The Egyptian Journal of Neurology, Psychiatry and Neurosurgery

RESEARCH

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Percutaneous full-endoscopic transforaminal discectomy versus open microdiscectomy in the treatment of lumbar disc herniation: randomized controlled trial

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Abstract

Background Lumbar disc herniation is one of the most common degenerative spine conditions. In our center, the standard surgical technique for treatment of lumbar disc herniation is open microdiscectomy. The full-endoscopic transforaminal discectomy is done for selective cases of lumbar disc herniation under local anesthesia, achieving good results. This study aims to compare the clinical outcomes, operative data, and complications of the treatment of lumbar disc herniation with "percutaneous full-endoscopic transforaminal discectomy" (TED) and the gold standard "open microdiscectomy" (MD). This was a randomized controlled trial that included 65 patients with lumbar disc herniation: 32 in the TED group and 33 in the MD group.

Results There was no statistically significant difference between the two groups with regard to the visual analogue scale (VAS) for leg pain, the VAS for back pain, or the Oswestry Low Back Pain Disability Questionnaire (ODI) score at the end of the 1-year follow-up. The operative time in minutes was statistically shorter in the TED group, with a mean value of 50.38 (± 11.65) and 61.09 (± 12.32) in the MD group. The blood loss was 77.33 CC (± 23.14) in the TED group and 170 CC (± 56.06) in the MD group. The mean duration of hospital stay in days was statistically shorter in the TED group. Exposure to radiation in minutes was higher in the TED group: 1.09 (± 0.33) and 0.18 (± 0.08) in the TED group and MD group, respectively. There was no statistically significant difference in the rate of complications.

Conclusion TED showed superiority over MD with regard to blood loss, operative time and shorter hospital stays, but with increased radiation exposure. There was no difference in clinical outcomes regarding VAS for leg and back pain and ODI score at 1 year follow-up with no significant difference in complications.

Keywords Discectomy, Endoscopic discectomy microdiscectomy, Minimally invasive spine surgery (MISS), Transforaminal endoscopic discectomy

Background

Lumbar disc herniation is one of the most common degenerative spine conditions. 95% of lumbar disc herniation occurs at the L5/S1 and L4/L5 levels, as these are the levels most subjected to recurrent torsional strain [1].

Conservative management is the first line of treatment for this condition, as 90% of patients with symptomatic

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lumbar disc prolapse will show improvement in symptoms without surgical intervention [2]. The absolute indications for surgery for lumbar disc prolapse are in patients with cauda equina syndrome symptoms and in patients with progressive muscle weakness. Also, surgery is relatively indicated for rapid pain relief in patients whose recovery is slow and causing dysfunction in daily life activities with failure of conservative management [3].

The open microdiscectomy through the posterior approach is considered the gold standard surgical procedure for decompression of radiculopathy caused by lumbar disc herniation [4].

The transforaminal endoscopic discectomy approach was first described by Kambin in 1988. He described the safe triangle working zone (Kambin Triangle) for passing the endoscope through the neural foramen and provided the first intraoperative endoscopic view of the herniated disc [5]. Since then, the technique has undergone remarkable technical advancement. The current aim of this procedure is to perform a herniated disc fragmentectomy and direct decompression of the nerve root [6].

The study aims to compare the clinical outcomes, operative data, and complications of the treatment of lumbar disc herniation with the "percutaneous full-endoscopic transforaminal discectomy technique" (TED) and the gold standard "open microdiscectomy technique" (MD).

The author's hypothesis is that percutaneous full-endoscopic transforaminal discectomy can achieve the same clinical outcomes as open microdiscectomy for managing cases of lumbar disc herniation with the advantages of being done under local anesthesia with less hospital stay and less blood loss.

Methods

This was a prospective randomized controlled clinical trial (RCT) that was done in the period between January 2020 and January 2022. The study protocol and the consent were reviewed and approved by the Ethical Committee in our center. Informed consent for surgery by both approaches and randomization was obtained from all the involved patients enrolled in our study.

The inclusion criteria of our study were adult patients aged 18 to 70 years old with single-level symptomatic lumbar disc herniation with main symptoms of radiculopathy (leg pain) confirmed with MRI and clinical correlation with failed adequate conservative lines of treatment for at least 6 weeks. Patients with isolated low back pain, multi-level lumbar disc herniation, lumbar spine instability, lumbar spinal canal stenosis, and recurrent disc herniation were excluded.

The study included 65 patients. The participants were blindly randomized into two groups: 32 patients underwent full-endoscopic transforaminal discectomy (TED) and 33 patients underwent open microdiscectomy (MD). Randomization was done by the medical secretary by the simple randomization method using a randomization list into the two groups one week before surgery.

Patients were clinically evaluated preoperatively through a detailed medical history and full clinical examination. Plain X-rays (static and dynamic views) of the lumbosacral spine and MRI of the lumbosacral region were evaluated to confirm the pathology in correlation with the clinical picture. Preoperative Visual analogue scale (VAS) for back pain and leg pain [10] and Arabic version of the Oswestry Low Back Pain Disability Questionnaire (ODI) [11] were obtained for patients who met our inclusion criteria.

All patients were admitted to the hospital on the same day of surgery. An intravenous antibiotic (1 g of cefazolin) was administered 1 h before surgery. Operative details, including duration of surgery, blood loss, time of radiation exposure, and intraoperative complications (as, dural tears, instrument failure, and neural structure injuries) were recorded.

Patients were subjected to two different techniques; the minimally invasive full-endoscopic transforaminal discectomy (TED) and the standard open microdiscectomy (MD).

With regard to TED group, all patients were operated awake using local anesthesia under sedation in a prone position. C-arm imaging was used to obtain skin marking for needle access, which was always 12–16 cm from the med-line. A spinal cannula was inserted, targeting the level of lumbar disc prolapse under fluoroscopic guidance. In the lateral view, the needle tip should had been at the level of the dorsal annulus, and in the AP view the tip should had been at the medial pedicular line before entering the disc space with the cannula. Then a guide wire was inserted through the cannula followed by a blunt cannulated dilator and a working sheath through a 0.8 cm skin incision and pushed through the foramen fluoroscopically guided to stop at the medial pedicle line. The endoscope was then inserted through the working sheath with an outer diameter of 6.9 mm and a working channel diameter of 4.1 mm (Fig. 1). Decompression was done under complete visualization with the help of different instruments, including rongeurs, punches, and dissectors. Hemostasis and dissection were done by a radiofrequency probe. After complete decompression and removal of the disc fragment, strong pulsations of the dural sac were seen, indicating the free mobilization of the nerve root (Figs. 2, 3). In some cases, especially at the level of L5 or S1, foraminotomy was needed using a burr to cut part of the superior articular facet in order to allow the working sheath to pass through the foramen.

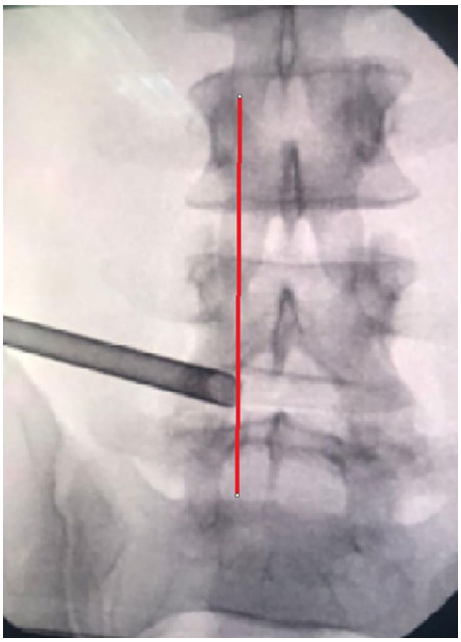

Fig. 1 Working cannula enters the disc space through the foramen with its end on the medial pedicle line (red line) in the AP view

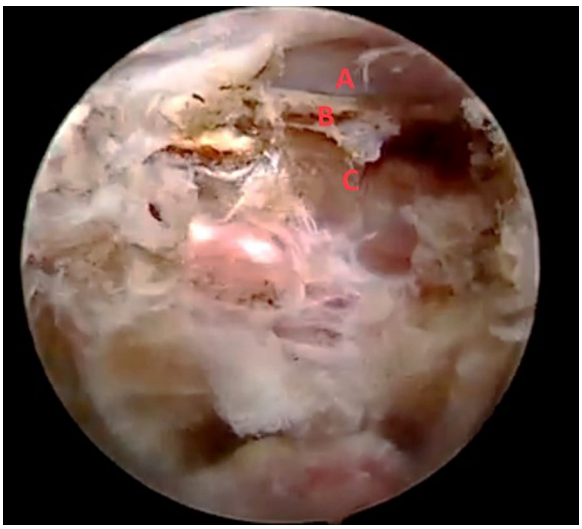

Fig. 2 Endoscopic anatomy is identified as the traversing root is seen compressed by disc fragment. **A** The traversing root. **B** Disc annulus. **C** Herniated disc fragment

With regard to the MD group, the procedure was done by standard technique under general anesthesia. We used Casper retractors with suitable blade sizes to retract the muscles through a 3–5 cm incision, and the procedure was done under the magnification of a surgical microscope (Fig. 4).

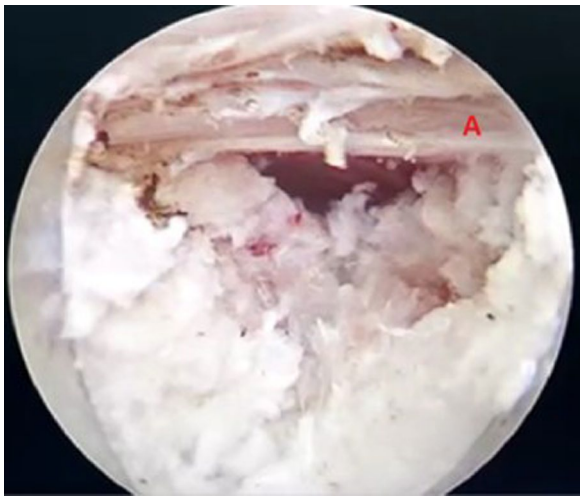

Fig. 3 The root is seen fully decompressed after removal of herniated disc fragment

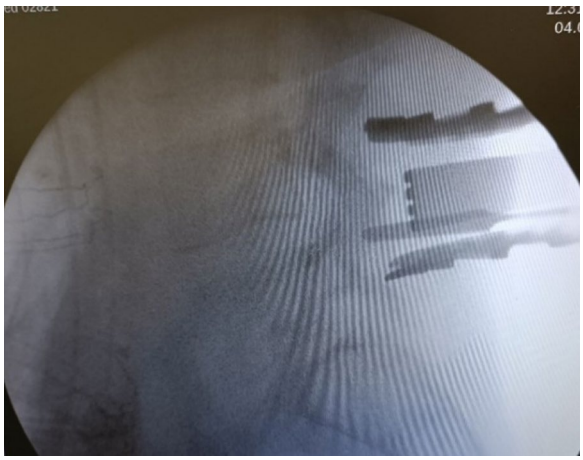

Fig. 4 Lateral view imaging to ensure correct level and good position of the Caspar retractor

Postoperative treatment for the two groups included only paracetamol (2 g daily for 1 week). Patients were allowed free mobilization with a lumbar support brace postoperatively with the restriction of sitting for long periods, forward bending more than 90 degrees, and lifting objects from the ground for 2 weeks.

VAS for back and leg pain was recorded during the first follow-up after 2 weeks postoperatively, and follow-up was done at 3, 6, and 12 months postoperatively by VAS for back and leg pain in addition to the ODI questionnaire. Also, postoperative complications and the time of return to work were recorded. A postoperative MRI was done if the patient has residual symptoms or at 3 months follow-up for all patients.

The collected data were revised, coded, tabulated and introduced to a PC using Statistical package for Social Science (SPSS 25). Data were presented and suitable analysis was done according to the type of data obtained for each parameter. Student's *t* test was used to assess the statistical significance of the difference between two study group means. Chi-square test was used to examine the relationship between two qualitative variables. Fisher's exact test was used to examine the relationship between two qualitative variables when the expected count is less than 5 in more than 20% of cells. *P*-value of less than 0.05 is considered significant.

Results

Out of 80 patients with single-level lumbar disc herniation assessed for eligibility for this study, 70 patients met our inclusion criteria and were randomized into two groups. Two patients in the MD group and three patients in the TED group were lost during follow-up. The consortium diagram is shown in Fig. 5.

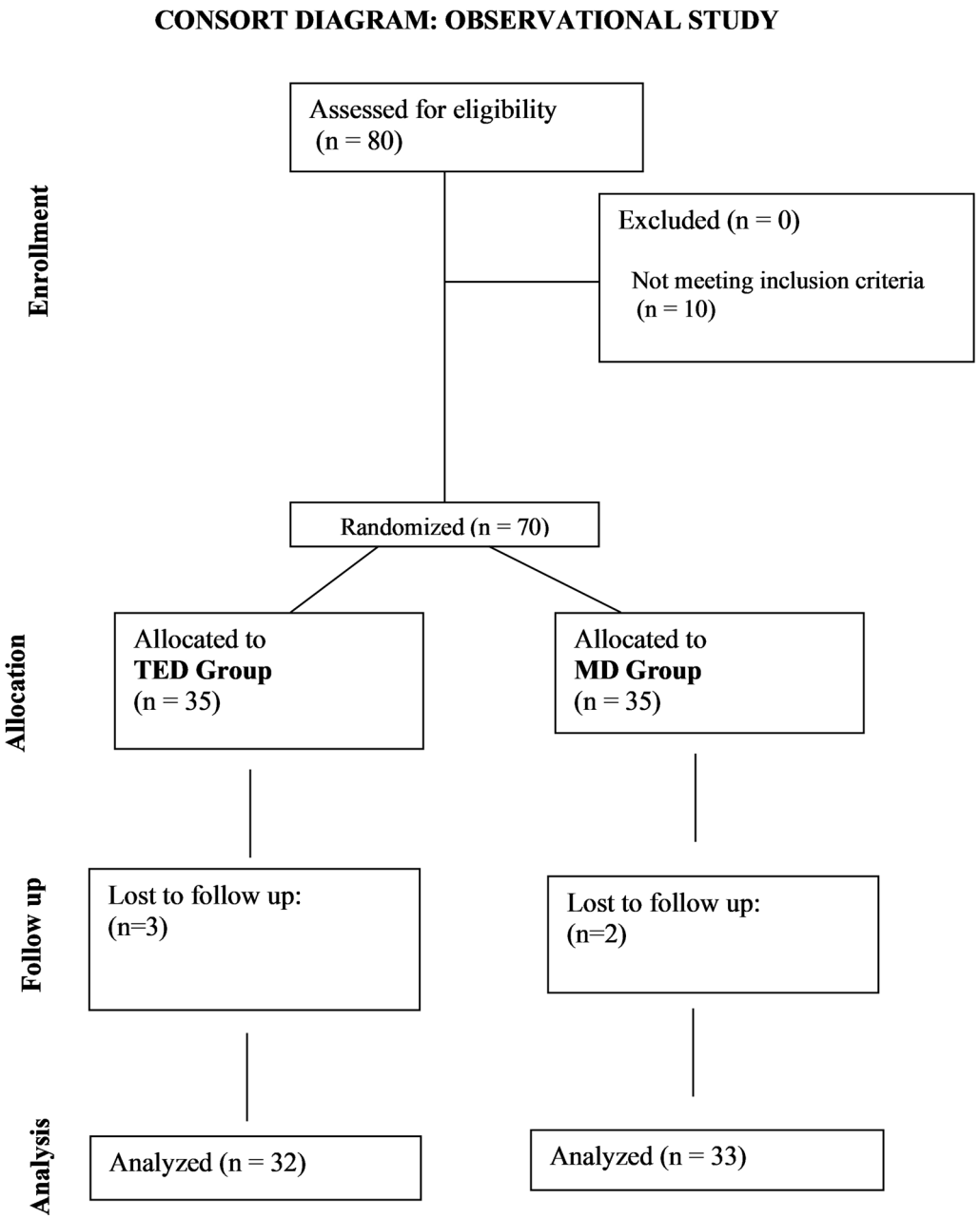

Fig. 5 Consort diagram for the study

There was no statistically significant difference between the two groups regarding gender, age, body mass index (BMI), operated level, or side of leg pain. Also, there was no statistically significant difference between the two groups regarding the preoperative values of VAS for back pain, VAS score for leg pain, and ODI score. Results are summarized in Table 1.

The mean value (± SD) of VAS for leg pain was calculated in the follow-up at 2 weeks, 3 months, 6 months, and 12 months in the two groups with no statistically significant difference between the two groups during the follow-up (Table 2).

The mean value (± SD) VAS of back pain was also calculated at 2 weeks, 3 months, 6 months, and 12 months. There was improvement in both groups, with a statistically significant difference between the two groups in favor of the TED group during follow-up at 2 weeks and 3 months with no statistically significant difference between the two groups at 6 months and 12 months follow-up (Table 3).

Regarding the ODI score, the TED group showed statistically significant improvements in ODI score when compared to the MD group at 3 and 6 months of follow-up with no statistically significant difference between the two groups regarding the ODI score at 12 months of follow-up (Table 4).

The mean operative time was 50.38 (± 11.65) minutes in the TED group and 61.09 (± 12.32) minutes in the MD group with statistically significant difference between the two groups ($P=0.001$). The mean value of blood loss calculated in cubic centimeters was 77.19 (± 22.89) and 168.18 (± 54.22) in TED group and MD group, respectively, with statistically significant difference between the two groups in favor of TED group ($P<0.001$). Exposure to radiation in minutes was calculated intraoperatively with a mean value (± SD) of 1.09 (± 0.33) and 0.18 ± 0.08 in the TED group and MD, respectively, with significantly higher exposure to radiation in the TED group ($P<0.001$). Also, the mean duration of hospital stay in days was 1 (± 0) and 1.97 (± 0.81) in the TED group and

Table 2 Showing comparison of VAS for leg pain during follow-up between the two groups: transforaminal endoscopic discectomy group (TED) and microdiscectomy group (MD)

VAS leg pain (mean ± SD)	TED group	MD group	*p*-value*	Significance
Preoperative	8.47 ± 0.51	8.4 ± 0.65	0.607	NS
2 weeks postoperative	3.54 ± 0.66	3.92 ± 0.86	0.051	NS
3 months postoperative	2.69 ± 0.77	2.53 ± 0.6	0.362	NS
6 months postoperative	1.85 ± 0.46	2.11 ± 0.61	0.062	NS
12 months postoperative	1.33 ± 0.53	1.54 ± 0.54	0.138	NS

NS; non-significant

*Calculated by Student's *t* test

Table 1 Showing baseline characteristics for the two groups

Variable	TED group	MD group	*P* value	Significance
Age (mean ± SD)	35.47 ± 9.34	39.27 ± 7	0.067*	NS
BMI (mean ± SD)	23.13 ± 2.61	24 ± 3.91	0.295*	NS
Gender (n %)				
Male	25 (78.13%)	19 (57.58%)	0.077**	NS
Female	7 (21.88%)	14 (42.42%)		
Side of leg pain, (n %)				
Right	14 (43.75%)	22 (66.67%)	0.063**	NS
Left	18 (56.25%)	11 (33.33%)		
Operated level, (n %)				
L3–L4	2 (6.25%)	2 (6.06%)	0.731***	NS
L4–L5	19 (59.38%)	16 (48.48%)		
L5–S1	11 (34.38%)	15 (45.45%)		
Preoperative VAS leg pain, (mean ± SD)	5.65 ± 0.77	5.42 ± 0.88	0.264*	NS
Preoperative VAS back pain, (mean ± SD)	8.47 ± 0.51	8.4 ± 0.65	0.607*	NS
Preoperative ODI, (mean ± SD)	64.75 ± 5.41	64.18 ± 7.92	0.738*	NS

NS, non-significant; SD, standard deviation; n, number

* Calculated by Student's T test

**Calculated by Chi-square test (χ^2)

***Calculated by Fisher's exact test

Table 3 Showing comparison of VAS for back pain during follow-up between the two groups: transforaminal endoscopic discectomy group (TED) and microdiscectomy group (MD)

VAS back pain (mean ± SD)	TED group	MD group	*p*-value*	Significance
Preoperative	5.65 ± 0.77	5.42 ± 0.88	0.264	NS
2 weeks postoperative	3.37 ± 0.63	4.07 ± 0.52	< 0.001	S
3 months postoperative	2.25 ± 0.68	3.45 ± 0.88	< 0.001	S
6 months postoperative	2.24 ± 0.57	2.56 ± 0.71	0.051	NS
12 months postoperative	1.87 ± 0.64	2.09 ± 0.73	0.202	NS

S; significant, NS; non-significant

*Calculated by Student's *t* test

Table 4 Showing comparison of ODI results during follow-up between the two groups: transforaminal endoscopic discectomy group (TED) and microdiscectomy group (MD)

ODI (mean ± SD)	TED group	MD group	*p*-value	Significance
Preoperative	64.75 ± 5.41	64.18 ± 7.92	0.738	NS
3 months postoperative	22.73 ± 5.05	26.32 ± 4.59	0.005	S
6 months postoperative	17.4 ± 4.87	19.68 ± 3.9	0.048	S
12 months postoperative	14.13 ± 3.19	15.03 ± 3.75	0.369	NS

S; significant, NS; non-significant

*Calculated by Student's *t* test

MD group, respectively, with statistically significant shorter hospital stay in the TED group ($P < 0.001$).

The mean time of return to work postoperatively was calculated in weeks with a mean value of 4.64 (± 1.62) in the TED group and 9.43 (± 2.23) in the MD, with a significant difference in favor of the TED group.

Regarding complications recorded in the study, there was one case of dural tear in the MD group, which was managed by direct dura sac repair by sutures. There were two cases of instrument failure in the TED group, in which a disc punch was broken in the disc space and the broken part was removed through the endoscopic working channel without the need to change to open surgery in the two patients. We experienced four cases of recurrence, two in each group. One case in the MD group needed reoperation with revision discectomy and posterior spinal fusion. In the other case, a revision discectomy was done through a full-endoscopic transforaminal approach. A case in the TED group required revision, and microdiscectomy was done. The second case in the TED group with recurrence refused further intervention with improvement of symptoms after 3 weeks of conservative management. There was one case of wound complication in the MD group in the form of wound dehiscence. There were no cases of postoperative infection recorded in either group. There was no statistically significant difference between the two groups regarding complication.

Discussion

Full endoscopic transforaminal discectomy is an emerging technique that has gone through many advancements in technique and instruments during the last few years, achieving good results in the management of lumbar disc herniation with less tissue damage [6–8]. Although microdiscectomy is still the standard surgical management for lumbar disc herniation in many centers, including Ain Shams University Hospitals, full-endoscopic transforaminal discectomy has gained popularity among surgeons as an alternative to the standard surgery in many cases.

In this study, both techniques the full-endoscopic transforaminal discectomy and the open microdiscectomy showed favorable clinical outcomes. This study showed that the full-endoscopic transforaminal discectomy gave similar results as the gold standard microdiscectomy regarding the improvement of VAS for leg pain, VAS for back pain, and ODI score at the end of the follow-up at 1 year, with superiority with regard to duration of hospital stay, blood loss, faster return to work, and a similar rate of complications and recurrence.

Also, in this study, the VAS for back pain (2 weeks and 3 months) and ODI (3 and 6 months) following surgery showed superiority in the group of patients who underwent transforaminal endoscopic discectomy. These results contribute to increased patient satisfaction and rapid recovery of the patients following the endoscopic discectomy, reducing the duration of hospital stay and sick leave in patients who underwent full-endoscopic transforaminal discectomy and thus making this technique a cost-effective procedure [8, 9].

Those results are similar to those reported in the literature in the previous published studies [10–13]. Mayer and colleagues published the first randomized controlled trial in 1993 comparing the two techniques and showed good results for the transforaminal endoscopic discectomy, but they included only patients with contained disc herniations, with a high selection of patients eligible for the transforaminal discectomy technique [13].

Kim and colleagues published in 2007 their study with a huge sample size of 915 patients comparing the two techniques retrospectively with follow up of at least 18 months. Both techniques showed a similar success rate and a similar rate of complications and recurrence. while

the transforaminal discectomy showed inferior results in managing downward far-migrating cases beneath the pedicle of the lower vertebra or in cases involving L5–S1 with a high pelvis [12].

Gibson and colleagues also compared both techniques in the study with a sample size of 143 patients, but they showed superiority of the transforaminal endoscopic discectomy technique in improving the VAS of leg pain at the end of a 2-year follow-up [14].

Gadjradj and colleagues published a systematic review and meta-analysis comparing the results of both techniques, including the results of 14 studies, and showed similar results for both techniques in improving leg pain and functional status at intermediate and long-term follow-up [15].

Although in this study the operative time recorded from skin incision to skin closure was shorter in the TED group, settings and preparation time in endoscopic surgeries usually take longer, so a trained team of surgeons, assistants, nurses, and technicians familiar with this type of surgery is mandatory to carry out this procedure in a professional way and decrease operative time [16].

During the study, there was one patient who had an accidental dural tear in the microdiscectomy group; the tear was managed by direct repair during the procedure. Dural tears in endoscopic transforaminal techniques are rare, with a reported incidence of 1.1% [17]. Management of dural tears during transforaminal endoscopic surgery is controversial, as some authors report the use of dural sealants such as fibrin glue and fibrin patches, which are an effective way to repair such small tears [18, 19], while some authors recommended conversion to open surgery and direct injury repair [17].

The recurrence rate was similar between the two groups in our study. We had two patients with early recurrences in each group. A missed fragment may be the cause of the recurrence of symptoms, as a loose disc fragment may be missed, causing compression of the nerve root later on with activity. Reoperation in cases of recurrence in the TED group was easier due to fewer adhesions and less trauma to the paraspinal muscles caused by this technique, as reported in other studies [7].

The patient with instrument failure during the endoscopic discectomy intraoperative had no complications postoperatively as the broken part of the instrument was removed immediately through the endoscopic working channel, but this incidence may have necessitated conversion of the endoscopic surgery to open surgery, so consent for open surgery should be taken prior to the endoscopic discectomy and the surgeon should be ready for this. Also, high-quality instruments should be used to avoid such complications, with close follow-up on the instruments preoperatively and strict application of the manufacturer's instructions, especially regarding the usage replacement strategy.

One of the disadvantages of the transforaminal endoscopic discectomy technique is the increased exposure to radiation for the surgeon and operation room staff. This can be optimized by using protective barriers, knowing the needed positions during the procedure, and using image guidance and navigation-assisted technology.

We did not experience any cases of postoperative discitis in either group, although discitis following discectomy surgery is reported in the literature following discectomy surgeries with an incidence of 0.12%–4% [20–22].

The limitation in this study is the small sample size and relatively short follow-up period; also, the endoscopic surgeries are carried out by experienced surgeons in this type of surgery who have passed their learning curve, so the results of this technique may differ with surgeons starting their spine endoscopy career.

Conclusion

Transforaminal endoscopic discectomy showed similar clinical outcomes regarding VAS for back pain, VAS for leg pain, and ODI score and rate of complication as the gold standard for microdiscectomy at one-year follow-up. The transforaminal endoscopic discectomy showed superiority over microdiscectomy with regard to reduction of VAS of back pain at 3 months follow-up and ODI score improvement at 3 and 6 months postoperatively with less blood loss, shorter hospital stay duration, and faster return to work, but with increased hazards of high intraoperative radiation exposure.

Abbreviations

BMI	Body mass index
MD	Open microdiscectomy
MI	Minimally invasive
ODI	Oswestry Low Back Pain Disability Questionnaire
RCT	Randomized controlled clinical trial
SD	Standard deviation
TED	Percutaneous full-endoscopic transforaminal discectomy
VAS	Visual analogue scale

Acknowledgements

Not applicable.

Author contributions

MK: methodology, software, writing—original draft, project administration. MY: supervision, conceptualization, data curation, writing—original draft preparation. AS: supervision, conceptualization, methodology, writing—review and editing. ZA: supervision, writing—original draft preparation.

Funding

The authors did not receive any funds to conduct the research.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request. The figures used in this study are originals and belong to the authors.

Declarations

Ethics approval and consent to participate

The study protocol and the consent were reviewed and approved by the Ethical Committee of the Faculty of Medicine, Ain Shams University (FMASU MD 144 /2020). Informed consent for surgery by both approaches and randomization was obtained from all the involved patients enrolled in our study.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Received: 11 August 2023 Accepted: 7 January 2024
Published online: 24 January 2024

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