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REVIEW ARTICLE

Systematic review of microendoscopic discectomy for lumbar disc herniation

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Abstract
Study design Systematic review.
Objective To search and analyse randomised controlled trials (RCTs) published since the Cochrane review by Gibson and Waddell (2007) comparing microendoscopic discectomy (MED) with open discectomy (OD) or microdiscectomy (MD) and to assess whether MED improves patient-reported outcomes.
Summary of background Discectomy for symptomatic herniated lumbar discs is an effective operative treatment. A number of operative techniques exist including OD, MD, and MED. A 2007 Cochrane review identified OD as an effective treatment for symptom improvement, and found sufficient evidence for MD. However, evidence for MED was lacking.
Methods A systematic review of Medline and Embase was carried out. Aiming to identify RCTs carried out after 2007, which compared OD with MD and MED which reported the Oswestry disability index (ODI) as an outcome.
Results Four RCTs were identified. None of the studies found a significant difference in the ODI scores between study groups at any time point. Three studies compared MED to OD and one compared OD, MD, and MED. The largest study reported an increased number of severe complications in the MED group.
Conclusions There is some evidence to suggest that MED performed by surgeons skilled in the technique in tertiary referral centres is as effective as OD.

Keywords Microendoscopic discectomy · Lumbar disc herniation · Sciatica · Discectomy

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Introduction

Sciatica describes the symptoms of leg pain and occasionally neurological disturbance in the dermatome of the affected nerve root. It is caused by nerve root compression or irritation and over 90 % of cases are due to lumbar disc herniation [1]. The symptoms of sciatica can be disabling and around 30 % of patients will still report symptoms beyond 1 year [2].

Conservative treatment including physiotherapy, hydrotherapy, and analgesia are routinely used for sciatica caused by lumbar disc herniation. Operative options include chemonucleolysis, open discectomy (OD), microdiscectomy (MD), and microendoscopic discectomy (MED).

Open discectomy was shown to be more effective at reducing symptoms than chemonucleolysis or non-operative treatment in carefully selected patients [3]. In 2007, a Cochrane review on surgical interventions for lumbar disc prolapse concluded that there was considerable evidence that OD was effective in reducing symptoms in the short term [4]. It also noted that there was moderate evidence that MD was as effective as OD [4]. The indications for discectomy are lumbar disc herniation causing sciatica symptoms and a failed course of conservative treatment [3, 4].

Microendoscopic discectomy was first described in 1997 as a minimally invasive transmuscular approach using advanced optics [5]. The perceived benefits are minimal muscle and soft tissue damage with excellent visualisation, combining the benefits of MD and OD, respectively. This may mean that patients have a faster postoperative recovery and better functional outcomes; however, MED is more expensive, has a long learning curve and is more technically demanding than OD or MD. The updated Cochrane review (2007) found only one small randomised controlled trial (RCT) of 22 patients, concluding that the role of MED is uncertain [4].

Our aim was to search and analyse RCTs comparing MED with OD or MD to assess whether MED improves patient reported outcomes.

Methods

Eligibility criteria

Published RCT, written in the English language with the following criteria were eligible:

Participants

- Humans
- Over 18 years old
- Sciatica symptoms: pain in the leg, with or without dermatomal signs
- Had a failed course of non-operative treatment prior to the trial
- Had no prior spinal surgery for the same problem.

Intervention

- Any method of MED, as defined by the authors of each study, but must involve the use of an endoscope
- Single or multiple surgeons and/or centres
- Any method of postoperative rehabilitation.

Comparator

- Any method of OD or MD as defined by the authors of each study
- A microscope or loupes may be used
- Single or multiple surgeons and/or centres
- Any method of postoperative rehabilitation.

Primary outcome measure

- Any patient reported outcome measure (PROM).

Secondary outcome measures

- Incision length
- Blood loss
- Length of hospital stay
- Return to work.

Search strategy

The search strategy was developed using the eligibility criteria with the aim of maximising sensitivity. Search terms were mapped to subject headings to ensure relevant subject headings were used and these were exploded. Keywords were used and if multiple suffixes were possible, the words were truncated with a '*' to maximise the sensitivity of the search. Medline, Cochrane Central Register of Controlled Trials and Embase were searched using the Ovid interface (Table 1). The searches were restricted to humans and studies in the English language. All references of eligible studies were reviewed for further studies that met the eligibility criteria.

Selection and appraisal method

The results of the searches in Medline, Cochrane Central Register of Controlled Trials and Embase were transferred into endnote in order to remove duplicates and systematically view titles and abstracts. Two authors separately reviewed the studies for eligibility by their title, followed by their abstract, and then the full paper if it was still not excluded. Any papers with inclusion conflicts were then reviewed together.

Studies that met the eligibility criteria and were included for review were first assessed using the titles participants, intervention, comparator, outcome measure (PICO), results, and conclusion for easy comparison between studies (Table 2) [7]. Each study was then assessed using the CONSORT questionnaire (Table 3) [8].

Results

Results of the search

On Sunday 12th September 2012, the databases of Medline, Cochrane Central Register of Controlled Trials and Embase were searched. Once duplicates were removed there were 109 unique references. Nine studies were left following review of the title and abstracts. Four studies were excluded as they did not randomise participants [9–12], one study did not have an appropriate intervention group [13] and one study included participants that were having revision surgery [14]. A total of four studies met the eligibility criteria and were included in this systematic review [15–17]. The studies are summarised in Table 2.

Table 1 Search strategy for Ovid Medline and replicated for Embase and Cochrane Central Register of Controlled Trials

1	(herniat* or prolapse* or compress*).mp.	127457
2	endoscopy.mp. or exp endoscopy/	247713
3	(microendoscop* or arthroscop* or (micro and endoscop*)).mp.	19968
4	MED.mp.	25218
5	2 or 3 or 4	276806
6	(lumbar or lower).mp.	1041507
7	exp lumbar vertebrae/	35163
8	6 or 7	1041507
9	1 and 5 and 8	646
10	exp randomized controlled trial/	331300
11	exp controlled clinical trial/	84583
12	(randomi* or randomly or compar* or control*).mp.	5346761
13	10 or 11 or 12	5346761
14	9 and 13	290
15	limit 14 to (english language and humans and yr = "2007 –Current")	95

Huang et al. [6]

This RCT compared MED to OD, taking a particular interest in serum inflammatory markers as a metric for operative stress. They also reported the visual analogue scale (VAS) and MacNab score. This small study of 22 patients remarked on a significantly reduced operative stress in the MED group as evidenced by a significantly lower serum C-reactive protein postoperatively. In line with the other studies included in this review the MED group had a longer operative time but smaller incision size and less operative blood loss.

This study failed to show a difference in VAS postoperatively and MacNab score. The authors conclude that MED is favourable as it appeared to reduce 'surgical stresses' to the patient compared with OD [6].

Righesso et al. [15]

This RCT compared OD to MED in patients with sciatica caused by lumbar disc herniation, failing to respond to a minimum of 4 weeks conservative management. Multiple outcomes were measured, including the Oswestry disability index (ODI), although no outcome measure was formally identified. There were 40 patients that took part in the trial. No significant differences in ODI scores were found at any time point and mean return to work and normal activities was 21 days in both groups. Other parameters considered in this study include VAS, incision size and operative blood loss. This study also found MED to be a longer procedure, and also showed that the VAS for the MED group were significantly higher 12 h postoperatively. The authors conclude that the technical superiority of MED has not been evidenced, but it may speed up recovery time [15].

Teli et al. [16]

This was a well-conducted RCT with three arms (OD, MD, and MED) in patients that had sciatica caused by lumbar disc herniation and had a failed course of at least 6 weeks conservative care. The primary outcome measure was VAS, with ODI being a secondary outcome measure. There were a total of 240 patients in all groups. They found no significant differences in VAS or ODI but differences between the groups in complications. This study additionally noted significantly smaller surgical incision, and a shorter hospital stay for patients randomised to MED. They conclude that MED causes more severe complications and cannot be recommended as routine practice.

Garg et al. [17]

This RCT compared OD to MED for patients with sciatica unresponsive to at least 6 weeks conservative treatment. There were 112 patients and although no primary outcome measure was identified, the ODI was assessed. Despite significantly longer operative and anaesthetic times, the patients who received MED had a significantly shorter hospital stay and a smaller amount of intraoperative blood loss. They found no significant differences the ODI or complication rates between groups, concluding that both interventions were equally effective; however, MED should not be attempted without appropriate training.

Discussion

The literature search found four published RCTs. None of the studies found a significant difference in the PROM scores between study groups at any time point. All four studies had significant methodological flaws, which are highlighted by low scoring on the CONSORT questionnaire in Table 3. It is likely that the studies by Righesso et al. [15], Huang et al. [6], and Garg et al. [17] were underpowered and had a high risk of a type II error. In all of these studies, the PROM scores for both MED and OD are similar at all time points. The study by Teli et al. [16] did perform a power calculation based on pilot data and had 240 participants in the trial. The ODI scores at each time point were similar for each group, with relatively small standard deviations. Based on this study, it does appear likely that, in terms of the ODI scores, the interventions have a similar efficacy. If they are not similar, the magnitude of difference is very likely to be small.

Table 2 Summary of included studies

Study	Participants	Intervention (I) Comparator (C)	Outcome measures	Results
Righesso et al. [15]	Sciatica, + herniated lumbar disc (MRI), + failed conservative treatment under 60 years Exclusion—Previous surgery or foraminal herniations or spondylolisthesis or worker's compensation	I = 21 patients MED using the technique described by Foley and Smith [9] C = 19 patients OD using the technique described by Caspar [6]	ODI, visual analogue scale (VAS) for pain, complications, return to work, neurological exam, length of stay, surgical time, blood loss, size of incision	ODI pre-op and 2 years postop I = 54 (28–100) and 10 (0–22); C = 50 (22–96) and 10 (0–30); $p = 0.87$ VAS for pain at 2 years I = 1, C = 0, $p = 0.15$ Complications I = 1 recurrence, 1 seroma, 1 dural tear C = 1 recurrence Mean return to work 21 days in both groups % altered sensory/motor/reflexes at 2 years I = 33/38/48, C = 26/37/58 Length of stay (hours) I = 24 (11–72), C = 26 (16–72), $p = 0.05$ Surgical time (minutes) I = 82.6, C = 63.7, $p < 0.01$ Blood loss (ml) I = 50 C = 40, $p = 0.98$ Size of incision (mm) I = 21, C = 26 , $p = 0.01$
Teli et al. [16]	Symptomatic (pain or neurology) single level posterior lumbar disc herniation, age 18 – 65, over 6 weeks failed conservative treatment Exclusion— Cauda equina symptoms, foraminal herniation, stenosis, other spinal disease or surgery, malignancy, infection or rheumatic disease	240 pts enrolled, with 28 dropping out I = 70 patients MED using previously published technique C1 = 72 patients MD using previously published technique C2 = 70 patients OD using previously published technique	Primary VAS for pain Secondary SF 36, ODI, complications, scar length, hospital stay, costs	VAS for back/legs and SF36 No significant difference ODI at 2 years I = 14, C1 = 16, C2 = 15 Complications I = 6 dural tears (0 requiring secondary repair), 2 root injuries, 8 recurrent herniations (requiring surgery), 1 spondylodiscitis, 2 worsening deficit C1 = 2 dural tears (one requiring secondary repair), 3 recurrent herniations, 4 wound infections, 1 worsening deficit C2 = 2 dural tears (1 requiring secondary repair, 2 recurrent herniations, 3 wound infections Scar length (mm) I = 10, C1 = 22, C2 = 23 Hospital stay (hours) I = 54, C1 = 49 ($p = 0.021$), C2 = 49 Direct surgical costs (euros) I = 3010, C1 = 2450 ($p = 0.002$), C2 = 2310 ($p = 0.012$)
Garg et al. [11]	Single level lumbar disc herniation, symptomatic radiculopathy despite at least 6 weeks conservative therapy Exclusion— Spinal stenosis, previous operations, severe disc narrowing, cauda equina, Known psychological disturbance	I = 55 patients, MED using a paraspinal approach C = 57 patients, OD in the "standard fashion"	ODI, complications, hospital stay, surgical time, blood loss, weight of disc removal	ODI (1 year postop) I = 1.75, C = 2.14 Complications I = 5 durals leaks, 4 temporary urinary retention, 2 transient S1 neuralgia, 1 recurrence C = 5 dural leaks, 6 transient urinary retention, 3 urinary tract infection, 1 foot drop Hospital stay (days) I = 3, C = 12, $p < 0.001$ Surgical time (minutes) I = 84, C = 56, $p < 0.001$ Blood loss (ml) I = 41, C = 306, $p < 0.001$ Weight of disc removal (g) I = 3.7, C = 3.6, $p = 0.654$

Table 2 continued

Study	Participants	Intervention (I) Comparator (C)	Outcome measures	Results
Huang [6]	Symptomatic HIVD awaiting elective decompression of lumbar spine. Having failed 3 months of conservative treatment OR acute attack of leg/back pain with no improvement after 2 weeks of absolute bed rest	I = 10 patients, MED C = 12 patients, OD	MacNab criteria, CRP, IL-6, VAS, blood loss, skin incision length, operating time, hospital stay	MacNab criteria (mean 18.9 months follow up) I = 90 % satisfactory, C = 91.6 % satisfactory VAS scores I = 1.5, C = 1.4, $p = 0.91$ Peak CRP (mg/litre) I = 13.84, C = 27.78, $p = 0.026$ Peak IL-6 (pg/ml) I = 6.27, C = 17.18, $p = 0.025$ Blood loss (ml) I = 87.5, C = 190, $p = 0.042$ Skin incision length (mm) I = 18.6, C = 63, $p = 0.001$ Operating time (minutes) I = 109, C = 72.1 $p = 0.01$ Hospital stay (days) I = 3.57, C = 5.92 $p = 0.025$

Teli et al. [16] emphasise the increased risk of severe complications for MED; it is the key point in the title. In this paper the reporting and grouping of complications is selective and potentially misleading. Individually, no complication is significantly more common in any intervention group and the authors have failed to show that complications in general are more common in any group. Also, dural tears that did not require further surgery were not reported. Dural tears in the MED group were repaired with fibrin glue only, whilst in the MD and OD groups they were treated with direct suture and fibrin glue. It is possible that the higher rate of recurrent herniations that had further surgery in the MED group reflected the smaller surgical procedure to address it. Publishing the number of recurrent herniations that did not have further surgery would help to address this concern. Righesso et al. [15], Huang et al. [6], and Garg et al. [17] report similar frequency and type of complications in each group.

There are a number of flaws in all the studies that could have introduced systematic error and reduced the robustness of the results. The study by Teli et al. [16] is the most robust and adequately powered. It scores highest on the CONSORT questionnaire in Table 3 but does also have some flaws. All four studies were, however, RCTs providing a reasonable level of evidence to base recommendations on. It is unlikely that there was a large confounding effect in these studies. All three studies produced a table showing that the baseline characteristics of the groups were similar. Randomisation helps to balance confounding factors and the study by Teli et al. [16] would have been the least at risk from unknown confounding factors affecting the results as it had the highest number of participants.

One major consideration is the external validity of the studies. It is difficult to assess the external validity of two of the studies as very little detail is given, for example, on the experience and number of surgeons [15, 17]. In the study by Teli et al. [16], recruitment was at a tertiary referral centre and surgeons with at least 5 years experience of MED performed the surgery. This makes it more of a study of the efficacy of MED in an 'ideal' environment, reducing the external validity. On the basis of good results in these studies, it is not then possible to extrapolate these results to a non-tertiary hospital or to a surgeon with less experience in MED. This is particularly relevant as it is thought that MED has a long learning curve [18].

Limitations

Only studies written in the English language were included, potentially biasing the results. Unpublished work was not searched, increasing the already known risk of publication bias.

Table 3 CONSORT statement for each study

Section/topic	No	Checklist item	Huang	Righesso	Teli	Garg
Title/abstract	1a	Identification as a randomised trial in the title	Yes	Yes	No	Yes
	1b	Structured summary of trial design, methods, results, and conclusions	No	Yes	No	Yes
Introduction						
Background/ objectives	2a	Scientific background and explanation of rationale	Yes	Yes	Yes	Partly
	2b	Specific objectives or hypotheses	Partly	No	Yes	No
Methods						
Trial design	3a	Description of trial design (such as parallel, factorial) including allocation ratio	Yes	No	No	No
	3b	Important changes to methods after trial commencement (such as eligibility criteria), with reasons	No	No	No	No
Participants	4a	Eligibility criteria for participants	Yes	Yes	Yes	Yes
	4b	Settings and locations where the data were collected	No	No	Yes	No
Interventions	5	The interventions for each group with sufficient details to allow replication, including how and when they were actually administered	No	No	Yes	No
Outcomes	6a	Completely defined pre-specified primary and secondary outcome measures, including how and when they were assessed		No	Yes	No
	6b	Any changes to trial outcomes after the trial commenced, with reasons		–	–	–
Sample size	7a	How sample size was determined	No	No	Yes	No
	7b	When applicable, explanation of any interim analyses and stopping guidelines		No	No	No
Randomisation: sequence	8a	Method used to generate the random allocation sequence	No	No	Yes	No
Generation	8b	Type of randomisation; details of any restriction (such as blocking and block size)	No	No	No	No
Allocation concealment	9	Mechanism used to implement the random allocation sequence (such as sequentially numbered containers), describing any steps taken to conceal the sequence until interventions were assigned	No	No	No	No
Implementation	10	Who generated the random allocation sequence, who enrolled participants, and who assigned participants to interventions	No	No	No	No
Blinding	11a	If done, who was blinded after assignment to interventions (for example, participants, care providers, those assessing outcomes) and how	No	No	Yes	No
	11b	If relevant, description of the similarity of interventions	No	–	–	–
Statistical methods	12a	Statistical methods used to compare groups for primary and secondary outcomes	Yes	Yes	Yes	Yes
	12b	Methods for additional analyses, such as subgroup analyses and adjusted analyses	No	No	No	No
Results						
Participants flow	13a	For each group, the numbers of participants who were randomly assigned, received intended treatment, and were analysed for the primary outcome	No	No	Yes	No
	13b	For each group, losses and exclusions after randomisation, together with reasons	Yes	No	Yes	No
Recruitment	14a	Dates defining the periods of recruitment and follow-up	No	Yes	Yes	Yes
	14b	Why the trial ended or was stopped	No	No	Yes	No
Baseline data	15	A table showing baseline demographic and clinical characteristics for each group	No	Yes	Yes	Yes
Numbers analysed	16	For each group, number of participants (denominator) included in each analysis and whether the analysis was by original assigned groups	Yes	Yes	Yes	Yes
Outcomes and estimation	17a	For each primary and secondary outcome, results for each group, and the estimated effect size and its precision (such as 95 % confidence interval)	Yes	No	Yes	No
	17b	For binary outcomes, presentation of both absolute and relative effect sizes is recommended	–	–	–	–
Ancillary analyses	18	Results of any other analyses performed, including subgroup analyses and adjusted analyses, distinguishing pre-specified from exploratory	No	No	No	No
Harms	19	All important harms or unintended effects in each group	Yes	Yes	Partly	Yes

Table 3 continued

Section/topic	No	Checklist item	Huang	Righesso	Teli	Garg
Discussion						
Limitations	20	Trial limitations, addressing sources of potential bias, imprecision, and, if relevant, multiplicity of analyses	No	No	No	No
Generalisability	21	Generalisability (external validity, applicability) of the trial findings	No	No	No	No
Interpretation	22	Interpretation consistent with results, balancing benefits and harms, and considering other relevant evidence	Yes	Partly	No	Yes
Other information						
Registration	23	Registration number and name of trial registry	No	No	No	No
Protocol	24	Where the full trial protocol can be accessed, if available	No	No	No	No
Funding	25	Sources of funding and other support (such as supply of drugs), role of funders	Yes	No	No	No

Recommendations for practice

The Cochrane review in 2007 provided strong evidence that OD (and moderate evidence that MD) are effective interventions for sciatica in carefully selected patients [4]. It did not have enough evidence to draw conclusions on MED, although suggested that it would be worth further study [4]. This systematic review included studies with the participants known to benefit from OD or MD, therefore these studies were able to compare MED to a gold standard intervention. Although there were methodological flaws in all studies, they all showed very similar ODI scores in all groups at all time points. A meta-analysis would help to confirm this, but it is likely that MED is as effective as OD or MD at up to 2 years postoperatively when performed in specialised centres by surgeons experienced in microendoscopic surgery.

Directions for future research

If a further study were to be performed, it may be reasonable to perform a pragmatic study to test the intervention in 'real life' conditions. A multicentre study would increase the external validity of the results compared with studies only assessing the results of experienced surgeons in tertiary referral centres; however, there must be a clear case for performing a future study as there is no indication that MED is superior in the studies already performed in an ideal setting. The perceived benefits of microendoscopic surgery including shorter hospital stay, postoperative pain and time to full recovery should be fully scrutinised and evaluated in the outcome measures of any future studies.

Conflict of interest None.

References

1. Valat JP, Genevay S, Marty M, Rozenberg S, Koes B (2010) Sciatica. Best Pract Res Clin Rheumatol 24:241–252
2. Weber H, Holme I, Amlie E (1993) The natural course of acute sciatica with nerve root symptoms in a double-blind placebo-controlled trial evaluating the effect of piroxicam. Spine 18:1433–1438
3. Vroomen PC, de Krom KM, Slofstra PD, Knottnerus JA (2000) Conservative treatment of sciatica: a systematic review. J Spinal Disord 13:463–469
4. Gibson JN, Waddell G (2007) Surgical interventions for lumbar disc prolapse. Cochrane Database Syst Rev 2: CD001350
5. Foley KT, Smith MM (1997) Micro endoscopic discectomy. Op Neurosurg 3:301–307
6. Huang TJ, Hsu RW, Li YY, Cheng CC (2005) Less systemic cytokine response in patients following micro endoscopic versus open lumbar discectomy. J Orthop Res 23(2):406–411
7. Bragge P (2010) Asking good clinical research questions and choosing the right study design. Injury Supp1(1): S3–S6
8. Schulz KF, Altman DG, Moher D (2010) CONSORT 2010 Statement: updated guidelines for reporting parallel group randomised trials. BMC Med 8(18)
9. Liu T, Zhou Y, Wang J, Chu TW, Li C, Zhang ZF et al (2012) Clinical efficacy of three different minimally invasive procedures for far lateral lumbar disc herniation. Chin Med J 125(6): 1082–1088
10. Liu WG, Wu XT, Guo JH, Zhuang SY, Teng GJ (2010) Long-term outcomes of patients with lumbar disc herniation treated with percutaneous discectomy: comparative study with micro endoscopic discectomy. Cardiovasc Intervent Radiol 33(8003538, com): 780–6
11. Shin D, Kim K, Shin H, Yoon D (2008) The efficacy of micro endoscopic discectomy in reducing iatrogenic muscle injury. J Neurosurg Spine 8(101223545):39–43
12. Zhang C, Zhou Y, Chu TW, Wang J, Hao Y, Pan Y (2007) Microendoscopic discectomy, a less traumatic procedure for lumbar disk herniation. Chin J Traumatol 10(5):311–314
13. Arts MP, Brand R, Van Den Akker ME, Koes BW, Bartels RHMA, Peul WC (2009) Tubular diskectomy vs conventional microdiskectomy for sciatica: a randomized controlled trial. JAMA 302(2):149–158
14. Ruetten S, Komp M, Merk H, Godolias G (2009) Recurrent lumbar disc herniation after conventional discectomy: a prospective, randomized study comparing full-endoscopic interlaminar and transforaminal versus microsurgical revision. J Disord 22(101140323):122–129
15. Righesso O, Falavigna A, Avanzi O (2007) Comparison of open discectomy with microendoscopic discectomy in lumbar disc herniations: results of a randomized controlled trial. Neurosurg 61(nzl, 7802914): 545–549
16. Teli M, Lovi A, Brayda-Bruno M, Zagra A, Corriero A, Giudici F, et al (2010) Higher risk of dural tears and recurrent herniation with lumbar micro-endoscopic discectomy. Eur Spine J 19(9301980, b9y): 443–450

17. Garg B, Nagraja UB, Jayaswal A (2011) Microendoscopic versus open discectomy for lumbar disc herniation: a prospective randomised study. J Orthop Surg (Hong Kong) 19(9440382, 101265112): 30–4

18. Nakagawa H, Yoshida M, Maia K (2006) Microendoscopic discectomy (MED) for surgical management of lumbar disc disease: technical note. J Spine Surg 2(2)