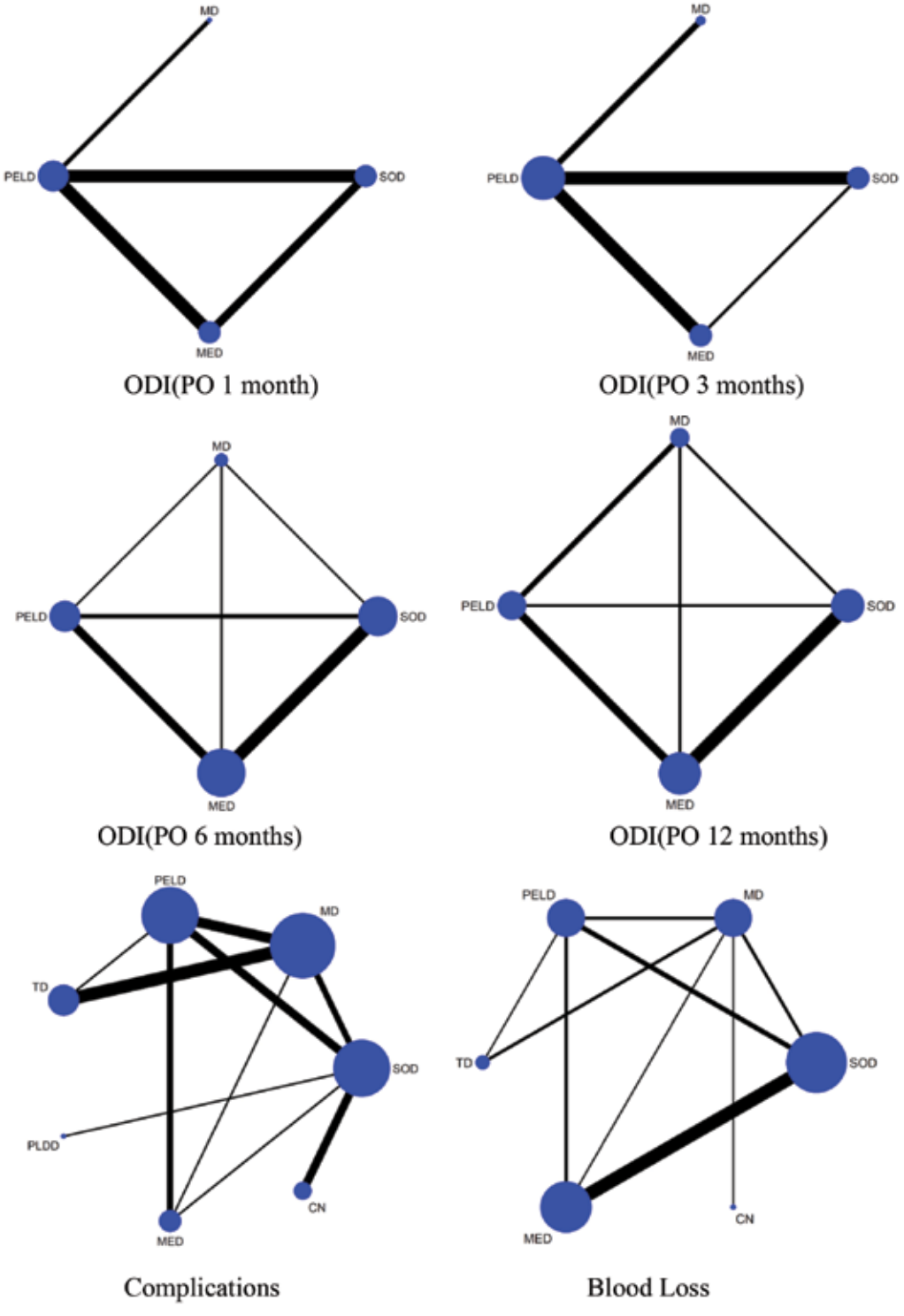
22. Higgins JP, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta-analyses, *BMJ* 2003; 327:557-560.
23. Chaimani A, Higgins JP, Mavridis D, Spyridonos P, Salanti G. Graphical tools for network meta-analysis in STATA. *PLoS One* 2013; 8:e76654.
24. Higgins JP, Jackson D, Barrett JK, Lu G, Ades AE, White IR. Consistency and inconsistency in network meta-analysis: Concepts and models for multi-arm studies. *Res Synth Methods* 2012; 3:98-110.
25. White IR, Barrett JK, Jackson D, Higgins JP. Consistency and inconsistency in network meta-analysis: Model estimation using multivariate meta-regression. *Res Synth Methods* 2012; 3:111-125.
26. Dias S, Welton NJ, Caldwell DM, Ades AE. Checking consistency in mixed treatment comparison meta-analysis. *Stat Med* 2010; 29:932-944.
27. Zhang Q, Qian J, Zhu Y. Meta-analysis on microdiscectomy and sequestrectomy for lumbar disc herniation. *J Invest Surg* 2015; 28:225-229.
28. Yu P, Mao F, Chen J, et al. Characteristics and mechanisms of resorption in lumbar disc herniation. *Arthritis Res Ther* 2022; 24:205.
29. Amin RM, Andrade NS, Neuman BJ. Lumbar disc herniation. *Curr Rev Musculoskelet Med* 2017; 10:507-516.
30. Kim M, Lee S, Kim HS, Park S, Shim SY, Lim DJ. A comparison of percutaneous endoscopic lumbar discectomy and open lumbar microdiscectomy for lumbar disc herniation in the Korean: A meta-analysis. *Biomed Res Int* 2018; 2018:9073460.
31. Alvi MA, Kerezoudis P, Wahood W, Goyal A, Bydon M. Operative approaches for lumbar disc herniation: A systematic review and multiple treatment meta-analysis of conventional and minimally invasive surgeries. *World Neurosurg* 2018; 114:391-407.
32. Ding W, Yin J, Yan T, Nong L, Xu N. Meta-analysis of percutaneous transforaminal endoscopic discectomy vs. fenestration discectomy in the treatment of lumbar disc herniation. *Orthopade* 2018; 47:574-584.
33. He J, Xiao S, Wu Z, Yuan Z. Microendoscopic discectomy versus open discectomy for lumbar disc herniation: a meta-analysis. *Eur Spine J* 2016; 25:1373-1381.
34. Phan K, Xu J, Schultz K, et al. Full-endoscopic versus micro-endoscopic and open discectomy: A systematic review and meta-analysis of outcomes and complications. *Clin Neurol Neurosurg* 2017; 154:1-12.
35. Wei FL, Zhou CP, Zhu KL, et al. Comparison of different operative approaches for lumbar disc herniation: A network meta-analysis and systematic review. *Pain Physician* 2021; 24:E381-E392.
36. Wei FL, Li T, Gao QY, et al. Eight surgical interventions for lumbar disc herniation: A network meta-analysis on complications. *Front Surg* 2021; 8:679142.
37. Chen X, Chamoli U, Lapkin S, Castillo JV, Diwan AD. Complication rates of different discectomy techniques for the treatment of lumbar disc herniation: A network meta-analysis. *Eur Spine J* 2019; 28:2588-2601.
38. Feng F, Xu Q, Yan F, et al. Comparison of 7 surgical interventions for lumbar disc herniation: A network meta-analysis. *Pain Physician* 2017; 20:E863-E871.
39. Li CH, Yew AY, Kimball JA, McBride DQ, Wang JC, Lu DC. Comparison of operating field sterility in open versus minimally invasive microdiscectomies of the lumbar spine. *Surg Neurol Int* 2013; 4:S295-S298.
40. Belykh E, Giers MB, Preul MC, Theodore N, Byvaltsev V. Prospective comparison of microsurgical, tubular-based endoscopic, and endoscopically assisted diskectomies: Clinical effectiveness and complications in railway workers. *World Neurosurg* 2016; 90:273-280.
41. Teli M, Lovi A, Brayda-Bruno M, et al. Higher risk of dural tears and recurrent herniation with lumbar micro-endoscopic discectomy. *Eur Spine J* 2010; 19:443-450.
42. Nakagawa H, Kamimura M, Uchiyama S, Takahara K, Itsubo T, Miyasaka T. Microendoscopic discectomy (MED) for lumbar disc prolapse. *J Clin Neurosci* 2003; 10:231-235.
43. Hussein M, Abdeldayem A, Mattar MM. Surgical technique and effectiveness of microendoscopic discectomy for large uncontained lumbar disc herniations: A prospective, randomized, controlled study with 8 years of follow-up. *Eur Spine J* 2014; 23:1992-1999.
44. Garg B, Nagraja UB, Jayaswal A. Microendoscopic versus open discectomy for lumbar disc herniation: A prospective randomised study. *J Orthop Surg (Hong Kong)* 2011; 19:30-34.
45. Huang TJ, Hsu RW, Li YY, Cheng CC. Less systemic cytokine response in patients following microendoscopic versus open lumbar discectomy. *J Orthop Res* 2005; 23:406-411.
46. Jenner JR, Buttle DJ, Dixon AK. Mechanism of action of intradiscal chymopapain in the treatment of sciatica: A clinical, biochemical, and radiological study. *Ann Rheum Dis* 1986; 45:441-449.
47. Rasouli MR, Rahimi-Movaghar V, Shokraneh F, Moradi-Lakeh M, Chou R. Minimally invasive discectomy versus microdiscectomy/open discectomy for symptomatic lumbar disc herniation. *Cochrane Database Syst Rev* 2014; CD010328.

A



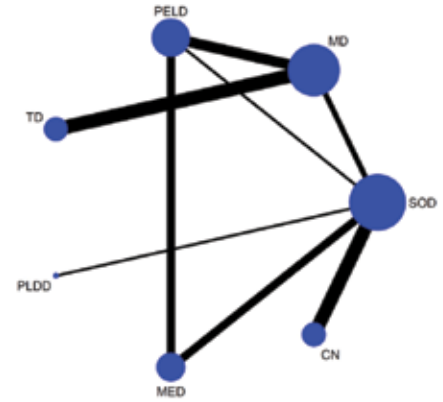
Supplemental Fig 1. *Network plots of all outcomes (PO = postoperative).*

B

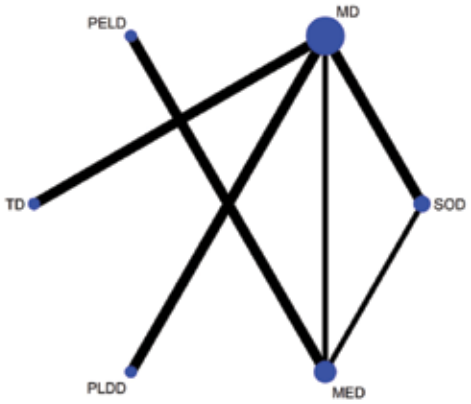


Supplemental Fig 1 continued. *Network plots of all outcomes (PO = postoperative).*

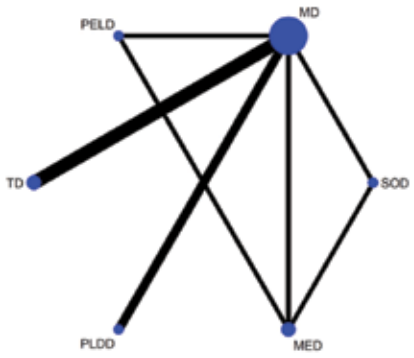
C



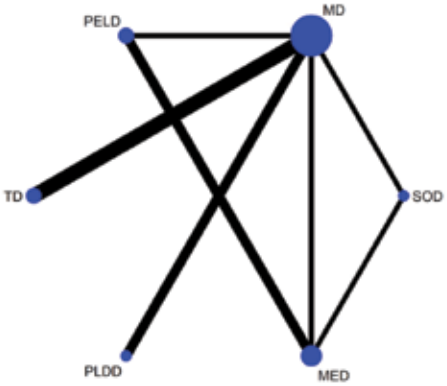
Reoperation Rate



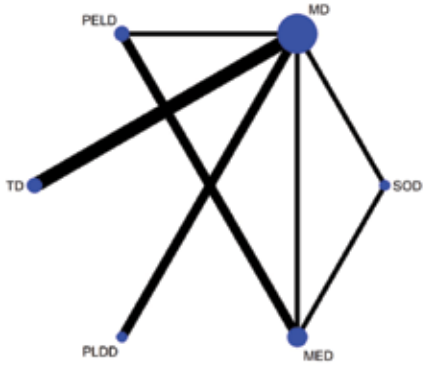
SF36-BP(PO 6 months)



SF36-BP(PO 12 months)



SF36-PF(PO 6 months)

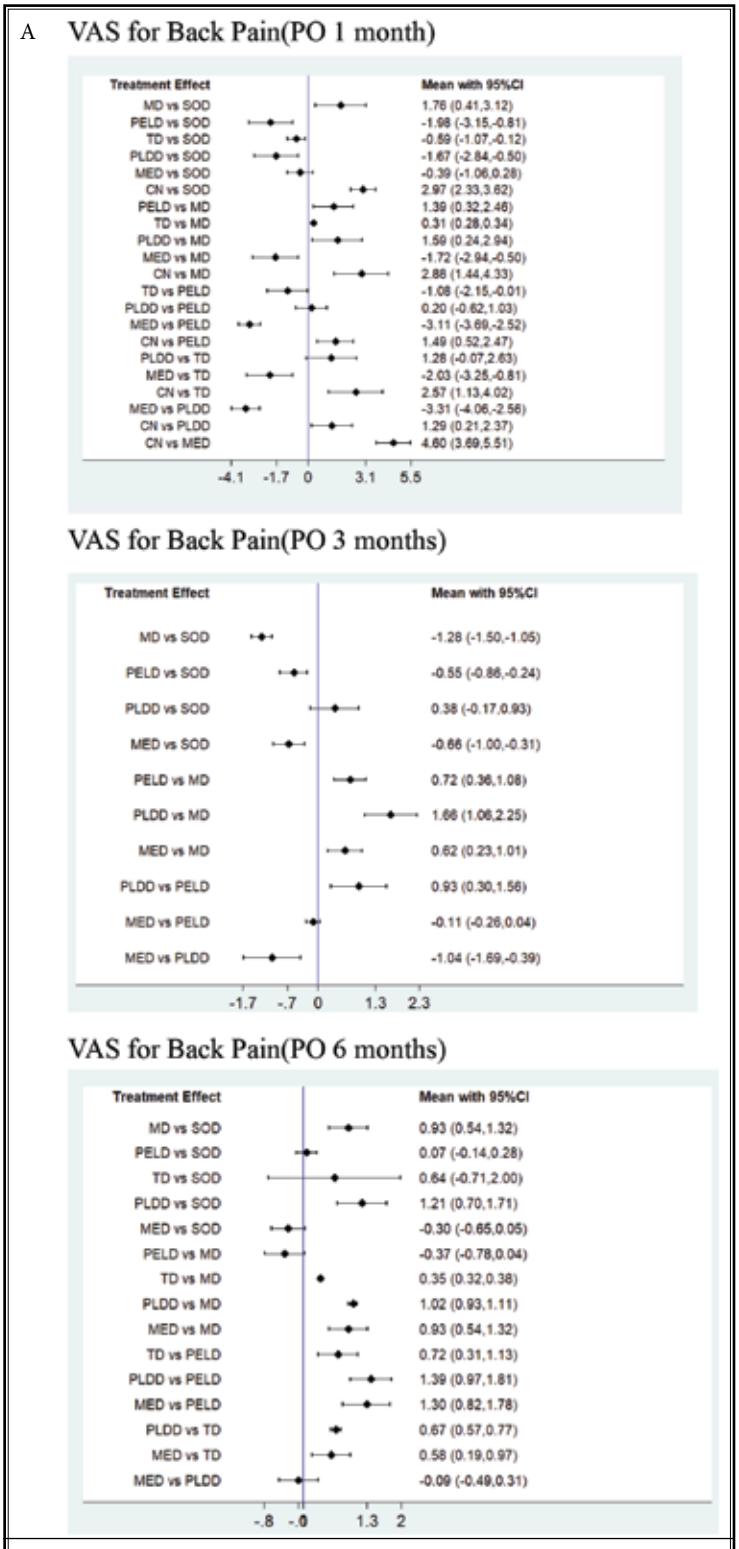


SF36-PF(PO 12 months)

VAS: Visual Analogue Scale
ODI: Oswestry disability index
SF36-BP: Short Form-36 Bodily Pain
SF36-PF: Short Form-36 Physical Function

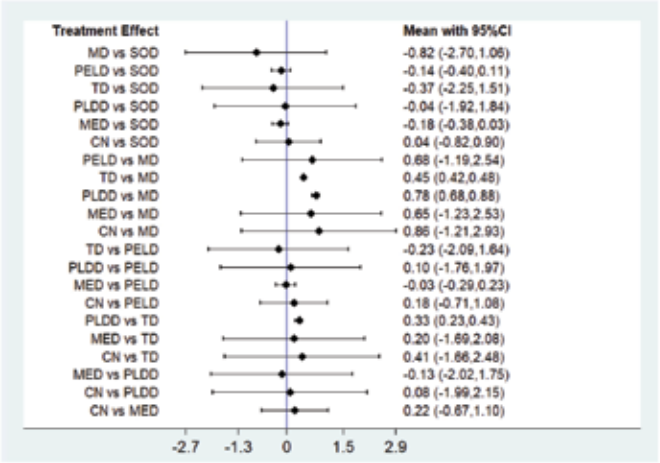
Supplemental Fig 1 continued. *Network plots of all outcomes (PO = postoperative)*.

A

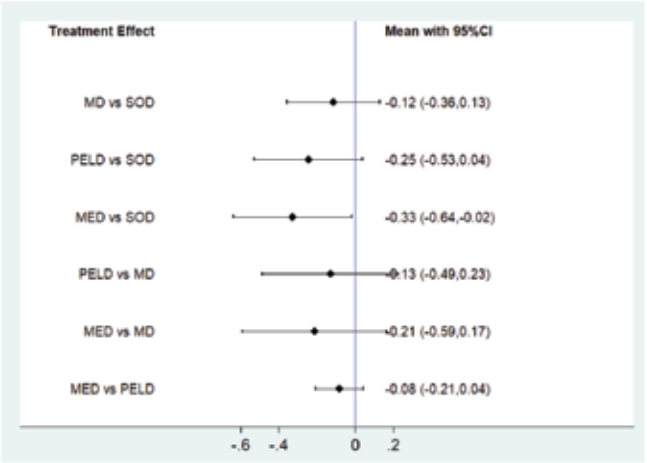


Supplemental Fig 2. ***Forest plots of all outcomes (PO = postoperative)***.

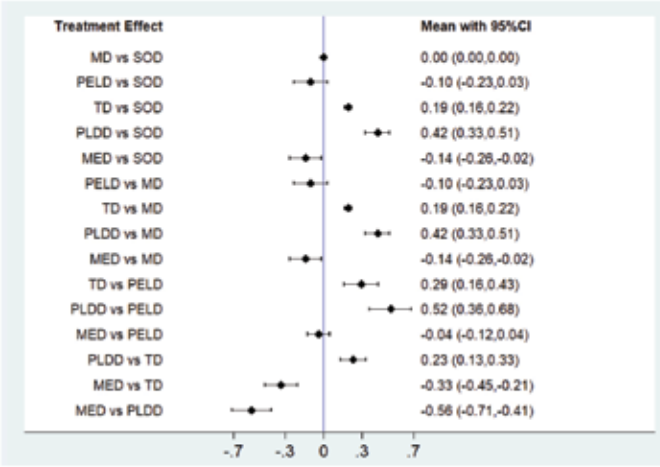
B VAS for Leg Pain(PO 1 month)



VAS for Leg Pain(PO 3 months)

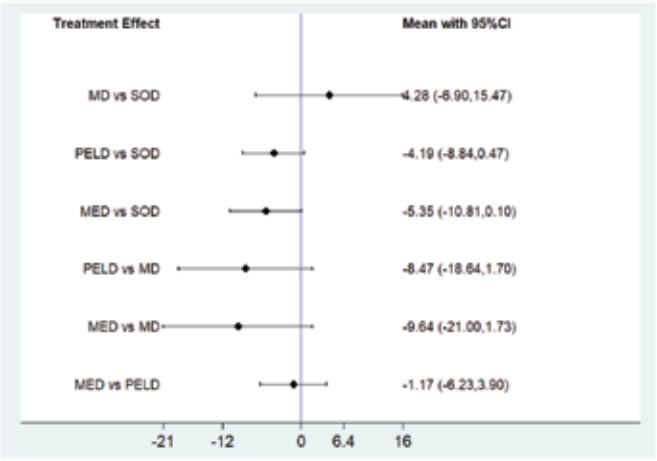


VAS for Leg Pain(PO 6 months)

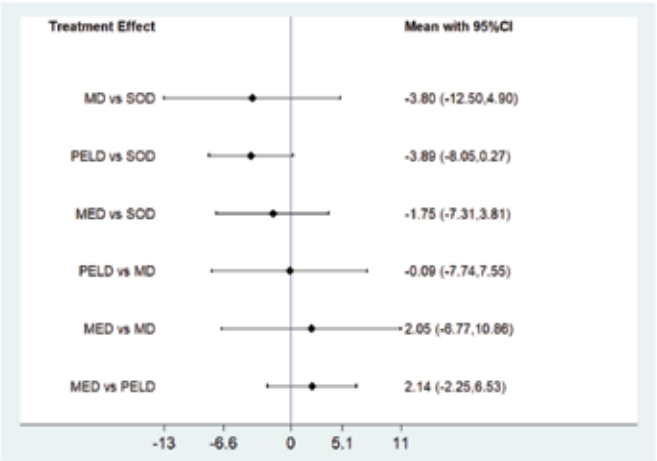


Supplemental Fig 2 continued. ***Forest plots of all outcomes (PO = postoperative)***.

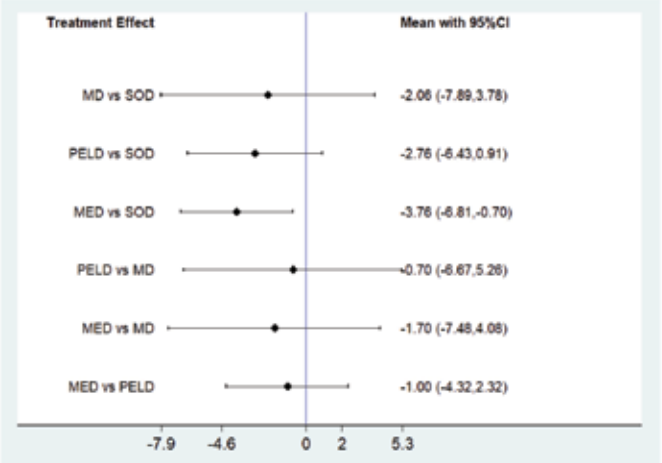
C ODI(PO 1 month)



ODI(PO 3 months)



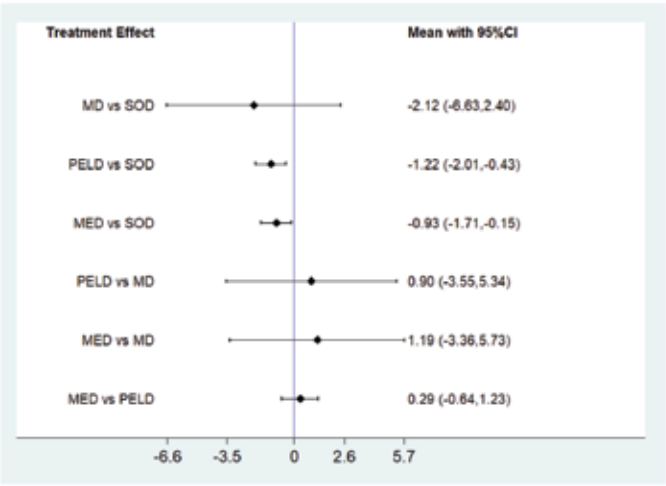
ODI(PO 6 months)



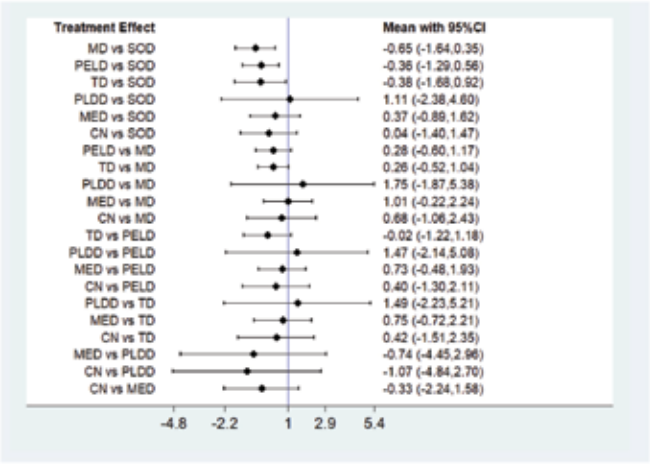
Supplemental Fig 2 continued. ***Forest plots of all outcomes (PO = postoperative)***.

D

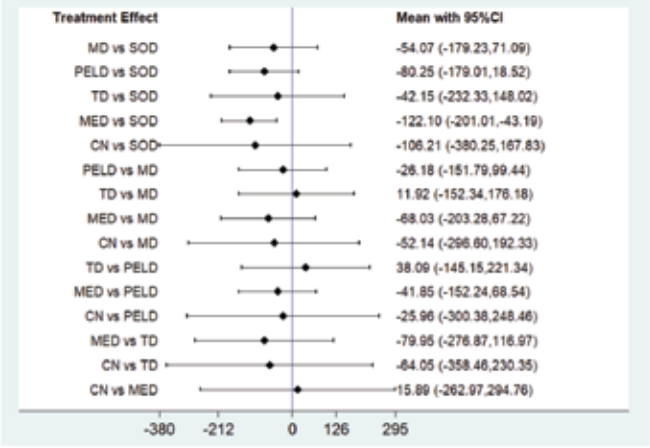
ODI(PO 12 months)



Complications



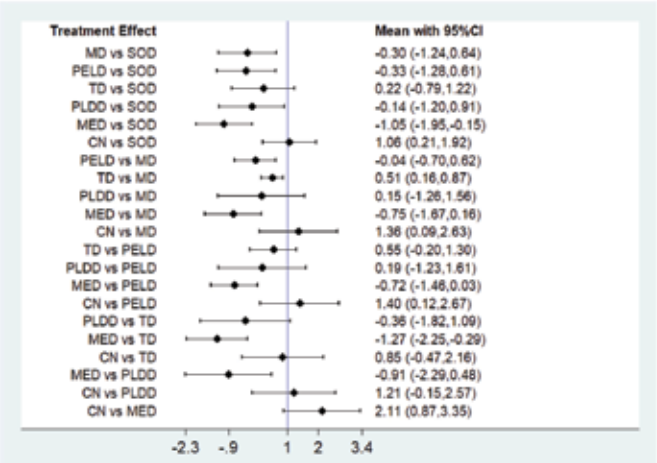
Blood Loss



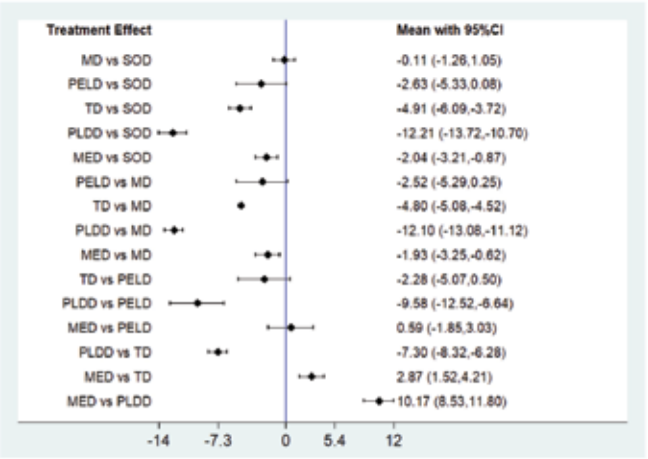
Supplemental Fig 2 continued. ***Forest plots of all outcomes (PO = postoperative)***.

E

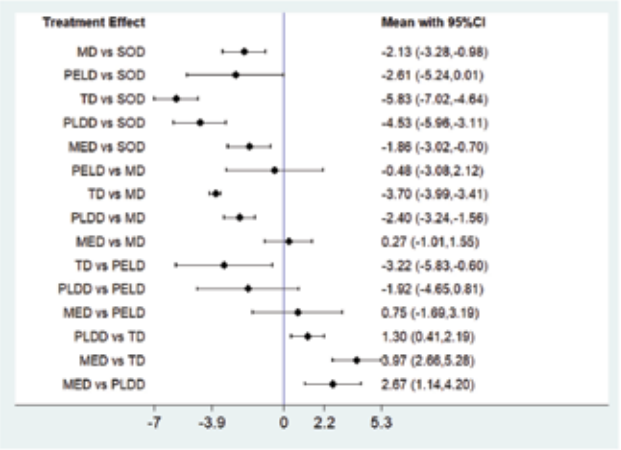
Reoperation Rate



SF36-BP(PO 6 months)

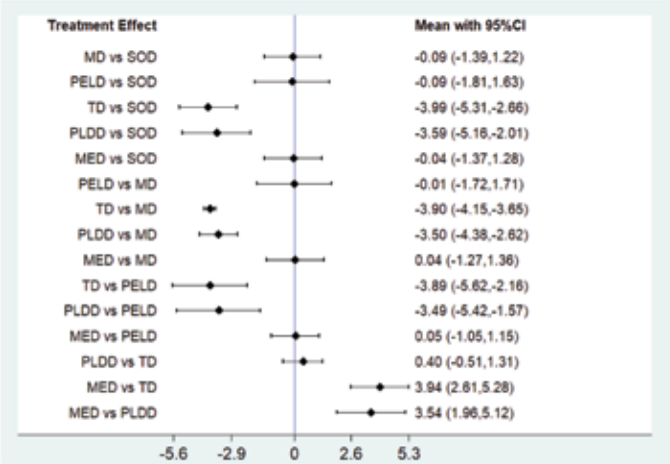


SF36-BP(PO 12 months)

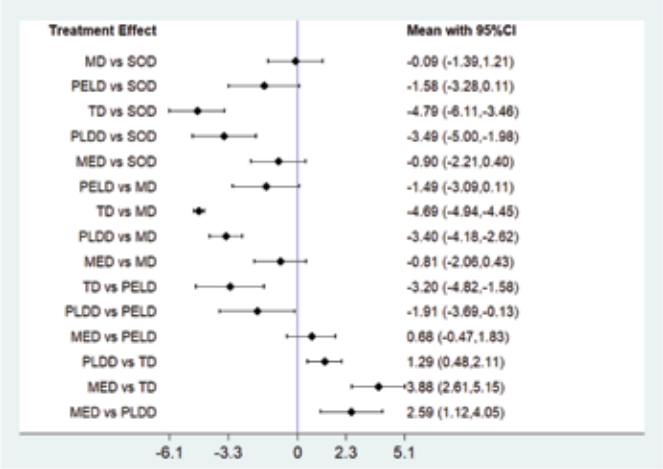


Supplemental Fig 2 continued. ***Forest plots of all outcomes (PO = postoperative)***.

F SF36-PF(PO 6 months)

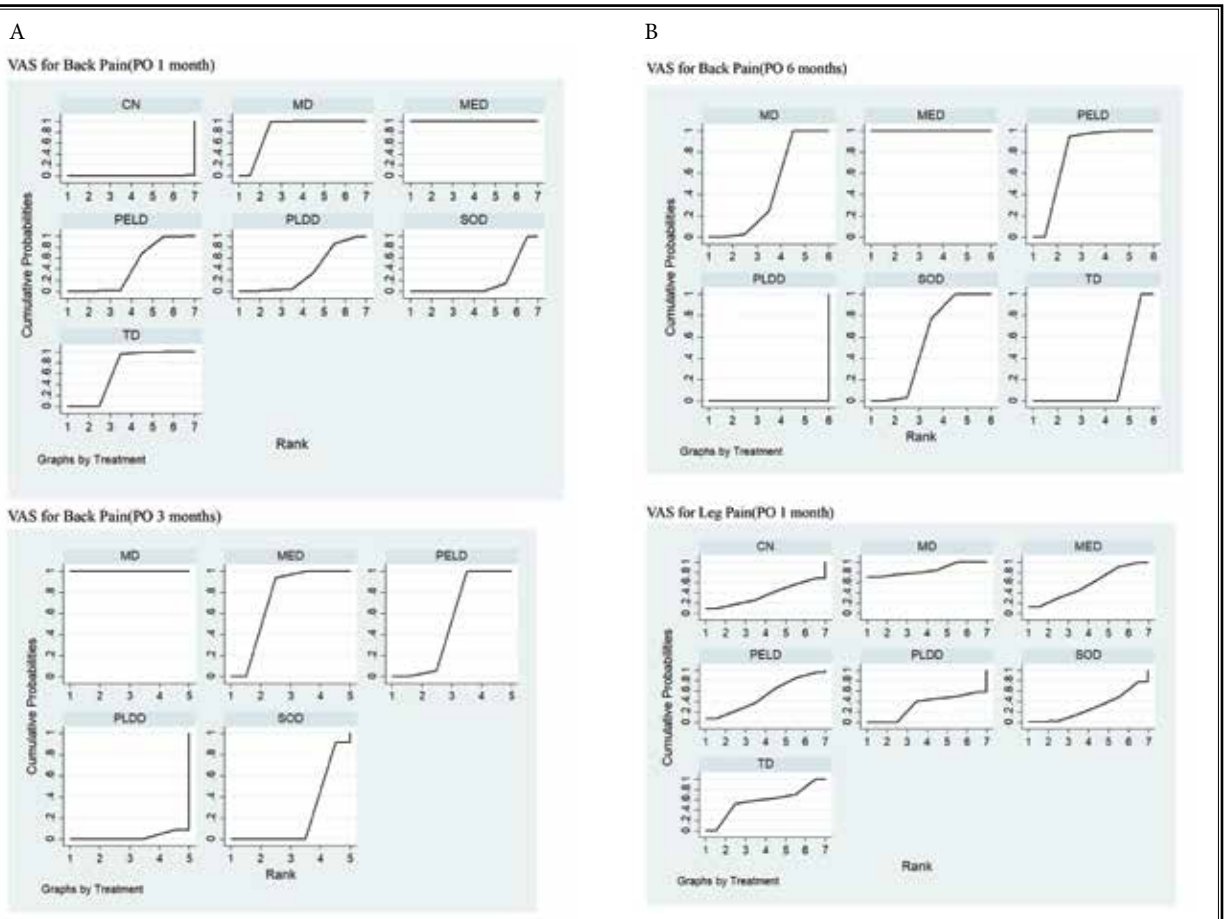


SF36-PF(PO 12 months)

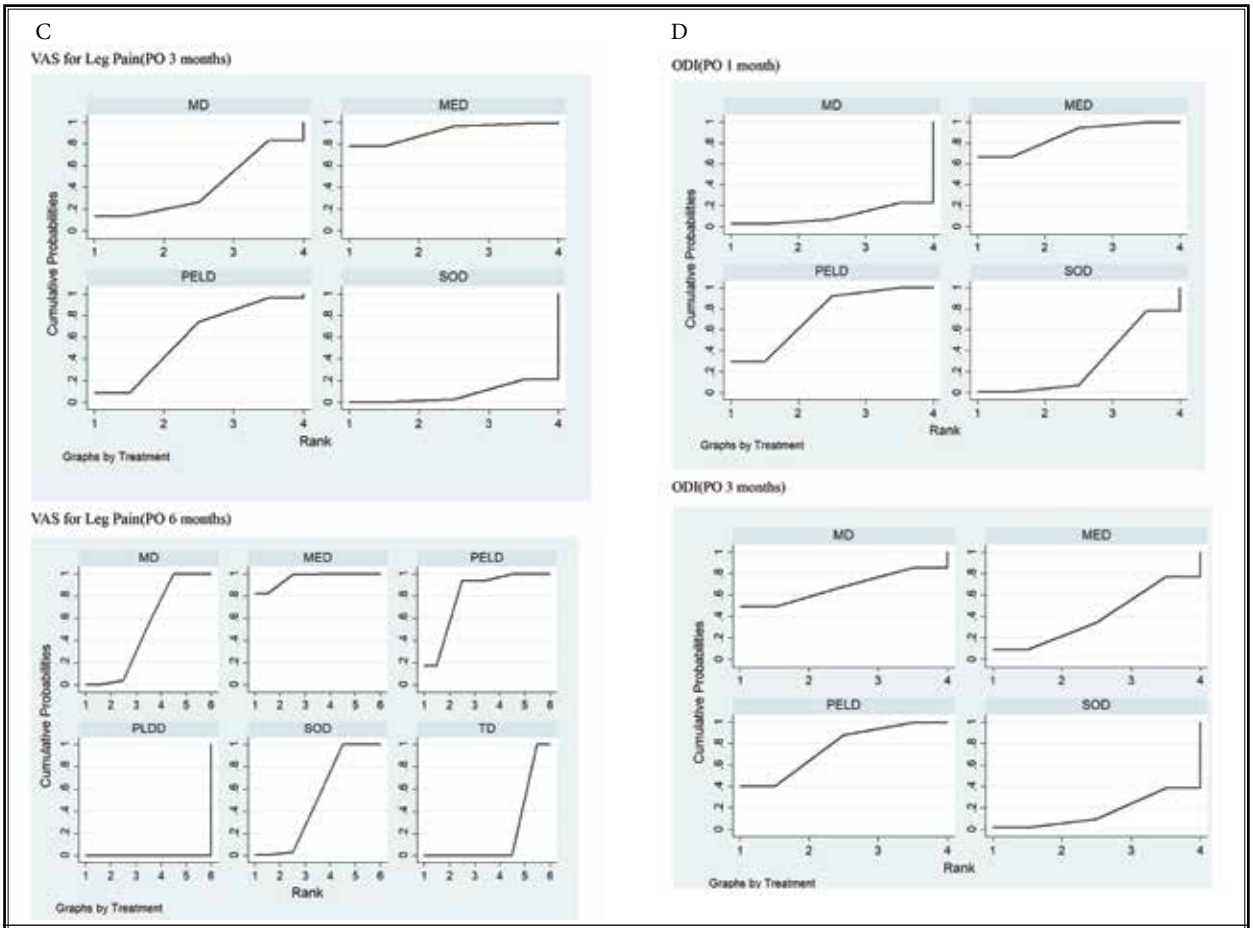


VAS: Visual Analogue Scale
ODI: Oswestry disability index
SF36-BP: Short Form-36 Bodily Pain
SF36-PF: Short Form-36 Physical Function

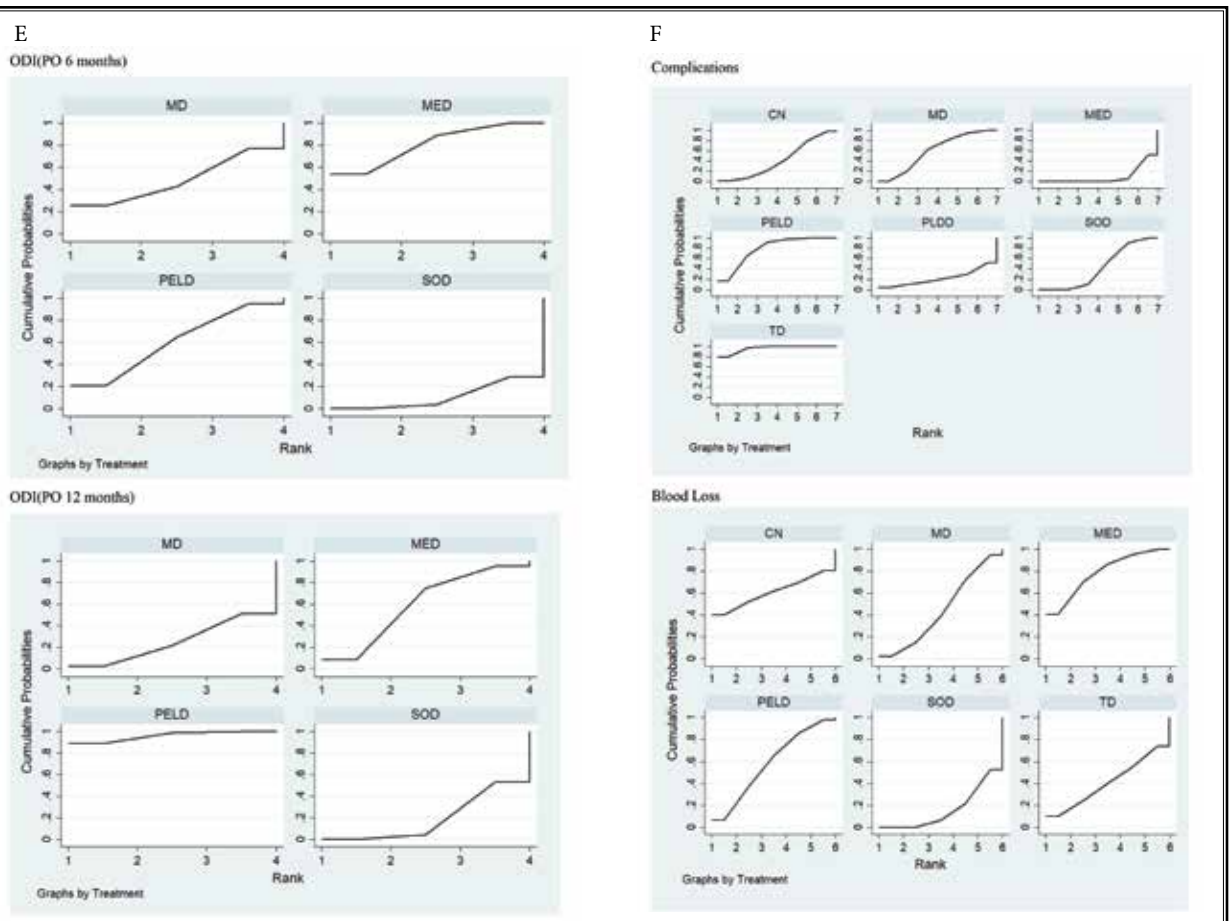
Supplemental Fig 2 continued. ***Forest plots of all outcomes (PO = postoperative)***.



Supplemental Fig 3. ***Surface under the cumulative ranking (SUCRA) of all outcomes (PO = postoperative).***

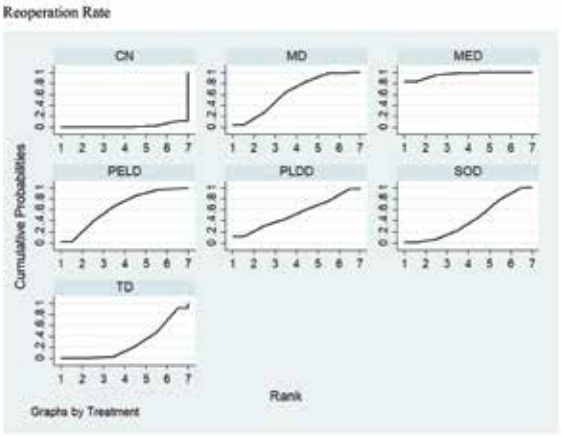


Supplemental Fig 3 continued. ***Surface under the cumulative ranking (SUCRA) of all outcomes (PO = postoperative).***

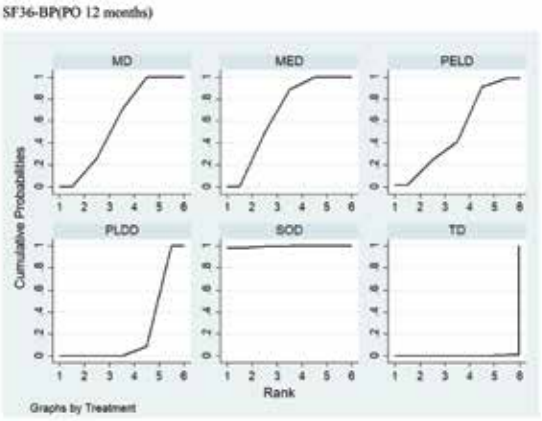


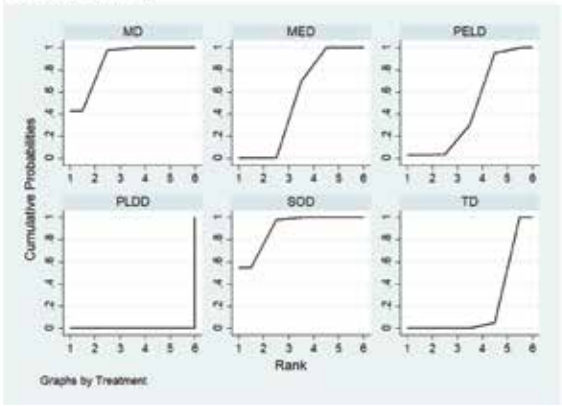
Supplemental Fig 3 continued. ***Surface under the cumulative ranking (SUCRA) of all outcomes (PO = postoperative).***

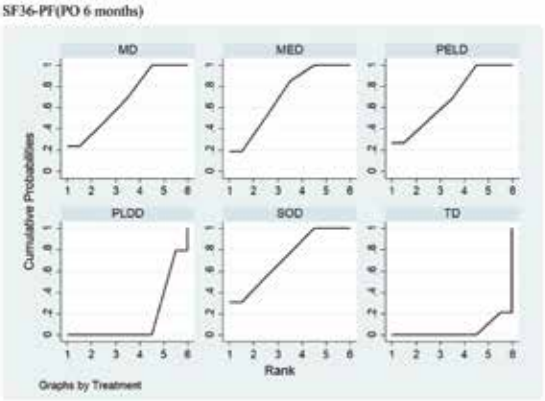
G



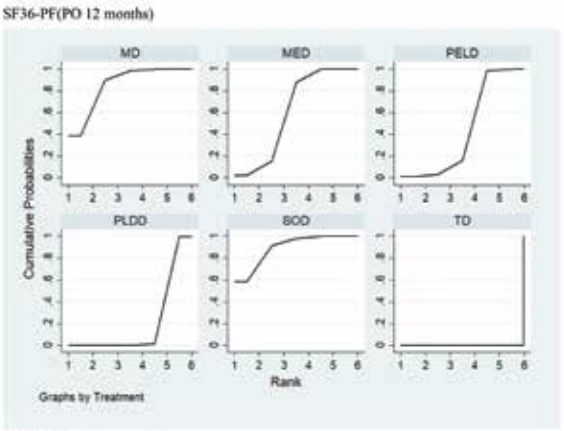
H





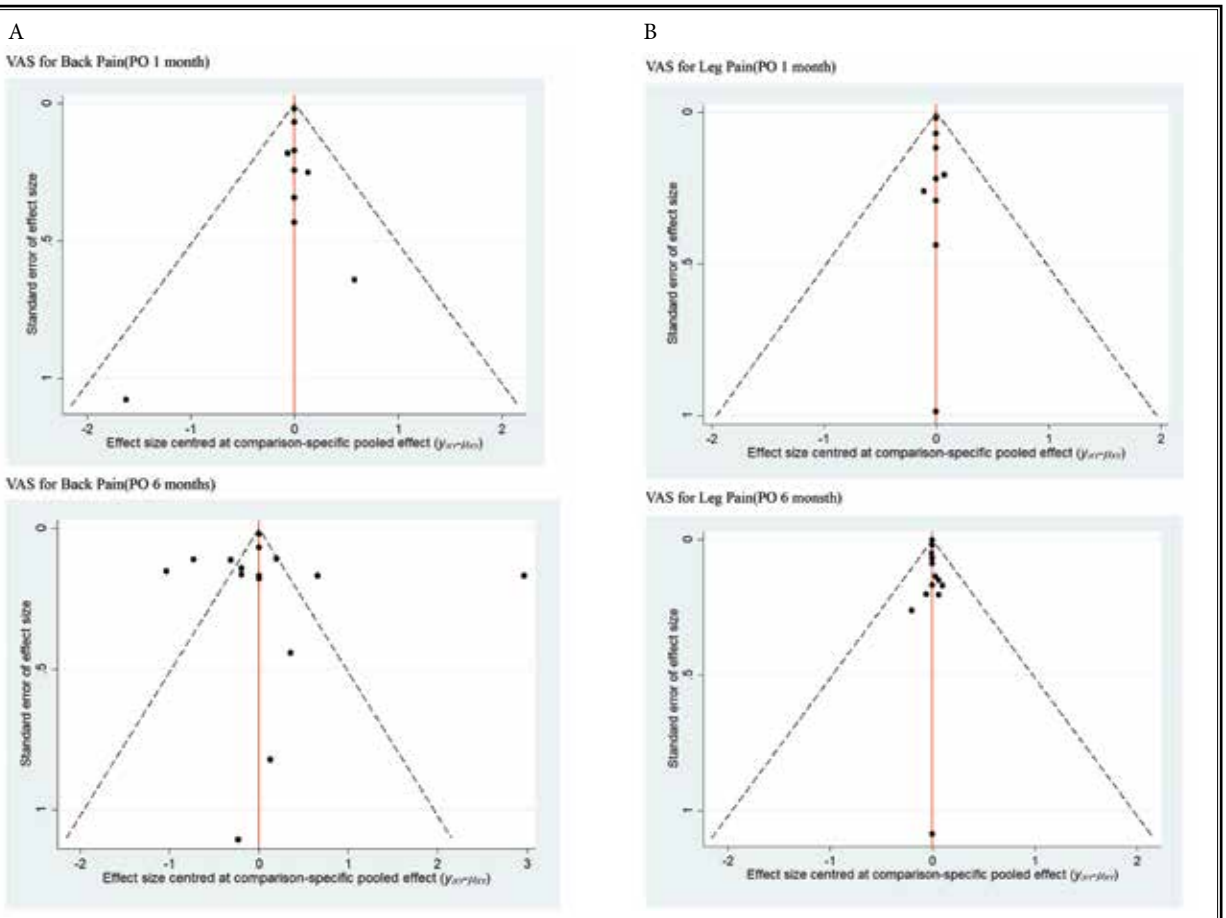


I

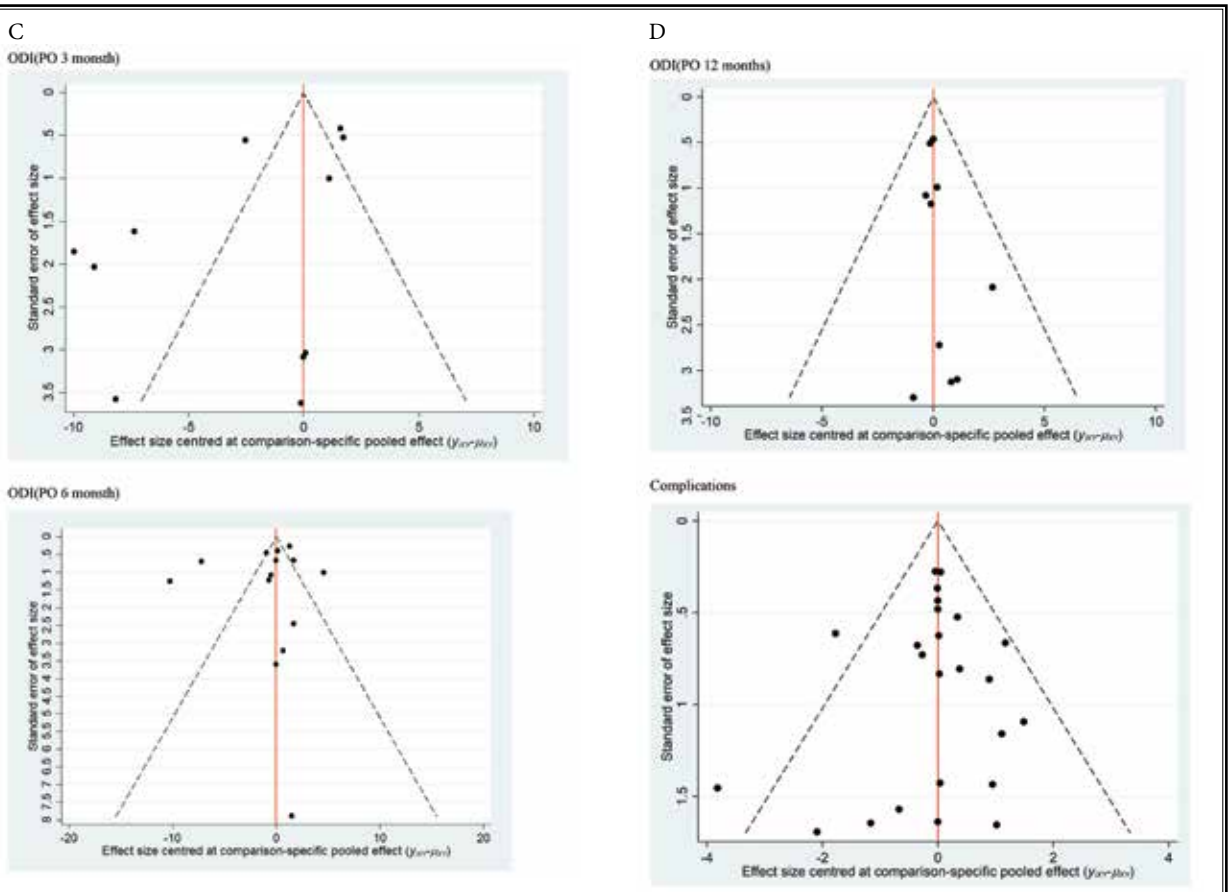


VAS: Visual Analogue Scale
ODI: Oswestry disability index
SF36-BP: Short Form-36 Bodily Pain
SF36-PF: Short Form-36 Physical Function

Supplemental Fig 3 continued. ***Surface under the cumulative ranking (SUCRA) of all outcomes (PO = postoperative).***

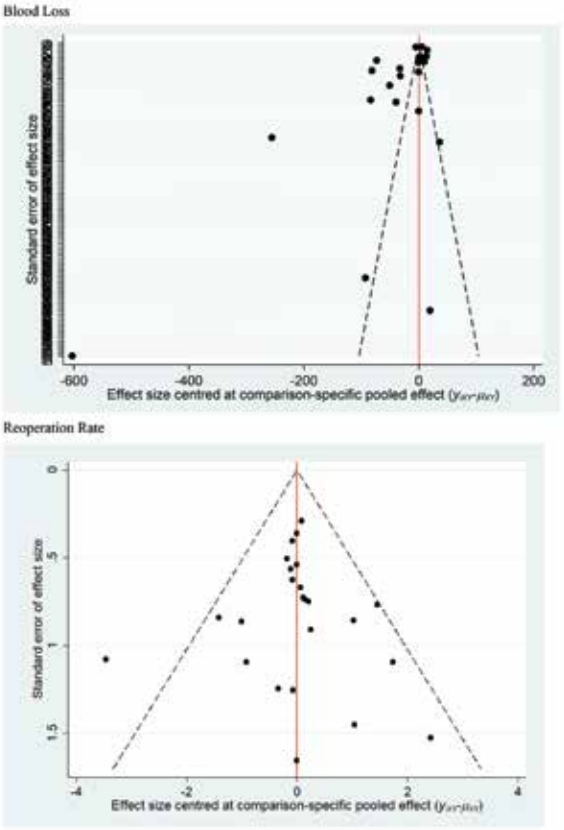


Supplemental Fig 4. ***Funnel plots of all outcomes (PO= postoperative)***.



Supplemental Fig 4 continued. ***Funnel plots of all outcomes (PO= postoperative)***.

E



Supplemental Fig 4 continued. ***Funnel plots of all outcomes (PO= postoperative)***.

Supplemental Table 1. *Node-splitting results of all outcomes.*
Primary Outcomes
SOD: Standard Open Discectomy; MD: Micro-discectomy; TD: Tubular Discectomy;
PELD: Percutaneous Endoscopic Lumbar Discectomy; CN: Chemonucleolysis;
PLDD: Percutaneous Laser Disc Decompression; MED: Micro-endoscopic Discectomy
Visual Analog Scale (VAS)

1. VAS for Back Pain
(1) Postoperative one month

Treatment Contrast	Direct		Indirect		Difference		*P* > |z|
	Coef.	SE	Coef.	SE	Coef.	SE	
A vs C	-0.5999999	1.148675	-1.736256	1.07081	1.136256	1.572611	0.470
A vs E	-0.3899999	1.003946	-2.856684	1.312616	2.477784	1.652534	0.136
A vs F	-3.7	0.1710461	-0.5108221	0.2708543	-3.189178	0.3203417	0.000
B vs C	1.149438	0.8889403	-1.607194	1.353145	2.756632	1.619434	0.089
B vs D*	0.3099999	0.7776418	3.25582	8.379515	-2.94582	8.415522	0.726
B vs E	-0.169999	0.667823	2.357516	1.516246	-2.527515	1.656801	0.127
C vs F	-0.1320257	0.1465535	-3.321199	0.2848585	3.189173	0.3203472	0.000

A: SOD; B:MD; C: PELD; D: PLDD; E:MED; F:CN; *: no evidence is provided in the indirect study

(2) Postoperative 3 months

Treatment Contrast	Direct		Indirect		Difference		*P* > |z|
	Coef.	SE	Coef.	SE	Coef.	SE	
A vs B	-1.3	0.1216004	-1.010919	0.4003315	-0.289081	0.4183921	0.490
A vs C	-0.5	0.176268	-0.7881257	0.379283	0.2881257	0.4182416	0.491
B vs C	0.5110579	0.3594514	0.8001141	0.214128	-0.2890562	0.4183971	0.491
C vs E*	-0.1069248	0.0756198	1.102043	24.83335	-1.208968	24.8335	0.961

A: SOD; B:MD; C: PELD; E: MED; *: no evidence is provided in the indirect study

(3) Postoperative 6 months

Treatment Contrast	Direct		Indirect		Difference		*P* > |z|
	Coef.	SE	Coef.	SE	Coef.	SE	
A vs B	0.5632759	0.4902434	-2.516267	0.954945	3.079543	1.072332	0.004
A vs C	-0.3	1.136833	-0.8826944	0.75656	0.5826944	1.365567	0.670
A vs F	-1.574395	0.6119272	0.0028161	0.9862257	-1.577211	1.160561	0.174
B vs C	0.2434578	1.01817	-1.182433	0.8633924	1.425891	1.33496	0.285
B vs D*	0.3499999	0.7687819	0.2443101	8.237928	-0.1056898	8.273723	0.990
B vs E*	1.02	0.7687012	0.2681395	16.16989	0.7518605	16.18813	0.963
B vs F	-0.0003797	1.059393	-1.558829	0.785219	1.558449	1.318657	0.237
C vs F	0.0309092	0.6116683	-1.504927	0.9510836	1.535836	1.130788	0.174

A: SOD; B:MD; C: PELD; D:TD; E: PLEE; F: MED; *: no evidence is provided in the indirect study

Supplemental Table 1 continued. *Node-splitting results of all outcomes.*
Primary Outcomes

2. VAS for Leg Pain
(1) Postoperative one month

Treatment Contrast	Direct		Indirect		Difference		*P* > |z|
	Coef.	SE	Coef.	SE	Coef.	SE	
A vs C	-0.2893974	0.1616026	0.1011854	0.2102014	-0.3905828	0.2651416	0.141
A vs F	-0.1	0.1170521	-0.4879364	0.2381057	0.3879363	0.2653215	0.144
B vs C*	0.7199988	0.9869775	0.1120761	3.545846	0.6079227	3.680656	0.869
B vs D*	0.45	0.0137454	1.706909	8.074769	-1.256909	8.074783	0.876
B vs E*	0.78	0.0501953	1.666683	16.88897	-0.8866827	16.88903	0.958
B vs F	-0.1999999	0.1750111	0.1879463	0.199411	-0.3879462	0.265318	0.144

A: SOD; B: MD; C: PELD; D:TD; E: PLDD; F: MED; *: no evidence is provided in the indirect study

(2) Postoperative 3 months

Treatment Contrast	Direct		Indirect		Difference		*P* > |z|
	Coef.	SE	Coef.	SE	Coef.	SE	
A vs B	-0.1	0.1290994	-0.3449297	0.4843549	0.2449297	0.5012647	0.625
A vs C	-0.2696018	0.1524811	-0.0244486	0.4769686	-0.2451532	0.500749	0.624
B vs C	0.075406	0.4597371	-0.1695294	0.1997792	0.2449354	0.5012683	0.625
C vs D*	-0.083711	0.0632052	0.4882182	19.95303	-0.5719291	19.95317	0.977

A: SOD; B: MD; C: PELD; D: MED; *: no evidence is provided in the indirect study

(3) Postoperative 6 months

Treatment Contrast	Direct		Indirect		Difference		*P* > |z|
	Coef.	SE	Coef.	SE	Coef.	SE	
A vs B	7.59e-10	0.001	-0.3496308	0.3089004	0.3496308	0.308902	0.258
A vs C	-0.2284728	0.1125648	-0.0291605	0.0844842	-0.1993124	0.1407424	0.157
A vs F	-0.0970032	0.0739358	-0.2410898	0.1114779	0.1440867	0.1337678	0.281
B vs C	0.2900001	1.086658	-0.102493	0.0677071	0.3924931	1.088765	0.718
B vs D*	0.1900001	0.0137454	-0.0040851	7.819951	0.1940852	7.819965	0.980
B vs E*	0.42	0.0477126	0.0056501	15.84945	0.4143498	15.8495	0.979
B vs F	-0.000757	0.1678477	-0.1627506	0.0662008	0.1619936	0.1803182	0.369
C vs F	-0.0599755	0.0452627	0.1318718	0.1329248	-0.1918473	0.1404197	0.172

A: SOD; B: MD; C: PELD; D: TD; E: PLDD; F: MED; *: no evidence is provided in the indirect study

Supplemental Table 1 continued. *Node-splitting results of all outcomes*.

Oswestry Disability Index (ODI)
(1) Postoperative one month

Treatment Contrast	Direct		Indirect		Difference		*P* > |z|
	Coef.	SE	Coef.	SE	Coef.	SE	
A vs C	-0.3140792	2.721996	-7.47921	4.90928	4.338419	5.620738	0.440
A vs D	-7.303485	3.819379	-2.96159	4.114132	-4.341895	5.621725	0.440
B vs C*	-8.47	5.190624	-8.375289	399.8169	-0.0947113	399.8382	1.000
C vs D	0.1790275	3.085396	-4.162279	4.698748	4.341307	5.62199	0.440

A: SOD; B: MD; C: PELD; D: MED; *: no evidence is provided in the indirect study

(2) Postoperative 3 months

Treatment Contrast	Direct		Indirect		Difference		*P* > |z|
	Coef.	SE	Coef.	SE	Coef.	SE	
A vs C	-3.69285	2.389174	-5.324763	6.097995	1.631913	6.553746	0.803
A vs D	-3	5.566568	-1.446795	3.489455	-1.6632-5	6.569854	0.800
B vs C*	-0.0936402	3.899326	-7.783919	611.0824	7.690279	611.0955	0.990
C vs D	2.351939	2.535188	0.7002393	6.055582	1.651699	6.569148	0.801

A: SOD; B: MD; C: PELD; D: MED; *: no evidence is provided in the indirect study

(3) Postoperative 6 months

Treatment Contrast	Direct		Indirect		Difference		*P* > |z|
	Coef.	SE	Coef.	SE	Coef.	SE	
A vs B	-0.0004713	3.870901	-5.060591	4.70023	5.060119	3.089354	0.406
A vs C	-1.729245	2.855256	-3.632253	2.650004	1.903008	3.84977	0.625
A vs D	-4.187109	1.813276	-2.056659	3.546018	-2.13045	3.981417	0.593
B vs C	-2.699987	5.360264	-0.9237722	3.886296	0.6537735	6.620855	0.921
B vs D	-0.0005606	3.918658	-4.045163	4.630688	4.044602	6.066569	0.505
C vs D	-0.3503298	2.130649	-2.335103	3.075415	1.984774	3.741007	0.596

A: SOD; B: MD; C: PELD; D: MED; *: no evidence is provided in the indirect study

(4) Postoperative 12 months

Treatment Contrast	Direct		Indirect		Difference		*P* > |z|
	Coef.	SE	Coef.	SE	Coef.	SE	
A vs C	-1.50001	0.4626029	-0.2914494	0.8420338	-1.208551	0.9607405	0.208
A vs D	-0.6606561	0.4513132	-1.869151	0.8481389	1.208495	0.960741	0.208
B vs C	0.8954598	2.268259	-2.107974	540.5861	3.003433	540.595	0.996
C vs D	-0.3691907	0.7108801	0.8393385	0.6462851	-1.208529	0.9607478	0.208

A: SOD; B: MD; C: PELD; D: MED; *: no evidence is provided in the indirect study

Supplemental Table 1 continued. *Node-splitting results of all outcomes*.

Complications

Treatment Contrast	Direct		Indirect		Difference		*P* > |z|
	Coef.	SE	Coef.	SE	Coef.	SE	
A vs B	-0.1225968	0.5994935	-1.502986	0.7937355	1.380389	0.9825779	0.160
A vs C	-0.9805461	0.5594823	0.5336831	0.657227	-1.514229	0.863508	0.080
A vs F	1.177141	0.7400536	-0.7776309	0.9136991	1.954772	1.190057	0.100
B vs C	0.5899137	0.5629033	-0.2977161	0.7770993	0.8876298	0.9551627	0.353
B vs D*	0.2619776	0.3978934	1.384618	75.65148	-1.12264	75.65264	0.988
B vs F	0.8671497	0.8942703	1.243069	1.051637	-0.375919	1.387658	0.786
C vs F	0.1949725	0.957768	1.132694	0.8413269	-0.9377216	1.274814	0.462

A: SOD; B: MD; C: PELD; D: TD; E: PLDD; F: MED; *: no evidence is provided in the indirect study

Secondary Outcomes
SOD: Standard Open Discectomy; MD: Micro-discectomy; TD: Tubular Discectomy;
PELD: Percutaneous Endoscopic Lumbar Discectomy; CN: Chemonucleolysis;
PLDD: Percutaneous Laser Disc Decompression; MED: Micro-endoscopic Discectomy

Blood Loss

Treatment Contrast	Direct		Indirect		Difference		*P* > |z|
	Coef.	SE	Coef.	SE	Coef.	SE	
A vs B	-44.10828	91.52922	-64.39929	95.90683	20.29101	132.6106	0.878
A vs C	-63.72576	74.27804	-95.3073	72.69141	31.58154	103.9297	0.761
A vs E	-148.8558	44.63853	-17.48927	88.17287	-131.3666	98.90377	0.184
B vs C	-30.98556	91.68946	-20.49571	97.08927	-10.48985	133.541	0.937
B vs D*	18.64786	91.72243	-45.9386	271.0033	64.58646	286.1001	0.821
B vs E	-28.29892	129.1243	-85.99849	85.75738	57.69957	155.0047	0.710
B vs F*	-52.99999	125.1871	110.1547	1720.705	-163.1547	1725.329	0.925
C vs D	10.00006	129.0259	74.18148	146.3897	-64.18142	195.1344	0.742
C vs E	19.26395	89.2797	-84.27512	74.22365	103.5391	116.1035	0.373

A: SOD; B: MD; C: PELD; D: TD; E: MED; F: CN; *: no evidence is provided in the indirect study

Reoperation Rate

Treatment Contrast	Direct		Indirect		Difference		*P* > |z|
	Coef.	SE	Coef.	SE	Coef.	SE	
A vs B	-0.3782057	0.62774	-0.1811819	0.7431128	-0.1970238	0.9727663	0.839
A vs C	1.131949	1.653285	-0.4710647	0.5053387	1.603013	1.728791	0.354
A vs F	-1.153432	0.5621678	-0.845683	0.7881934	-0.3077487	0.968133	0.751
B vs C	-0.656001	0.3645384	0.1314018	0.9019529	-0.1970019	0.9728346	0.840
B vs D*	0.5145656	0.1799847	0.5376734	91.69381	-0.0231078	91.69406	1.000
C vs F	-0.6566062	0.4237924	-0.9643219	0.8704712	0.3077158	0.9681532	0.751

A: SOD; B: MD; C: PELD; D: TD; F: MED; *: no evidence is provided in the indirect study

Supplemental Table 1 continued. *Node-splitting results of all outcomes*.

Function Score
1. Short Form-36 Bodily Pain (SF36-BP)
(1) Postoperative 6 months

Treatment Contrast	Direct		Indirect		Difference		*P* > |z|
	Coef.	SE	Coef.	SE	Coef.	SE	
A vs B*	-0.1073515	0.5884815	3.157893	36.87068	-3.265245	36.87537	0.929
A vs F*	-0.1999976	0.5976142	-18.3248	10.36076	16.32482	10.36835	0.115
B vs D*	-4.800003	0.1452971	0.3174708	82.86484	-5.117474	82.86499	0.951
B vs E*	-12.1	0.4983417	-0.0024152	165.1609	-12.09758	165.1613	0.942
B vs F*	-2	0.6714117	14.34674	10.35405	-16.34674	10.37519	0.115
C vs F*	0.5861855	1.245063	-4.184003	555.1631	4.770189	555.1636	0.993

A: SOD; B: MD; C: PELD; D: TD; E:PLDD; F: MED; *: no evidence is provided in the indirect study

(2) Postoperative 12 months

Treatment Contrast	Direct		Indirect		Difference		*P* > |z|
	Coef.	SE	Coef.	SE	Coef.	SE	
A vs B*	-2.000966	0.5922726	-11.86091	5.573266	9.859944	5.720077	0.085
A vs F*	-1.999887	0.597608	8.179549	5.714623	-10.17944	5.772851	0.078
B vs C	3.1	2.426785	-2.000586	1.581277	5.100586	2.896501	0.078
B vs D*	-3.697974	0.1490527	4.351794	85.0108	-8.049768	85.01094	0.925
B vs E*	-2.400002	0.4289968	4.225762	142.9188	-6.625763	142.9193	0.963
B vs F*	0.000149	0.6714117	5.081385	2.815502	-5.08137	2.894448	0.079
C vs F	2.000003	1.431672	-3.100639	2.51792	5.100641	2.896475	0.078

A: SOD; B: MD; C: PELD; D: TD; E:PLDD; F: MED; *: no evidence is provided in the indirect study

2. Short Form-36 Physical Function (SF36-PF)
(1) Postoperative 6 months

Treatment Contrast	Direct		Indirect		Difference		*P* > |z|
	Coef.	SE	Coef.	SE	Coef.	SE	
A vs B*	-0.0863159	0.6663087	1.908007	32.01023	-1.994323	32.01717	0.950
A vs F*	5.12e-11	0.6761234	-10.89516	10.70088	10.89516	10.72221	0.310
B vs D*	-3.90002	0.1255435	0.2569034	71.39778	-4.156905	71.3979	0.965
B vs E*	-3.5	0.4485401	0.1086879	149.9841	-3.608688	149.9846	0.981
B vs F*	-2.38e-06	0.6714117	10.95988	10.73305	-10.95988	10.75344	0.308
C vs F*	0.0478482	0.5611096	-0.0916124	241.1262	0.1394606	241.127	1.000

A: SOD; B: MD; C: PELD; D: TD; E:PLDD; F: MED; *: no evidence is provided in the indirect study

Supplemental Table 1 continued. *Node-splitting results of all outcomes*.

(2) Postoperative 12 months

Treatment Contrast	Direct		Indirect		Difference		*P* > |z|
	Coef.	SE	Coef.	SE	Coef.	SE	
A vs B*	0.0000375	0.6714117	-3.375394	4.007889	3.375432	4.062201	0.406
A vs F	-1	0.6761234	2.47265	4.027364	-3.47265	4.083724	0.395
B vs C	-0.099986	1.834004	-1.835679	0.9107778	1.73568	2.047703	0.397
B vs D*	-4.694746	0.1255114	0.2894164	71.55229	-4.984163	71.5524	0.944
B vs E*	-3.399994	0.3962806	0.121865	131.8042	-3.521859	131.8064	0.979
B vs F	-0.9999899	0.6714117	0.7293892	1.933553	-1.729379	2.046805	0.398
C vs F	0.8352083	0.6154498	-0.9005632	1.952975	1.735771	2.047649	0.397

A: SOD; B: MD; C: PELD; D: TD; E:PLDD; F: MED; *: no evidence is provided in the indirect study

Supplemental Table 2. *League tables of all outcomes*.

Primary Outcomes
SOD: Standard Open Discectomy; MD: Micro-discectomy; TD: Tubular Discectomy;
PELD: Percutaneous Endoscopic Lumbar Discectomy; CN: Chemonucleolysis;
PLDD: Percutaneous Laser Disc Decompression; MED: Micro-endoscopic Discectomy
Visual Analog Scale (VAS)

1. VAS for Back Pain
(1) Postoperative one month

TD	0.59 (0.12,1.07)	1.28 (-0.07,2.63)	1.08 (0.01,2.15)	-2.03 (-3.25,-0.81)	-0.31 (-0.34,-0.28)	2.57 (1.13,4.02)
-0.59 (-1.07,-0.12)	SOD	-1.67 (-2.84,-0.50)	-1.98 (-3.15,-0.81)	-0.39 (-1.06,0.28)	1.76 (0.41,3.12)	2.97 (2.33,3.62)
-1.28 (-2.63,0.07)	1.67 (0.50,2.84)	PLDD	-0.20 (-1.03,0.62)	-3.31 (-4.06,-2.56)	-1.59 (-2.94,-0.24)	1.29 (0.21,2.37)
-1.08 (-2.15,-0.01)	1.98 (0.81,3.15)	0.20 (-0.62,1.03)	PELD	-3.11 (-3.69,-2.52)	-1.39 (-2.46,-0.32)	1.49 (0.52,2.47)
2.03 (0.81,3.25)	0.39 (-0.28,1.06)	3.31 (2.56,4.06)	3.11 (2.52,3.69)	MED	1.72 (0.50,2.94)	4.60 (3.69,5.51)
0.31 (0.28,0.34)	-1.76 (-3.12,-0.41)	1.59 (0.24,2.94)	1.39 (0.32,2.46)	-1.72 (-2.94,-0.50)	MD	2.88 (1.44,4.33)
-2.57 (-4.02,-1.13)	-2.97 (-3.62,-2.33)	-1.29 (-2.37,-0.21)	-1.49 (-2.47,-0.52)	-4.60 (-5.51,-3.69)	-2.88 (-4.33,-1.44)	CN

Supplemental Table 2 continued. *League tables of all outcomes*.

(2) Postoperative 3 months

SOD	0.38 (-0.17,0.93)	-0.55 (-0.86,-0.24)	-0.66 (-1.00,-0.31)	-1.28 (-1.50,-1.05)
-0.38 (-0.93,0.17)	PLDD	-0.93 (-1.56,-0.30)	-1.04 (-1.69,-0.39)	-1.66 (-2.25,-1.06)
0.55 (0.24,0.86)	0.93 (0.30,1.56)	PELD	-0.11 (-0.26,0.04)	-0.72 (-1.08,-0.36)
0.66 (0.31,1.00)	1.04 (0.39,1.69)	0.11 (-0.04,0.26)	MED	-0.62 (-1.01,-0.23)
1.28 (1.05,1.50)	1.66 (1.06,2.25)	0.72 (0.36,1.08)	0.62 (0.23,1.01)	MD

(3) Postoperative 6 months

TD	-0.64 (-2.00,0.71)	0.67 (0.57,0.77)	-0.72 (-1.13,-0.31)	0.58 (0.19,0.97)	-0.35 (-0.38,-0.32)
0.64 (-0.71,2.00)	SOD	1.21 (0.70,1.71)	0.07 (-0.14,0.28)	-0.30 (-0.65,0.05)	0.93 (0.54,1.32)
-0.67 (-0.77,-0.57)	-1.21 (-1.71,-0.70)	PLDD	-1.39 (-1.81,-0.97)	-0.09 (-0.49,0.31)	-1.02 (-1.11,-0.93)
0.72 (0.31,1.13)	-0.07 (-0.28,0.14)	1.39 (0.97,1.81)	PELD	1.30 (0.82,1.78)	0.37 (-0.04,0.78)
-0.58 (-0.97,-0.19)	0.30 (-0.05,0.65)	0.09 (-0.31,0.49)	-1.30 (-1.78,-0.82)	MED	-0.93 (-1.32,-0.54)
0.35 (0.32,0.38)	-0.93 (-1.32,-0.54)	1.02 (0.93,1.11)	-0.37 (-0.78,0.04)	0.93 (0.54,1.32)	MD

2. VAS for Leg Pain

(1) Postoperative 1 month

TD	0.37 (-1.51,2.25)	0.33 (0.23,0.43)	0.23 (-1.64,2.09)	0.20 (-1.69,2.08)	-0.45 (-0.48,-0.42)	0.41 (-1.66,2.48)
-0.37 (-2.25,1.51)	SOD	-0.04 (-1.92,1.84)	-0.14 (-0.40,0.11)	-0.18 (-0.38,0.03)	-0.82 (-2.70,1.06)	0.04 (-0.82,0.90)
-0.33 (-0.43,-0.23)	0.04 (-1.84,1.92)	PLDD	-0.10 (-1.97,1.76)	-0.13 (-2.02,1.75)	-0.78 (-0.88,-0.68)	0.08 (-1.99,2.15)
-0.23 (-2.09,1.64)	0.14 (-0.11,0.40)	0.10 (-1.76,1.97)	PELD	-0.03 (-0.29,0.23)	-0.68 (-2.54,1.19)	0.18 (-0.71,1.08)
-0.20 (-2.08,1.69)	0.18 (-0.03,0.38)	0.13 (-1.75,2.02)	0.03 (-0.23,0.29)	MED	-0.65 (-2.53,1.23)	0.22 (-0.67,1.10)
0.45 (0.42,0.48)	0.82 (-1.06,2.70)	0.78 (0.68,0.88)	0.68 (-1.19,2.54)	0.65 (-1.23,2.53)	MD	0.86 (-1.21,2.93)
-0.41 (-2.48,1.66)	-0.04 (-0.90,0.82)	-0.08 (-2.15,1.99)	-0.18 (-1.08,0.71)	-0.22 (-1.10,0.67)	-0.86 (-2.93,1.21)	CN

(2) Postoperative 3 months

TD	0.33 (0.02,0.64)	0.08 (-0.04,0.21)	0.21 (-0.17,0.59)
-0.33 (-0.64,-0.02)	SOD	-0.25 (-0.53,0.04)	-0.12 (-0.36,0.13)
-0.08 (-0.21,0.04)	0.25 (-0.04,0.53)	PELD	0.13 (-0.23,0.49)
-0.21 (-0.59,0.17)	0.12 (-0.13,0.36)	-0.13 (-0.49,0.23)	MD

Supplemental Table 2 continued. ***League tables of all outcomes***.

Oswestry Disability Index (ODI)

(1) Postoperative one month

SOD	-4.19 (-8.84,0.47)	-5.35 (-10.81,0.10)	4.28 (-6.90,15.47)
4.19 (-0.47,8.84)	PELD	-1.17 (-6.23,3.90)	8.47 (-1.70,18.64)
5.35 (-0.10,10.81)	1.17 (-3.90,6.23)	MED	9.64 (-1.73,21.00)
-4.28 (-15.47,6.90)	-8.47 (-18.64,1.70)	-9.64 (-21.00,1.73)	MD

(2) Postoperative 3 months

SOD	-3.89 (-8.05,0.27)	-1.75 (-7.31,3.81)	-3.80 (-12.50,4.90)
3.89 (-0.27,8.05)	PELD	2.14 (-2.25,6.53)	0.09 (-7.55,7.74)
1.75 (-3.81,7.31)	-2.14 (-6.53,2.25)	MED	-2.05 (-10.86,6.77)
3.80 (-4.90,12.50)	-0.09 (-7.74,7.55)	2.05 (-6.77,10.86)	MD

(3) Postoperative 6 months

SOD	-2.76 (-6.43,0.91)	-3.76 (-6.81,-0.70)	-2.06 (-7.89,3.78)
2.76 (-0.91,6.43)	PELD	-1.00 (-4.32,2.32)	0.70 (-5.26,6.67)
3.76 (0.70,6.81)	1.00 (-2.32,4.32)	MED	1.70 (-4.08,7.48)
2.06 (-3.78,7.89)	-0.70 (-6.67,5.26)	-1.70 (-7.48,4.08)	MD

(4) Postoperative 12 months

SOD	2.40 (-2.33,7.12)	2.87 (0.74,5.00)	-0.00 (-1.32,1.32)
-2.40 (-7.12,2.33)	PELD	2.50 (0.89,4.11)	1.50 (-0.10,3.10)
-2.87 (-5.00,-0.74)	-2.50 (-4.11,-0.89)	MED	-1.00 (-2.32,0.32)
0.00 (-1.32,1.32)	-1.50 (-3.10,0.10)	1.00 (-0.32,2.32)	MD

Complications

TD	-0.87 (-2.64,0.91)	3.07 (-0.54,6.67)	0.95 (-0.92,2.81)	3.17 (1.29,5.05)	1.44 (0.48,2.40)	2.00 (-0.02,4.02)
0.87 (-0.91,2.64)	SOD	1.17 (-0.64,2.98)	-0.52 (-1.83,0.79)	2.03 (0.62,3.44)	0.89 (-0.77,2.56)	-1.01 (-1.92,-0.09)
-3.07 (-6.67,0.54)	-1.17 (-2.98,0.64)	PLDD	-2.12 (-5.46,1.22)	0.10 (-3.25,3.45)	-1.63 (-5.10,1.84)	-1.07 (-4.50,2.36)
-0.95 (-2.81,0.92)	0.52 (-0.79,1.83)	2.12 (-1.22,5.46)	PELD	2.22 (0.91,3.53)	0.49 (-1.11,2.09)	1.05 (-0.46,2.56)
-3.17 (-5.05,-1.29)	-2.03 (-3.44,-0.62)	-0.10 (-3.45,3.25)	-2.22 (-3.53,-0.91)	MED	-1.73 (-3.34,-0.11)	-1.17 (-2.69,0.36)
-1.44 (-2.40,-0.48)	-0.89 (-2.56,0.77)	1.63 (-1.84,5.10)	-0.49 (-2.09,1.11)	1.73 (0.11,3.34)	MD	0.56 (-1.22,2.34)
-2.00 (-4.02,0.02)	1.01 (0.09,1.92)	1.07 (-2.36,4.50)	-1.05 (-2.56,0.46)	1.17 (-0.36,2.69)	-0.56 (-2.34,1.22)	CN

Supplemental Table 2 continued. *League tables of all outcomes.*

Secondary Outcomes
SOD: Standard Open Discectomy; MD: Micro-discectomy; TD: Tubular Discectomy;
PELD: Percutaneous Endoscopic Lumbar Discectomy; CN: Chemonucleolysis;
PLDD: Percutaneous Laser Disc Decompression; MED: Micro-endoscopic Discectomy

Blood Loss

TD	42.15 (-148.02,232.33)	-38.09 (-221.34,145.15)	-79.95 (-276.87,116.97)	-11.92 (-176.18,152.34)	-64.05 (-358.46,230.35)
-42.15 (-232.33,148.02)	SOD	-80.25 (-179.01,18.52)	-122.10 (-201.01,-43.19)	-54.07 (-179.23,71.09)	-106.21 (-380.25,167.83)
38.09 (-145.15,221.34)	80.25 (-18.52,179.01)	PELD	-41.85 (-152.24,68.54)	26.18 (-99.44,151.79)	-25.96 (-300.38,248.46)
79.95 (-116.97,276.87)	122.10 (43.19,201.01)	41.85 (-68.54,152.24)	MED	68.03 (-67.22,203.28)	15.89 (-262.97,294.76)
11.92 (-152.34,176.18)	54.07 (-71.09,179.23)	-26.18 (-151.79,99.44)	-68.03 (-203.28,67.22)	MD	-52.14 (-296.60,192.33)
64.05 (-230.35,358.46)	106.21 (-167.83,380.25)	25.96 (-248.46,300.38)	-15.89 (-294.76,262.97)	52.14 (-192.33,296.60)	CN

Reoperation Rate

TD	-0.22 (-1.22,0.79)	-0.36 (-1.82,1.09)	-0.55 (-1.30,0.20)	-1.27 (-2.25,-0.29)	-0.51 (-0.87,-0.16)	0.85 (-0.47,2.16)
0.22 (-0.79,1.22)	SOD	-0.14 (-1.20,0.91)	-0.33 (-1.28,0.61)	-1.05 (-1.95,-0.15)	-0.30 (-1.24,0.64)	1.06 (0.21,1.92)
0.36 (-1.09,1.82)	0.14 (-0.91,1.20)	PLDD	-0.19 (-1.61,1.23)	-0.91 (-2.29,0.48)	-0.15 (-1.56,1.26)	1.21 (-0.15,2.57)
0.55 (-0.20,1.30)	0.33 (-0.61,1.28)	0.19 (-1.23,1.61)	PELD	-0.72 (-1.46,0.03)	0.04 (-0.62,0.70)	1.40 (0.12,2.67)
1.27 (0.29,2.25)	1.05 (0.15,1.95)	0.91 (-0.48,2.29)	0.72 (-0.03,1.46)	MED	0.75 (-0.16,1.67)	2.11 (0.87,3.35)
0.51 (0.16,0.87)	0.30 (-0.64,1.24)	0.15 (-1.26,1.56)	-0.04 (-0.70,0.62)	-0.75 (-1.67,0.16)	MD	1.36 (0.09,2.63)
-0.85 (-2.16,0.47)	-1.06 (-1.92,-0.21)	-1.21 (-2.57,0.15)	-1.40 (-2.67,-0.12)	-2.11 (-3.35,-0.87)	-1.36 (-2.63,-0.09)	CN

Function Score
1. Short Form-36 Bodily Pain (SF36-BP)

(1) Postoperative 6 months

TD	4.91 (3.72,6.09)	-7.30 (-8.32,-6.28)	2.28 (-0.50,5.07)	2.87 (1.52,4.21)	4.80 (4.52,5.08)
-4.91 (-6.09,-3.72)	SOD	-12.21 (-13.72,-10.70)	-2.63 (-5.33,0.08)	-2.04 (-3.21,-0.87)	-0.11 (-1.26,1.05)
7.30 (6.28,8.32)	12.21 (10.70,13.72)	PLDD	9.58 (6.64,12.52)	10.17 (8.53,11.80)	12.10 (11.12,13.08)
-2.28 (-5.07,0.50)	2.63 (-0.08,5.33)	-9.58 (-12.52,-6.64)	PELD	0.59 (-1.85,3.03)	2.52 (-0.25,5.29)
-2.87 (-4.21,-1.52)	2.04 (0.87,3.21)	-10.17 (-11.80,-8.53)	-0.59 (-3.03,1.85)	MED	1.93 (0.62,3.25)
-4.80 (-5.08,-4.52)	0.11 (-1.05,1.26)	-12.10 (-13.08,-11.12)	-2.52 (-5.29,0.25)	-1.93 (-3.25,-0.62)	MD

Supplemental Table 2 continued. ***League tables of all outcomes***.

(2) Postoperative 12 months

TD	5.83 (4.64,7.02)	1.30 (0.41,2.19)	3.22 (0.60,5.83)	3.97 (2.66,5.28)	3.70 (3.41,3.99)
-5.83 (-7.02,-4.64)	SOD	-4.53 (-5.96,-3.11)	-2.61 (-5.24,0.01)	-1.86 (-3.02,-0.70)	-2.13 (-3.28,-0.98)
-1.30 (-2.19,-0.41)	4.53 (3.11,5.96)	PLDD	1.92 (-0.81,4.65)	2.67 (1.14,4.20)	2.40 (1.56,3.24)
-3.22 (-5.83,-0.60)	2.61 (-0.01,5.24)	-1.92 (-4.65,0.81)	PELD	0.75 (-1.69,3.19)	0.48 (-2.12,3.08)
-3.97 (-5.28,-2.66)	1.86 (0.70,3.02)	-2.67 (-4.20,-1.14)	-0.75 (-3.19,1.69)	MED	-0.27 (-1.55,1.01)
-3.70 (-3.99,-3.41)	2.13 (0.98,3.28)	-2.40 (-3.24,-1.56)	-0.48 (-3.08,2.12)	0.27 (-1.01,1.55)	MD

2. Short Form-36 Physical Function (SF36-PF)

(1) Postoperative 6 months

TD	3.99 (2.66,5.31)	0.40 (-0.51,1.31)	3.89 (2.16,5.62)	3.94 (2.61,5.28)	3.90 (3.65,4.15)
-3.99 (-5.31,-2.66)	SOD	-3.59 (-5.16,-2.01)	-0.09 (-1.81,1.63)	-0.04 (-1.37,1.28)	-0.09 (-1.39,1.22)
-0.40 (-1.31,0.51)	3.59 (2.01,5.16)	PLDD	3.49 (1.57,5.42)	3.54 (1.96,5.12)	3.50 (2.62,4.38)
-3.89 (-5.62,-2.16)	0.09 (-1.63,1.81)	-3.49 (-5.42,-1.57)	PELD	0.05 (-1.05,1.15)	0.01 (-1.71,1.72)
-3.94 (-5.28,-2.61)	0.04 (-1.28,1.37)	-3.54 (-5.12,-1.96)	-0.05 (-1.15,1.05)	MED	-0.04 (-1.36,1.27)
-3.90 (-4.15,-3.65)	0.09 (-1.22,1.39)	-3.50 (-4.38,-2.62)	-0.01 (-1.72,1.71)	0.04 (-1.27,1.36)	MD

(2) Postoperative 12 months

TD	4.79 (3.46,6.11)	1.29 (0.48,2.11)	3.20 (1.58,4.82)	3.88 (2.61,5.15)	4.69 (4.45,4.94)
-4.79 (-6.11,-3.46)	SOD	-3.49 (-5.00,-1.98)	-1.58 (-3.28,0.11)	-0.90 (-2.21,0.40)	-0.09 (-1.39,1.21)
-1.29 (-2.11,-0.48)	3.49 (1.98,5.00)	PLDD	1.91 (0.13,3.69)	2.59 (1.12,4.05)	3.40 (2.62,4.18)
-3.20 (-4.82,-1.58)	1.58 (-0.11,3.28)	-1.91 (-3.69,-0.13)	PELD	0.68 (-0.47,1.83)	1.49 (-0.11,3.09)
-3.88 (-5.15,-2.61)	0.90 (-0.40,2.21)	-2.59 (-4.05,-1.12)	-0.68 (-1.83,0.47)	MED	0.81 (-0.43,2.06)
-4.69 (-4.94,-4.45)	0.09 (-1.21,1.39)	-3.40 (-4.18,-2.62)	-1.49 (-3.09,0.11)	-0.81 (-2.06,0.43)	MD

Supplemental Table 3. *SUCRA tables of all outcomes.*
(SUCRA: Surface Under the Cumulative Ranking Curve; PO: Postoperative)

Primary Outcomes
SOD: Standard Open Discectomy; MD: Micro-discectomy; TD: Tubular Diskectomy;
PELD: Percutaneous Endoscopic Lumbar Discectomy; CN: Chemonucleolysis;
PLDD: Percutaneous Laser Disc Decompression; MED: Micro-endoscopic Discectomy

Visual Analog Scale (VAS)

Treatment	VAS for back pain						VAS for leg pain					
	PO one mo		PO 3 mos		PO 6 mos		PO one mo		PO 3 mos		PO 6 mos	
	SUCRA	Rank	SUCRA	Rank	SUCRA	Rank	SUCRA	Rank	SUCRA	Rank	SUCRA	Rank
SOD	18.8	6	22.8	4	56.0	3	29.4	7	7.9	4	50.9	4
MD	83.0	2	100.0	1	45.4	4	84.6	1	41.2	3	51.9	3
PELD	45.0	4	51.4	3	78.5	2	52.0	4	59.7	2	80.9	2
TD	65.5	3	-		20.0	5	57.3	2	-		20.0	5
PLDD	37.2	5	2.3	5	0.0	6	32.4	6	-		0.0	6
MED	100.0	1	73.5	2	100.0	1	57.2	3	91.3	1	96.2	1
CN	0.4	7	-		-		37.1	5	-			

Oswestry Disability Index (ODI)

Treatment	PO one mo		PO 3 mos		PO 6 mos		PO 12 mos	
	SUCRA	Rank	SUCRA	Rank	SUCRA	Rank	SUCRA	Rank
SOD	28.6	3	16.6	4	10.7	4	19.2	4
MD	10.8	4	67.4	2	48.3	3	25.1	3
PELD	73.8	2	75.9	1	60.1	2	96.0	1
MED	86.8	1	40.1	3	80.9	1	59.7	2

Complications

Treatment	SUCRA	Rank
SOD	42.5	4
MD	59.7	3
PELD	78.7	2
TD	95.7	1
PLDD	22.4	6
MED	9.6	7
CN	41.5	5

Supplemental Table 3 continued. *SUCRA tables of all outcomes.*

Secondary Outcomes
SOD: Standard Open Discectomy; MD: Micro-diskectomy; TD: Tubular Discectomy; PELD: Percutaneous Endoscopic Lumbar Discectomy; CN: Chemonucleolysis; PLDD: Percutaneous Laser Disc Decompression; MED: Micro-endoscopic Discectomy

Blood Loss and Reoperation Rate

Treatment	Blood Loss		Reoperation Rate	
	SUCRA	Rank	SUCRA	Rank
SOD	16.5	6	42.5	5
MD	44.6	4	63.2	3
PELD	58.6	3	64.5	2
TD	40.9	5	27.4	6
PLDD	-		53.7	4
MED	78.6	1	96.3	1
CN	60.8	2	2.5	7

Function Score

Treatment	SF36-BP				SF36-PF			
	PO 6 mos		PO 12 mos		PO 6 mos		PO 12 mos	
	SUCRA	Rank	SUCRA	Rank	SUCRA	Rank	SUCRA	Rank
SOD	90.6	1	99.6	1	72.5	1	89.5	1
MD	88.1	2	59.2	3	67.8	4	85.4	2
PELD	46.3	4	51.5	4	68.7	3	43.8	4
TD	21.0	5	0.2	6	4.2	6	0.0	6
PLDD	0.0	6	21.7	5	15.8	5	20.3	5
MED	53.9	3	67.6	2	70.9	2	61.0	3

Randomized Controlled Trials Used in Our Network Meta-analysis

1. Abrishamkar S, Kouchakzadeh M, Mirhosseini A, et al. Comparison of open surgical discectomy versus plasma-laser nucleoplasty in patients with single lumbar disc herniation. *J Res Med Sci* 2015; 20:1133-1137.
2. Arts MP, Brand R, van den Akker ME, et al. Tubular diskectomy vs conventional microdiskectomy for the treatment of lumbar disk herniation: 2-year results of a double-blind randomized controlled trial. *Neurosurgery* 2011; 69:135-144.
3. Brouwer PA, Brand R, van den Akker-van Marle ME, et al. Percutaneous laser disc decompression versus conventional microdiscectomy in sciatica: a randomized controlled trial. *Spine J* 2015; 15:857-865.
4. Brouwer PA, Brand R, van den Akker-van Marle ME, et al. Percutaneous laser disc decompression versus conventional microdiscectomy for patients with sciatica: Two-year results of a randomised controlled trial. *Interv Neuroradiol* 2017; 23:313-324.
5. Crawshaw C, Frazer AM, Merriam WF, Mulholland RC, Webb JK. A comparison of surgery and chemonucleolysis in the treatment of sciatica. A prospective randomized trial. *Spine (Phila Pa 1976)* 1984; 9:195-198.
6. Ding ZM, Tao YQ. Clinical outcomes of percutaneous transforaminal endoscopic discectomy versus fenestration discectomy in patients with lumbar disc herniation. *J Int Transl Med* 2017; 5:29-33.
7. Hussein M. Minimal incision, multifidus-sparing microendoscopic diskectomy versus conventional microdiskectomy for highly migrated intracanal lumbar disk herniations. *J Am Acad Orthop Surg* 2016; 24:805-813.
8. Hussein M, Abdeldayem A, Mattar MM. Surgical technique and effectiveness of microendoscopic discectomy for large uncontained lumbar disc herniations: A prospective, randomized, controlled study with 8 years of follow-up. *Eur Spine J* 2014; 23:1992-1999.
9. Lau D, Han SJ, Lee JG, Lu DC, Chou D. Minimally invasive compared to open microdiscectomy for lumbar disc herniation. *J Clin Neurosci* 2011; 18:81-84.
10. Mojaz FM, Abdolhoseinpour H, Sigari RA. Unilateral discectomy: Outcomes, postoperative pain, complications. *Eur J Transl Myol* 2019; 29:8545.
11. Elkatatny AAAM, Hamdy TM, Moenes KM. Comparison between results of microdiscectomy and open discectomy in management of high-level lumbar disc prolapse. *Open Access Maced J Med Sci* 2019; 7:2851-2857.
12. Muralikuttan KP, Hamilton A, Kernohan WG, Mollan RA, Adair IV. A prospective randomized trial of chemonucleolysis and conventional disc surgery in single

level lumbar disc herniation. *Spine (Phila Pa 1976)* 1992; 17:381-387.

13. Overdevest GM, Peul WC, Brand R, et al. Tubular discectomy versus conventional microdiscectomy for the treatment of lumbar disc herniation: Long-term results of a randomised controlled trial. *J Neurol Neurosurg Psychiatry* 2017; 88:1008-1016.
14. Ran B, Wei J, Yang J, et al. Quantitative evaluation of the trauma of CT navigation PELD and OD in the treatment of HLDH: A randomized, controlled study. *Pain Physician* 2021; 24:E433-E441.
15. Righesso O, Falavigna A, Avanzi O. Comparison of open discectomy with microendoscopic discectomy in lumbar disc herniations: Results of a randomized controlled trial. *Neurosurgery* 2007; 61:545-549;
16. Ruetten S, Komp M, Merk H, Godolias G. Full-endoscopic interlaminar and transforaminal lumbar discectomy versus conventional microsurgical technique: A prospective, randomized, controlled study. *Spine (Phila Pa 1976)* 2008; 33:931-939.
17. Ryang YM, Oertel MF, Mayfrank L, Gilsbach JM, Rohde V. Standard open microdiscectomy versus minimal access trocar microdiscectomy: Results of a prospective randomized study. *Neurosurgery* 2008; 62:174-181.
18. van Alphen HA, Braakman R, Bezemer PD, Broere G, Berfelo MW. Chemonucleolysis versus discectomy: A randomized multicenter trial. *J Neurosurg* 1989; 70:869-875.
19. Dongli Y, Wang G, Wei Y, Guorui Y. The effect of posterior microendoscopy discectomy and open surgery on lumbar disc herniation. *Biomed Res* 2017; 28:8874-8877.
20. Arts MP, Brand R, van den Akker ME, et al. Tubular diskectomy vs conventional microdiskectomy for sciatica: A randomized controlled trial. *JAMA* 2009; 302:149-158.
21. Chen Z, Zhang L, Dong J, et al. Percutaneous transforaminal endoscopic discectomy compared with microendoscopic discectomy for lumbar disc herniation: 1-year results of an ongoing randomized controlled trial. *J Neurosurg Spine* 2018; 28:300-310.
22. Cristante AF, Rocha ID, MartusMarcon R, Filho TE. Randomized clinical trial comparing lumbar percutaneous hydrodiscectomy with lumbar open microdiscectomy for the treatment of lumbar disc protrusions and herniations. *Clinics (Sao Paulo)* 2016; 71:276-280.
23. Garg B, Nagraja UB, Jayaswal A. Microendoscopic versus open discectomy for lumbar disc herniation: A prospective randomised study. *J Orthop Surg (Hong Kong)* 2011; 19:30-34.
24. Hamawandi SA, Sulaiman II, Al-Humairi AK. Open fenestration discectomy versus microscopic fenestration discectomy for lumbar disc herniation: A randomized controlled trial. *BMC Musculoskel Dis* 2020; 21:384.
25. Kelekis A, Bonaldi G, Cianfoni A, et al. Intradiscal oxygen-ozone chemonucleolysis versus microdiscectomy for lumbar disc herniation radiculopathy: A non-inferiority randomized control trial. *Spine J* 2022; 22:895-909.
26. Meyer G, DA Rocha ID, Cristante AF, et al. Percutaneous endoscopic lumbar discectomy versus microdiscectomy for the treatment of lumbar disc herniation: Pain, disability, and complication rate-A randomized clinical trial. *Int J Spine Surg* 2020; 14:72-78.
27. Pan Z, Ha Y, Yi S, Cao K. Efficacy of transforaminal endoscopic spine system (TESSYS) technique in treating lumbar disc herniation. *Med Sci Monit* 2016; 22:530-539.
28. Sasaoka R, Nakamura H, Konishi S, et al. Objective assessment of reduced invasiveness in MED. Compared with conventional one-level laminotomy. *Eur Spine J* 2006; 15:577-582.
29. van den Akker ME, Arts MP, van den Hout WB, Brand R, Koes BW, Peul WC. Tubular diskectomy vs conventional microdiskectomy for the treatment of lumbar disk-related sciatica: Cost utility analysis alongside a double-blind randomized controlled trial. *Neurosurgery* 2011; 69:829-835.
30. Wang F, Guo D, Sun T, Guan K. A comparative study on short-term therapeutic effects of percutaneous transforaminal endoscopic discectomy and microendoscopic discectomy on lumbar disc herniation. *Pak J Med Sci* 2019; 35:426-431.
31. Yadav RI, Long L, Yanming C. Comparison of the effectiveness and outcome of microendoscopic and open discectomy in patients suffering from lumbar disc herniation. *Medicine (Baltimore)* 2019; 98:e16627.
32. Chen Z, Zhang L, Dong J, et al. Percutaneous transforaminal endoscopic discectomy versus microendoscopic discectomy for lumbar disc herniation: Two-year results of a randomized controlled trial. *Spine (Phila Pa 1976)* 2020; 45:493-503.
33. Chang F, Zhang T, Gao G, et al. Therapeutic effect of percutaneous endoscopic lumbar discectomy on lumbar disc herniation and its effect on oxidative stress in patients with lumbar disc herniation. *Exp Ther Med* 2018; 15:295-299.
34. Pan L, Zhang P, Yin Q. Comparison of tissue damages caused by endoscopic lumbar discectomy and traditional lumbar discectomy: A randomised controlled trial. *Int J Surg* 2014; 12:534-537.
35. Wardlaw D, Rithchie IK, Sabboubeh AF, Vavdha M, Eastmond CJ. Prospective randomized trial of chemonucleolysis compared with surgery for soft disc herniation with 1-year, intermediate, and long-term outcome: Part I: the clinical outcome. *Spine (Phila Pa 1976)* 2013; 38:E1051-E1057.
36. Thomé C, Barth M, Scharf J, Schmiedek P. Outcome after lumbar sequestrectomy compared with microdiscectomy: A prospective randomized study. *J Neurosurg Spine* 2005; 2:271-278.
37. Kong L, Shang XF, Zhang WZ, et al. Percutaneous endoscopic lumbar discectomy and microsurgical laminotomy : A prospective, randomized controlled trial of patients with lumbar disc herniation and lateral recess stenosis. *Orthopade* 2019; 48:157-164.
38. Huang TJ, Hsu RW, Li YY, Cheng CC. Less systemic cytokine response in patients following microendoscopic versus open lumbar discectomy. *J Orthop Res* 2005; 23:406-411.
39. Teli M, Lovi A, Brayda-Bruno M, et al. Higher risk of dural tears and recurrent herniation with lumbar micro-endoscopic discectomy. *Eur Spine J* 2010; 19:443-450.
40. Burton AK, Tillotson KM, Cleary J. Single-blind randomised controlled trial of chemonucleolysis and manipulation in the treatment of symptomatic lumbar disc herniation. *Eur Spine J* 2000; 9:202-207.
41. Ejeskär A, Nachemson A, Herberts P, et al. Surgery versus chemonucleolysis for herniated lumbar discs. A prospective study with random assignment. *Clin Orthop Relat Res* 1983; 174:236-242.
42. Franke J, Greiner-Perth R, Boehm H, et

al. Comparison of a minimally invasive procedure versus standard microscopic discotomy: A prospective randomised controlled clinical trial. *Eur Spine J* 2009; 18:992-1000.

43. Hermantin FU, Peters T, Quartararo L, Kambin P. A prospective, randomized study comparing the results of open discectomy with those of video-assisted arthroscopic microdiscectomy. *J Bone Joint Surg Am* 1999; 81:958-965.
44. Belykh E, Giers MB, Preul MC, Theodore N, Byvaltsev V. Prospective comparison of microsurgical, tubular-based endoscopic, and endoscopically assisted diskectomies: Clinical effectiveness and complications in railway workers. *World Neurosurg* 2016; 90:273-280.
45. Gibson JNA, Subramanian AS, Scott CEH. A randomised controlled trial of transforaminal endoscopic discectomy vs microdiscectomy. *Eur Spine J* 2017; 26:847-856.
46. Ruetten S, Komp M, Merk H, Godolias G. Recurrent lumbar disc herniation after conventional discectomy: A prospective, randomized study comparing full-endoscopic interlaminar and transforaminal versus microsurgical revision. *J Spinal Disord Tech* 2009; 22:122-129.
47. Jing Z, Li L, Song J. Percutaneous transforaminal endoscopic discectomy versus microendoscopic discectomy for upper lumbar disc herniation: A retrospective comparative study. *Am J Transl Res* 2021; 13:3111-3119.
48. Li Z, Zhang C, Chen W, et al. Percutaneous endoscopic transforaminal discectomy versus conventional open lumbar discectomy for upper lumbar disc herniation: A comparative cohort study. *Biomed Res Int* 2020; 2020:1852070.
49. He J, Wang P, Xia X, Tang J. Transforaminal endoscopic lumbar discectomy versus open decompression discectomy for lumbar disc herniation. *J Coll Physicians Surg Pak* 2022; 32:1553-1556.
50. Chen Z, Zhang L, Dong J, et al. Percutaneous transforaminal endoscopic discectomy versus microendoscopic discectomy for lumbar disk herniation: Five-year results of a randomized controlled trial. *Spine (Phila Pa 1976)* 2023; 48:79-88.