

Surgical technique and effectiveness of microendoscopic discectomy for large uncontained lumbar disc herniations: a prospective, randomized, controlled study with 8 years of follow-up

Mohamed Hussein · Ashraf Abdeldayem ·
Mahmoud M. M. Mattar

Received: 28 September 2013/Revised: 15 February 2014/Accepted: 28 March 2014/Published online: 16 April 2014
© Springer-Verlag Berlin Heidelberg 2014

Abstract

Background There is a long-held concept among spine surgeons that endoscopic lumbar discectomy procedures are reserved for small-contained disc herniation; 8-year follow-up has not been reported. The purpose of this study is to assess microendoscopic discectomy (MED) in patients with large uncontained lumbar disc herniation (the antero-posterior diameter of the extruded fragment is 6–12 mm or more on axial cuts of MRI) and report long-term outcome. **Methods** One hundred eighty-five patients with MED or standard open discectomy underwent follow-up for 8 years. Primary (clinical) outcomes data included Numerical Rating Scale (NRS) for back and leg symptoms and Oswestry Disability Index (ODI) to quantify pain and disability, respectively. Secondary (objective) outcomes data included operative time, blood loss, postoperative analgesics, length of hospital stay, time to return to work, reoperation and complication rate, patient satisfaction index (PSI), and modified (MacNab) criteria.

Results At the end of the follow-up, the leg pain relief was statistically significant for both groups. NRS back pain, ODI, PSI and MacNab criteria showed significant deterioration for control group. Secondary outcomes data of MED group were significantly better than the control group.

Conclusions Large, uncontained, lumbar disc herniations can be sufficiently removed using MED which is an effective alternative to open discectomy procedures with remarkable long-term outcome. Although the neurological outcome of the two procedures is the same, the morbidity of MED is significantly less than open discectomy. Maximum benefit can be gained if we adhere to strict selection criteria. The optimum indication is single- or multi-level radiculopathy secondary to a single-level, large, uncontained, lumbar disc herniation.

Keywords Microendoscopic discectomy (MED) · Large uncontained · Lumbar disc herniation

Introduction

Refinement of discectomy procedure continued since Dandy [1] reported removal of a “disc chondroma” from patients with sciatica. In 1934 Mixter and Barr [2, 3] attributed sciatica to lumbar disc herniation and suggested discectomy through total laminectomy and transdural approach. In 1939 Semmes [4] presented a subtotal laminectomy and retraction of the dural sac to remove the herniated disc.

Despite the conflicting outcome reports, open discectomy is considered the standard method of treatment for lumbar disc herniation [5]. Surgical violation in open lumbar discectomy predisposes to failed back surgery through segmental instability (occurred in 28 % of patients) and Perineural scarring (occurred in 34 % of patients) [6]. An analysis of several clinical studies revealed the occurrence of operation-induced destabilization due to the necessary resection of spinal canal structures [7–14]. The muscle and ligaments stripping,

M. Hussein (✉)
Tennessee University, Memphis, USA
e-mail: m_hussien9@yahoo.com

M. Hussein · A. Abdeldayem · M. M. M. Mattar
Department of Orthopedics and Traumatology,
Surgery Hospital, 4th Floor, Zagazig University Hospitals
and Faculty of Medicine, Zagazig University,
Zagazig City, Sharkiah 44519, Egypt

dissection and excessive cauterization influence the stabilization and coordination system in the innervation area of the dorsal nerve roots of the spinal nerves [15–17], and could aggravate segmental instability and cause an incidence of 11–15 % postoperative disabling low back pain [18–23].

Perineural scarring about the dura and nerve roots after lumbar disc surgery is another important cause of failed surgery. Many theories have been postulated to explain pathogenesis of epidural fibrosis. Postlaminectomy scar is caused by damage to the erector spine muscles overlying the laminectomy site [24]. Excessive cauterization of epidural veins inhibits nerve roots nutrition causing intraneural, epidural fibrosis and arachnoiditis [25]. Epidural hematoma, epidural venous bleeding and arterial bleeding from paravertebral muscles occurring in the path of surgical dissection are gradually absorbed and replaced by granulation tissue which matures into dense fibrous tissue [26].

In 1997 Foley and Smith [27, 28] introduced the microendoscopic discectomy (MED) procedure and presented the results of the first 100 cases. They introduced a rigid endoscope through a tubular retractor inserted in a minimally invasive muscle splitting approach produced by introduction of a series of sequential dilators, allowing discectomy through a direct posterior approach which is familiar to spine surgeons [29]. Since then, only one study compared retrospectively the clinical outcomes of MED and open discectomy with a mean follow-up of 28 months [30], other studies compared postoperative MRI [31] or intraoperative EMG studies [32] of patients with lumbar disc herniation treated with MED and control group treated with open discectomy.

Materials and methods

We enrolled 200 patients with clinically-symptomatic large uncontained lumbar disc herniation who underwent discectomies at Zagazig University Hospitals, Egypt, between August 2002 and August 2004. There were 112 male and 88 female whose age ranged from 18 to 54 years (mean 30.9 years). The mean duration of symptoms was 3.04 months for MED group and 3.5 months for open discectomy group. All patients had received conservative treatment in the form of limited duty, NSAIDs, muscle relaxants, neurotrophics, opioid analgesics and a comprehensive course of 20 sessions of physiotherapy (mean 3.1 months). Patient characteristics are listed in Table 1.

Patients were divided into two groups, 100 patients each who underwent either standard open discectomy, or Microendoscopic discectomy utilizing METRx system (Medtronic Sofamor Danek, Inc., Memphis, TN, USA). Patients

Table 1 Clinical characteristics of the patients in the MED and open discectomy groups

| Patients characteristics | MED-METRx | Open discectomy | Statistics |
|--|-----------|-----------------|------------|
| Number of patients at end of follow-up | 95 | 90 | NS |
| Mean age (years) | 30.2 | 31.5 | NS |
| Sex (male/female) | 58/42 | 54/46 | NS |
| Mean duration of symptoms (months) | 3.04 | 3.5 | NS |
| Level of disc herniation | | | |
| L2–L3 | 1 | 2 | NS |
| L3–L4 | 5 | 7 | NS |
| L4–L5 | 49 | 43 | NS |
| L5–S1 | 40 | 38 | NS |
| Mean follow-up (months) | 104.2 | 101.3 | NS |

NS not significant

of both groups had a very similar clinical profile. Determination of the general indication for disc surgery was made by two experienced physicians who were not affiliated with the study. Randomization was open since the patients must sign a detailed informed consent and was made by nonphysician study staff alternating between the open discectomy or MED in the sequence of presentation (were allocated so that the patient 1 got 1st, type of surgery, and number 2 a 2nd, type etc.). All operations were performed by the authors who have considerable experience in both techniques. All the participants gave their written consent in accordance to the Helsinki Declaration [33]. The study was approved by the Ethical Research Committees of Zagazig University Hospitals.

The inclusion criteria for patients in this study were: (1) single level of disc herniation, with typical radiculopathy that is more dominant than back pain on one side, (2) a history of disability that limits every day activity and work, (3) evident disc herniation on magnetic resonance imaging MRI with an antero-posterior diameter of the extruded fragment (6–12 mm) or more on axial cuts (Fig. 1) [34].

Exclusion criteria included: (1) successful non-operative measures, (2) long segment lumbar stenosis, (3) previous operative procedures on the same disc level, (4) clinical and radiographic evidence of congenital anomalies, marked instability, disc pulge or degeneration without radiculopathy, or infection.

The control group consisted of 90 patients (mean age of 31.5 years) with herniated lumbar disc disease treated via standard open posterior lumbar discectomy during the same period. These surgeries were performed at the same institution and by the same surgeons. The inclusion and exclusion criteria were similar to the MED group.

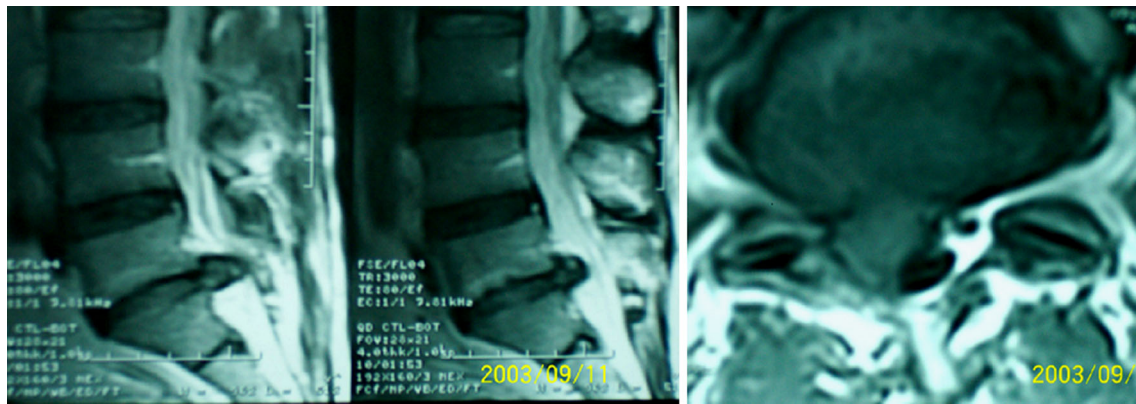


Fig. 1 (left) Two sagittal MRI cuts of lumbar spine of a patient showing huge disc extrusion obstructing the spinal canal, (right) axial cut of the same patient showing 15 mm (AP diameter) disc extrusion

displacing the neural elements to the other side and compressing them against the bony boundaries of the spinal canal

Evaluation

Primary (clinical) outcomes data included Numerical Rating Scale (NRS) (range 0–100) [35] for back and leg symptoms and Oswestry Disability Index (ODI) [36]—version 2.0 [the sex question (Section 8) is unacceptable in our community, therefore, it was removed from the questionnaire]. The total possible score became 45. The final score is calculated and presented as a percentage (0 % represents no pain and disability and 100 % represents the worst possible pain and disability). Secondary (objective) outcomes data included operative time, blood loss, postoperative analgesics, length of hospital stay, time to return to work/activity, reoperation rate and complication rate and patient satisfaction index [37] and modified MacNab criteria [38].

MED technique

An 18 mm tubular retractor was inserted over the sequential dilators that were inserted over a guide wire directed to superior lamina of the desired level then the rigid endoscope was inserted into the tubular retractor. Partial flavectomy was performed after laminotomy in which we limit the excision of the Ligamentum flavum enough to see the lateral edge of the dural sac and the traversing nerve root (5–10 mm) then retract them both medially with their covering of ligamentum flavum (to reduce epidural scarring and adhesions), then perform discectomy. In almost all cases we found the large extrusion directly under the ligamentum flavum. We could search for caudal sequestration by placing the endoscope cephalic and with the help of angled ball probe we could retrieve part or all of the sequestration by sweeping under the dural sac or posterior longitudinal ligament or searching into intervertebral foramen and lateral recess then we pull it out with the help of a rongeur (Fig. 2).

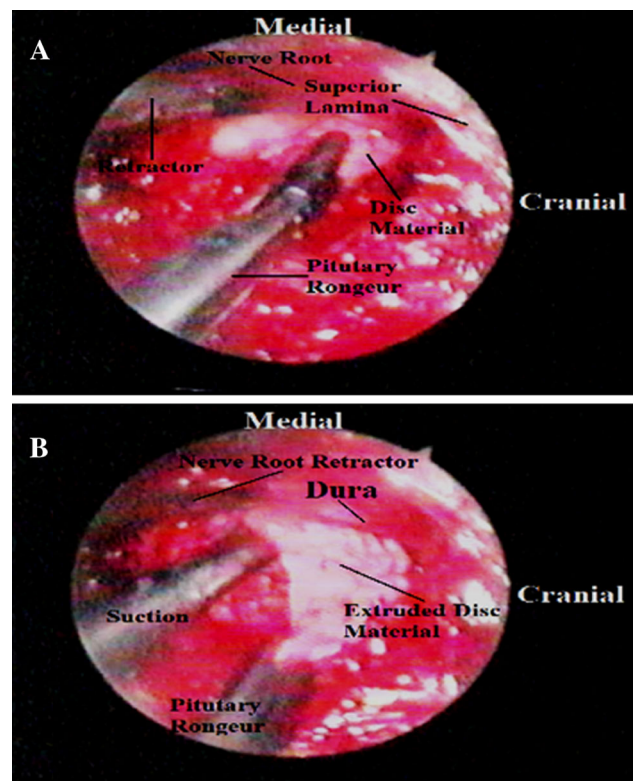


Fig. 2 **a** Traversing nerve root with its covering dura is medially retracted and the tip of the extruded disc material is grasped by pituitary rongeur. **b** Extraction of huge disc extrusion from under the dura

Open discectomy procedure

Without the use of operating microscope, 8–10 cm midline skin incision was centered over the affected level after fluoroscopic verification. Using cutting diathermy dorso-lumbar fascia was incised, then stripping the paraspinal muscles off the spinous processes and lamina was

performed until the facet joints laterally, then muscles were retracted laterally using a self-retaining retractor. Using Kerrison's Rongeur we did hemilaminectomy depending on the preoperative planning then locating and removal of the extruded or the sequestered disc material.

Follow-up

Follow-up data were obtained from clinic follow-up visits and telephone calls by two independent physicians; before surgery, after surgery at day 1 (200 patients in hospital before discharge), 6 months (198 patients: 132 in outpatient clinic and 66 by phone calls), 1 year (194 patients: 119 in OPC, 75 by phone), 2 years (192 patients: 85 in OPC, 107 by phone), 4 years (189 patients: 86 in OPC, 103 by phone), 6 years (187 patients: 83 in OPC, 104 by phone), and at the final follow-up visit at 8 years (185 patients: 86 in OPC, 99 by phone) (92.5 %) (95 × MED, 90 × open discectomy). The remaining cases were lost for the following reasons: 3 surgery-unrelated death, 2 patients did not respond to telephone calls, and 10 underwent intervertebral fusion at the same level of discectomy. Although eight patients in the MED group were converted to open procedure they were not counted among the control group (six to deal with intraoperative iatrogenic dural tear and two for revision after recurrence of radicular symptoms after 4 months).

Statistical analysis

Change in outcome measures from baseline during the entire follow-up was assessed with a general linear model for repeated measures (SPSS, version 12.0.1). The baseline measurement of the outcome variable was entered as a covariant into the model. To compare continuous

quantitative variables between the groups at different times of follow-up we utilized Student's *t* tests (Paired and Independent Sample *t* test). Chi-square test was used to test the differences between the two groups in terms of categorical data. A positive significance level was assumed at $P < 0.05$. Statistical analysis was performed to examine intraobserver reproducibility and interobserver reliability. Single-measure intraclass correlation coefficients were calculated to determine variability within and among examiners [39] and were considered excellent if >0.75 [40]. Intraobserver intraclass correlation coefficient was 0.997 and 0.995 for the two examiners with combined intraobserver intraclass correlation coefficient 0.996, which demonstrated high reproducible accuracy in surgical criteria and degree of disc herniation on MRI. The combined interobserver intraclass correlation coefficient was 0.993 which showed no significant difference between examiners and indicated that persons not involved with this study would have a high probability of similar surgical criteria and diagnosis of degree of disc herniation on MRI.

Results

There was no significant difference between the mean operative time of MED group (98.8 min \pm 26.9) and that of the control group (97.27 min \pm 13.5) ($P = 0.622$, $P > 0.1$). The mean blood loss of MED procedure (41.68 \pm 13.18 mL) was significantly less than that of the control group (124.22 \pm 24.5 mL) ($P < 0.05$) (Table 2).

The mean length of hospital stay for the MED group was 10.4 \pm 3.5 h and significantly shorter than that of the control group, which is 82.38 \pm 18.3 h (3.5 days) ($P < 0.05$). All the patients had intramuscular NSAIDs injection for pain control on recovery from anesthesia. For

Table 2 Collective objective results of MED-METRx and open discectomy groups

| Objective outcome measures | MED-METRx | Open discectomy | Difference between groups Means (95 % CI) |
|--|--------------------|----------------------|---|
| Mean operative time (min)* | 98.8 (\pm 26.9) | 97.27 (\pm 13.5) | 1.56 (−4.6 to 7.8) |
| Early 25 cases (min) | 133.0 (\pm 13) | 97.27 (\pm 13.5) | 35.7 (29.7 to 41.7) |
| Late 70 cases (min) | 86.6 (\pm 18.9) | 97.27 (\pm 13.5) | −10.6 (−15.6 to −5.5) |
| Mean blood loss (mL) | 41.6 (\pm 13.1) | 124.22 (\pm 24.5) | −82.5 (−88.2 to −76.8) |
| Mean length of hospital stay (h) | 10.46 (\pm 3.5) | 82.38 (\pm 18.3) | −71.9 (−75.7 to −68.1) |
| Percentage of patients received analgesics (%) | 18 | 73 | 55 ^a |
| Mean time to return to work(day) | 8.5 (\pm 2.6) | 31.4 (\pm 3.9) | −22.8 (−23.8 to −21.8) |

Values are mean standard deviation (SD) unless stated otherwise, *CI* confidence interval, Difference between groups' means is expressed as the difference between values of the two groups

P (paired *t* test) <0.001

* $P = 0.622$

^a Difference in percentage (not mean)

the MED group 21 patients (22.1 %) compared to 66 patients (73.3 %) of control group received NSAIDs during their hospital stay. The mean time to return to work/normal activities for the MED group (8.5 ± 2.6 days) was significantly shorter than that of the control group (31.4 ± 3.9 days) ($P < 0.05$).

There were no serious complications in either group, such as nerve root injury, cauda equina syndrome, spondylodiscitis or thrombosis. Dural tears were encountered in six patients (6.6 %) in MED group and five patients (5.6 %) in the open group two of them needed reoperation to excise a meningocele formed under the skin. Transient postoperative dysesthesia developed in five patients [2 (2.2 %) in MED group and 3 (3.3 %) in the open group]. Transient urinary retention developed in four patients [3 (3.3 %) in MED group and 1 (1.1 %) in the open group]. Five patient (5.6 %) in the open group and three patients (3.3 %) in the MED group had superficial wound infection. Overall, the complication rate difference was insignificant between both groups ($P > 0.05$).

Overall, 15 patients (8.1 %) in both groups required reoperation at the same level during the follow-up period because of recurrence of radicular symptoms: Five patients (2.7 %) [two patients (2.1 %) in the MED group and three patients (3.3 %) in the open group]. Disabling mechanical low back pain in 10 patients [four in the MED group and six in the open group] underwent intervertebral fusion. The operative time in revision after MED was 97 min and was significantly shorter than that after open discectomy (mean 161.2 ± 6.2 min, difference 64.6 min, $P = 0.003$).

For the MED group, the pain relief was statistically significant, the mean NRS leg and back pain score significantly decreased from 8.9 ± 0.8 and 3.3 ± 1.1 , respectively, to 1.05 ± 0.57 and 1.43 ± 0.8 by 8 years, with a mean difference of 7.8 ± 0.9 and 1.9 ± 1.2 ($P < 0.001$). For the control group, the mean NRS leg pain score also significantly decreased from 8.8 ± 0.8 preoperative to 2.18 ± 0.8 by 8 years, with a mean difference of 6.6 ± 1.16 ($P < 0.001$). Conversely, the mean NRS back pain score significantly increased from mean score of 3.17 ± 0.85 preoperative to 7.53 ± 0.58 by 8 years, with a mean difference of 4.35 ± 1.07 . There was no significant difference between preoperative means of the two groups for NRS leg pain ($P = 0.430$) and for NRS back pain ($P = 0.293$).

For MED group, the disability improvement was statistically significant and the mean ODI score significantly decreased from 72.7 ± 8.5 % preoperative to 21.51 ± 5.15 % at final follow-up, with a mean difference of 51.2 ± 9.7 % ($P < 0.001$). For the control group, the mean ODI score decreased from 70.8 ± 8.8 % preoperative to 59.66 ± 5.30 % at final follow-up, with a mean difference of 11.17 ± 9.5 % ($P < 0.001$). There was no significant

Table 3 Mean preoperative and postoperative NRS (leg and back) and ODI for MED and open discectomy groups through the follow-up period

| Outcome | Group | Preop. scores | 1 day | 6 months | 1 year | 2 years | 4 years | 6 years | 8 years | Difference | |
|---------------|-------|---------------|------------|------------|-------------|------------|------------|------------|-------------|--------------------------|--------------------------------|
| | | | | | | | | | | in group Means (95 % CI) | between groups Means (95 % CI) |
| NRS leg pain | MED | 8.9 (0.8)* | 1.2 (0.7) | 1.2 (0.7) | 1.0 (0.6) | 1.2 (0.6) | 1.2 (0.5) | 1.1 (0.4) | 1.05 (0.57) | 7.8 (0.9) | -1.13 (-1.34 to -0.92) |
| | Open | 8.8 (0.8) | 1.45 (0.5) | 1.3 (0.46) | 1.2 (0.41) | 1.2 (0.41) | 1.2 (0.41) | 1.3 (0.46) | 2.18 (0.85) | 6.6 (1.16) | |
| NRS back pain | MED | 3.3 (1.1)** | 1.7 (0.9) | 1.6 (0.8) | 1.4 (0.8) | 1.5 (0.9) | 1.5 (0.9) | 1.5 (0.8) | 1.43 (0.82) | 1.9 (1.2) | -6.10 (-6.3 to -5.8) |
| | Open | 3.17 (0.85) | 5.6 (0.9) | 4.3 (0.7) | 2.35 (0.7) | 2.9 (0.9) | 4.7 (0.99) | 6.4 (0.8) | 7.53 (0.58) | 4.35 (1.07) | |
| ODI | MED | 72.7 (8.5)*** | 18.8 (3.6) | 17.0 (3.2) | 15.8 (3.4) | 13.8 (2.4) | 12.9 (2.6) | 13.2 (2.6) | 21.5 (5.15) | 51.2 (9.7) | -38.14 % |
| | Open | 70.8 (8.8) | 48.8 (5.8) | 36.8 (5.8) | 17.6 (3.55) | 31.7 (4.5) | 40.6 (5.2) | 51.6 (4.5) | 59.6 (5.3) | 11.17 (9.5) | (-39.6 to -36.6 %) |

Values are mean standard deviation (SD), NRS Numerical Rating Scale (0–10), ODI Oswestry Disability Index, CI confidence interval, the mean ODI score is multiplied by 2 to give the mean disability score which is expressed in the table. Difference in group means is expressed as the difference between preoperative and postoperative values at the end of the follow-up period. Difference between groups' means is expressed as the difference between postoperative values of the two groups at the end of the follow-up period. Although the mean ODI and (NRS) leg and back scores for MED-METRx and the mean (NRS) leg scores for open discectomy group showed significant improvement at the end of the 8-year follow-up period, the mean ODI and (NRS) back scores for open discectomy group showed significant deterioration at the end of the 8-year follow-up period after initial significant improvement at the end of the first year postoperative. P (paired t test) < 0.001

Differences between the groups at different times of follow-up were checked for with the Mann–Whitney U test, (t tests); (paired and independent sample t test) for comparison of variables. A positive significance level was assumed at $P < 0.05$

Preoperative difference between group means was statistically insignificant: * $P = 0.430$, ** $P = 0.293$, *** $P = 0.140$

difference between preoperative means of the two groups ($P = 0.140$).

Differences between groups' means at the end of follow-up period were -1.13 (1.34 to -0.92) for NRS leg pain, -6.10 (-6.3 to -5.8) for NRS back pain and -38.14% (-39.6 to -36.6%) for ODI (Table 3).

According to modified MacNab criteria, for MED group 92.6 % had excellent outcomes, 4.2 % good, 1.1 % fair, and 2.1 % poor; these results remained unchanged throughout the 8-year follow-up period. For the control group, 1-year postoperative, 42.2 % had excellent outcomes, 28.9 % good, 24.4 % fair, and 4.4 % poor. At the end of the follow-up period 17.8 % had excellent outcomes, 37.8 % good, 21.1 % fair, and 23.3 % poor. If the excellent and good categories were regarded as success and fair and poor as failures, then the total success rate of the MED group was 96.8 % which remained unchanged till the end of the follow-up period and 71.1 % for the open group which decreased to 55.6 % by 8 years. 98 % of MED group showed complete satisfaction with MED procedure and outcome, and would undergo the surgery again for the same condition compared to 40 % of the control group.

Discussion

Large uncontained disc herniations (extrusion and sequestration) are not among the exclusion criteria of MED procedure [27–30, 41, 42, 44, 45]. However, some spine surgeons reserve MED procedure for small disc herniation. Wu et al. [30] found that some surgeons do not prefer to perform MED procedure because of the anticipated difficulty to decompress the nerve root with restricted surgical field to 18 mm diameter. In our study, these limitations have been overcome by: the ability to relocate the working channel, free positioning of the endoscope inside the working channel 360°, the 25° optics allowed expanded magnified field of vision with good illumination.

MED enables spine surgeon to decompress the neural elements through direct posterior approach and to extract the disc pathology with smaller skin incision. Moreover, it minimizes iatrogenic injury to paraspinal muscles and posterior osteoligamentous structures, which are invaluable to the stability of the motion segment [27–30, 41, 42, 44, 45]. Dvorak et al. [43] reviewed 575 open discectomy patients and found that 70 % of patients still complaining of low back pain, which was severe in 23 %, and residual sciatica was present in 45 %. In our study, for the control group the mean NRS back pain score significantly increased from mean score of 3.17 ± 0.85 preoperative to 7.53 ± 0.58 by 8 years. For both groups, the sciatic pain relief was statistically significant immediately

postoperative and by 8-year follow-up, with no statistical differences between the two groups.

The less the resection of spinal canal structures, the less operation-induced complications and instability caused by destruction of coordination system of the dorsal nerve roots. Preservation of ligamentum flavum reduces epidural scarring and adhesions which are responsible for more difficult and time-consuming reoperations [45]. We limited excision of the ligamentum flavum that made reoperation after MED much more easier than reoperation after open discectomy due to reduced epidural scarring and adhesions.

The total success rate of the MED group was 96.8 % which remained unchanged by 8 years and 71.1 % for the open group which has fallen to 55.6 % by 8 years and this was concurrent with Salenius and Laurent [20] who reported initial success rate of open discectomy of 70 % which had fallen to 56 % by 6 years.

Wu et al. [30] followed wide selection criteria and concluded that aged patients with segmental instability and patients with previous back surgery are not perfect candidates for MED. Knowing the impact of selection criteria on the outcome, we unified them for both groups to eliminate their effect as a variable on outcome data.

Hospital stays for MED range between 1 and 2 days [27–30, 41, 42, 44, 45], and the average length of hospital stays was 4.8 days in Wu et al. [30] series due to postoperative hospital rehabilitation. In our study, the length of hospital stay was decided by both independent doctors (who were not affiliated with the study) and patients depending on the general condition of the patient; as after complete recovery from anesthesia and thorough checking on the vitals and neural functions patients were encouraged to ambulate and after receiving the appropriate medications, uncomplicated MED patients were given the choice to be discharged at the same day of the procedure or stay in-patient for a short-term postoperative rehabilitation program (90 % of MED patients chose to be discharged after receiving rehabilitation instructions) except six patients with dural tears were discharged after 3 days for wound care, three for transient urinary retention and two for dysesthesia were discharged after 24 h. Whereas, open discectomy patients needed 3 days for wound care (e.g. removal of suction drainage after 48 h that was used in 65 patients to decrease the postoperative haematoma) including the time for a short-term postoperative rehabilitation program. In our opinion MED is a cost-effective procedure due to short hospital stay, rapid rehabilitation and low postoperative costs of care, reduced surgical trauma, easier revision operations, monitor image as training tool for assistants. The average length of hospital stays was 10.4 h, which was significantly less than the open group 83.45 h (3.5 days).

MED was proved by intraoperative EMG studies to be superior to open surgical techniques in producing less irritation of the nerve root during both approach and retraction [30, 32], less requirement of postoperative analgesia during hospital stay [44], less mean operative blood losses and less mean number of rest days [29, 30, 45]. We proved in our study that secondary outcome data of MED were significantly better than the control group and this may be attributable to less tissue trauma.

Tosteson et al. [46] in their study found that extension of assessment duration from 2 to 4 years increased the value of surgery in lumbar disc herniation. Likewise, extension of the follow-up period in our study has clarified the significant differences in outcome data between the two groups.

We found the following limitations of the MED: first, difficulty in suturing dural tears properly due to limited room for suturing tools; second, a demanding learning curve to gradually trade the hand–eye coupling of the open surgical field with the two-dimensional view and hand–eye spatial separation of the MED procedure. The surgeon should be engaged with senior surgeon in MED for observation and assistance plus attending workshops to practice on cadavers. As our series progressed, we gained skill and familiarity with instruments and the endoscopic view. The operative time, bleeding and iatrogenic dural tears decreased. We handled dural tears in MED procedures with watertight sutures in the dura after turning the procedure into an open one.

Large, uncontained, lumbar disc herniations can be sufficiently removed using MED procedure, which is an effective supplementation and alternative to open discectomy procedures with remarkable long-term outcome. Sciatic pain relief was statistically significant in both techniques with no significant difference between MED and open discectomy. The MED respects the anatomy of the spine and does not decrease its stability. Mechanical low back pain showed significant deterioration for control group. Maximum benefit can be gained if we adhere to strict selection criteria. The optimum indication is single- or multi-level radiculopathy secondary to a single-level, large, uncontained, lumbar disc herniation.

Acknowledgments The authors acknowledge the assistance of Dr. Safaa El-Najjar for providing statistical analysis and also acknowledge the rest of the Zagazig Orthopedic Department's members (medical and non-medical) for their contributions to the present study.

Conflict of interest The authors did not receive any outside funding or grants in support of their research for or preparation of this work. Neither they nor a member of their immediate families received payments or other benefits or a commitment or agreement to provide such benefits from a commercial entity. No commercial entity paid or directed, or agreed to pay or direct, any benefits to any research fund,

foundation, division, center, clinical practice, or other charitable or nonprofit organization with which the authors, or a member of their immediate families, are affiliated or associated.

References

1. Dandy WE (1929) Loose cartilage from intervertebral disk simulating tumor of the spinal cord. *Arch Surg* 19:660–672 (Reference unverified)
2. Mixter WJ, Barr JS (2001) Rupture of intervertebral disc with involvement of the spinal canal. *N Engl J Med* 211:210–215
3. Deyo RA, Weinstein JN (2001) Primary care: low back pain. *N Engl J Med* 344:363–370
4. Williams DK, Park LA (2007) Lower back pain and disorders of intervertebral disc. In: Terry Canale S, Beaty HJ (eds) *Campbell's operative orthopaedics*, 11th edn. Mosby-Year Book Inc., pp 2210–2212
5. Kim SM, Park K-W, Hwang C et al (2009) Recurrence rate of lumbar disc herniation after open discectomy in active young men. *Spine* 34(1):24–29
6. Skaf G, Bouclaous C, Alaraj A, Chamoun R (2005) Clinical outcome of surgical treatment of failed back surgery syndrome. *Surg Neurol* 64(6):483–488
7. Abumi K, Panjabi MM, Kramer KM et al (1990) Biomechanical evaluation of lumbar spinal stability after graded facetectomies. *Spine* 15:1142–1147
8. Kotilainen E, Valtonen S (1993) Clinical instability of the lumbar spine after microdiscectomy. *Acta Neurochir* 125:120–126
9. Hafer TR, O'Brien M, Dryer JW et al (1994) The role of the lumbar facet joints in spinal stability. Identification of alternative paths of loading. *Spine* 19:2667–2670
10. Hopp E, Tsou PM (1988) Postdecompression lumbar instability. *Clin Orthop* 227:143–151
11. Kaigle AM, Holm SH, Hansson TH (1995) Experimental instability in the lumbar spine. *Spine* 20:421–430
12. Kato Y, Panjabi MM, Nibu K (1998) Biomechanical study of lumbar spinal stability after osteoplastic laminectomy. *J Spinal Disord* 11:146–150
13. Kotilainen E (2001) Clinical instability of the lumbar spine after microdiscectomy. In: Gerber BE, Knight M, Siebert WE (eds) *Lasers in the musculoskeletal system*. Springer, Berlin, pp 241–243
14. Sharma M, Langrana NA, Rodrigues J (1995) Role of ligaments and facets in lumbar spinal stability. *Spine* 20:887–900
15. Lewis PJ, Weir BKA, Broad RW et al (1987) Longterm prospective study of lumbosacral discectomy. *J Neurosurg* 67:49–54
16. Cooper R, Mitchell W, Illingworth K et al (1991) The role of epidural fibrosis and defective fibrinolysis in the persistence of postlaminectomy back pain. *Spine* 16:1044–1048
17. Waddell G, Reilly S, Torsney B et al (1988) Assessment of the outcome of low back surgery. *J Bone Jt Surg Br* 70:723–727
18. Ozgen S, Naderi S, Ozgen MM et al (1999) Findings and outcome of revision lumbar disc surgery. *J Spinal Disord* 12:287–292
19. Vishteh AG, Dickman CA (2001) Anterior lumbar microdiscectomy and interbody fusion for the treatment of recurrent disc herniation. *Neurosurgery* 48:334–337
20. Salenius P, Laurent LE (1977) Results of operative treatment of lumbar disc herniation. A survey of 886 patients. *Acta Orthop Scand* 48:630–634
21. Weber H (1983) Lumbar disc herniation. A controlled, prospective study with ten years of observation. *Spine* 8:131–140
22. Hakelius A (1970) Prognosis in sciatica. A clinical follow-up of surgical and nonsurgical treatment. *Acta Orthop Scand Suppl* 129:1–76

23. Hanley EN Jr, Shapiro DE (1989) The development of low-back pain after excision of a lumbar disc. *J Bone Joint Surg (Am)* 71:719–721
24. Kim KD, Wang JC, Roderston DB, Brodke DS, Olson EM, Duberg AC, Bendebba M, Block KM, Dizerega GS (2003) Reduction of radiculopathy and pain with oxyplex/SP gel after laminectomy, laminotomy and discectomy: a pilot study. *Spine* 28:1080–1087
25. Hoyland JA, Freemnt AJ, Denton J, Thomas AMC, McMillan JJ, Jayson MIV (1988) Retained surgical swab in post-laminectomy arachnoiditis and peridural fibrosis. *J Bone Jt Surg* 70:659–662
26. Lee CK, Alexander H (1984) Prevention of postlaminectomy scar formation. *Spine* 9:707–713
27. Foley KT, Smith MM (1997) Microendoscopic discectomy. *Tech Neurosurg* 3:301–307
28. Smith MW, Foley KT (1998) Microendoscopic discectomy: the first 100 cases. Annual Meeting of the Congress of Neurological Surgeons, Seattle, Oct 1998
29. Perez-Cruet MJ, Smith M, Foley K (2002) Microendoscopic lumbar discectomy. In: Fessler RG, Perez-Cruet MJ (eds) Out-patient spinal surgery. Quality Medical, St. Louis, pp 171–183
30. Wu X, Zhuang S, Mao Z, Chen H (2006) Microendoscopic discectomy for lumbar disc herniation: surgical technique and outcome in 873 consecutive cases. *Spine* 31(23):2689–2694
31. Muramatsu K, Hachiya Y, Morita C (2001) Postoperative magnetic resonance imaging of lumbar disc herniation: comparison of microendoscopic discectomy and Love's method. *Spine* 26:1599–1605
32. Schick U, Döhnert J, Richter A et al (2002) Microendoscopic lumbar discectomy versus open surgery: an intraoperative EMG study. *Eur Spine J* 11:20–26
33. World Medical Association (2002) Declaration of Helsinki (Accessed 30 April 2002, at <http://www.wma.net/e/policy/b3.htm>)
34. Carragee EJ, Han M, Kim D, Yang B, Stanford CA (1999) Fragment-type and annular defect as predictive factors in lumbar discectomy. In: Presented at the 14th annual meeting of North American Spine Society (NASS), Chicago Hilton and Towers, Oct 1999
35. Derby R, Howard MW, Grant GM et al (1999) The ability of pressure controlled discography to predict surgical and nonsurgical outcomes. *Spine* 24(4):364–372
36. Fairbank J, Pynsent P (2000) The Oswestry Disability Index. *Spine* 25:2940–2953
37. Daltroy LH, Cats-Baril WL, Katz JN et al (1996) The North American Spine Society (NASS) lumbar spine outcome instrument: reliability and validity tests. *Spine* 21:741–749
38. MacNab I (1971) Negative disc exploration. *J Bone Jt Surg Am* 53:891–903
39. Landis JR, Koch GG (1977) The measurement of observer agreement for categorical data. *Biometrics* 33:159–174
40. Shrout PE, Fleiss JL (1979) Intraclass correlations: uses in assessing rater reliability. *Psychol Bull* 86:420–428
41. Palmer S (2002) Use of tubular retractor system in microscopic lumbar discectomy: one year prospective results in 135 patients. *Neurosurg Focus* 13(2):E5
42. Schizas C, Tsiridis E, Saksena J (2005) Microendoscopic discectomy compared with standard microsurgical discectomy for treatment for uncontained or large contained disc herniations. *Neurosurgery* 57(suppl. 3):357–360
43. Dvorak J, Gauchat M-H, Valach L (1988) The outcome of surgery for lumbar disc herniation. 1. A 4–17 years' follow-up with emphasis on somatic aspects. *Spine* 13:1418–1422
44. Brayda-Bruno M, Cinnella P (2000) Posterior endoscopic discectomy (and other procedures). *Eur Spine J* 9(Suppl. 1):24–29
45. Ruetten S, Komp M, Merk H, Godolias G (2008) Full-endoscopic interlaminar and transforaminal lumbar discectomy versus conventional microsurgical technique: a prospective, randomized, controlled study. *Spine* 33(9):931–939
46. Tosteson NAA, Tosteson DT, Lurie DJ et al (2011) Comparative effectiveness evidence from the spine patient outcomes research trial surgical versus nonoperative care for spinal stenosis, degenerative spondylolisthesis, and intervertebral disc herniation. *Spine* 36(24):2061–2068