Minimally invasive tubular microdiscectomy for recurrent lumbar disc herniation

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OBJECTIVE The aim of the study was to investigate the safety and efficacy of minimally invasive tubular microdiscectomy for the treatment of recurrent lumbar disc herniation (LDH). As opposed to endoscopic techniques, namely microendoscopic and endoscopic transforaminal discectomy, this microscopically assisted technique has never been used for the treatment of recurrent LDH.

METHODS Thirty consecutive patients who underwent minimally invasive tubular microdiscectomy for recurrent LDH were included in the study. The preoperative and postoperative visual analog scale (VAS) scores for pain, the clinical outcome according to modified Macnab criteria, and complications were analyzed retrospectively. The minimum follow-up was 1.5 years. Student t-test with paired samples was used for the statistical comparison of pre- and postoperative VAS scores. A p value < 0.05 was considered to be statistically significant.

RESULTS The mean operating time was 90 ± 35 minutes. The VAS score for leg pain was significantly reduced from 5.9 ± 2.1 preoperatively to 1.7 ± 1.3 postoperatively ($p < 0.001$). The overall success rate (excellent or good outcome according to Macnab criteria) was 90%. Incidental durotomy occurred in 5 patients (16.7%) without neurological consequences, CSF fistula, or negative influence to the clinical outcome. Instability occurred in 2 patients (6.7%).

CONCLUSIONS The clinical outcome of minimally invasive tubular microdiscectomy is comparable to the reported success rates of other minimally invasive techniques. The dural tear rate is not associated to higher morbidity or worse outcome. The technique is an equally effective and safe treatment option for recurrent LDH.

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KEY WORDS recurrent; lumbar disc herniation; minimally invasive; microdiscectomy; complication

SURGERY for recurrent lumbar disc herniation (LDH) is accompanied by higher morbidity rate compared with primary herniation surgery. Epidural scar tissue increases the risk of dural tear and nerve root injury.^{19,23,45,50} The majority of surgeons prefer the use of standard open microdiscectomy to treat recurrent LDH,^{5,46,47} since wider exposure is assumed to provide for more convenient recognition of anatomical landmarks and tissue manipulation. The limited operating window of minimally invasive approaches has been regarded as a discouraging factor.

Minimally invasive approaches have been used to treat primary LDH with equal or favorable outcomes compared with open microdiscectomy.^{10,17,34,42,43} Microendoscopic discectomy (MED) uses a tubular transmuscular working channel (16–20 mm) to approach the spine coupled with

an endoscope to enable visualization.^{8,9,31,33,35,44,51,52,54,55} The same muscle-splitting device can also be used with the microscope to perform a minimally invasive microdiscectomy.^{2–4,11–13,20–22,26,49} Also, full endoscopic techniques have been used for the treatment of LDH via an interlaminar or transforaminal (endoscopic transforaminal discectomy [ETD]) approach.^{16,28–30,36–41,53}

Over the last decade, MED and ETD have been applied to treat recurrent LDH^{1,7,14,15,24,25,32,39,43} (Table 1). The outcomes were reported to be equal and sometimes favorable compared with open microdiscectomy for recurrent LDH.

The microdiscectomy technique via a transmuscular tubular approach has not been reported as a treatment option for recurrent LDH thus far. As opposed to MED, where an endoscope is used, the operating microscope was used as

ABBREVIATIONS ETD = endoscopic transforaminal discectomy; FSP = fibrin sealant patch; LDH = lumbar disc herniation; MED = microendoscopic discectomy; VAS = visual analog scale.

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TABLE 1. Studies on recurrent LDH treated with minimally invasive surgery

Authors & Year	Study Type	Content
Nomura et al., 2013	Retro control	30 TD (MED) vs 27 MED
Eloqayli & Al-omari, 2012	Observ retro	6 ETD
Smith et al., 2010	Observ retro	16 MED
Ruetten et al., 2009	Prosp RCT	50 open vs 21 ETD vs 29 IL
Lee et al., 2009	Retro control	24 ETD vs 29 open
Hoogland et al., 2008	Prosp cohort	262 ETD
Ahn et al., 2004	Observ retro	43 ETD
Isaacs et al., 2003	Observ retro	10 MED
Le et al., 2003	Observ retro	10 MED

IL = interlaminar endoscopic discectomy; observ = observational; open = open microdiscectomy; prosp = prospective; RCT = randomized control trial; retro = retrospective; TD = transosseus discectomy.

visualization device. The aim of the study was to investigate the efficacy and safety of the minimally invasive tubular microdiscectomy technique for recurrent LDH and to compare these findings with reported results of other minimally invasive approaches (MED and ETD).

Methods

Patient Population

The study was approved by the local ethics committee. Between January 2011 and December 2012, 32 consecutive patients (15 males, 17 females; mean age 49.5 ± 13.4 years) with recurrent LDH were treated with minimally invasive tubular microdiscectomy in our neurosurgical department. Patients with clinical symptoms and signs of instability on dynamic radiographs were treated with fusion and had been primarily excluded from this study. Two patients with early recurrent LDH (< 12 weeks after primary surgery) were excluded from this retrospective study. Early recurrent LDH does not present a particular challenge in spine surgery because scar tissue has not yet developed, and revision surgery is unproblematic. We finally included 30 patients in our study (15 males, 15 females; mean age 49.4 ± 13.6 years). Various surgeons at different stages of neurosurgical training (e.g., neurosurgical residents, attending neurosurgeons, or neurosurgeons with subspecialization in spine surgery) performed the operations.

Surgical Technique

The operations were performed under general anesthesia, with the patient in prone position. The affected level was detected fluoroscopically in lateral projection. Then the skin incision is made along the initial scar, which is used partially or completely, depending on the initial length. A 2-cm incision is fully adequate for the transmuscular tubular approach. To insert the muscle dilators via a slightly more lateral trajectory through virgin tissue, the skin is mobilized laterally to the affected side. The muscle dilators are then inserted, aiming at the facet joint.

A 16–20-mm tubular retractor (METRx MD, Medtronic Sofamor Danek, Inc.) is then inserted. The retractor is always initially docked on the facet joint since this is a safe bony landmark for the muscle dilation process. Lateral and anteroposterior radiographs are then taken to ensure the optimal final position of the working channel along the craniocaudal axis as well as its position with respect to the facet joint, the pedicle, and midline (Fig. 1). The optimal position is pre- and intraoperatively determined after careful examination of the preoperative MR image for the remaining facet and localization of the recurrent LDH. The tube should be aimed at the causative pathology, but it should also keep bone structures within view as these offer safe planes for preparation. Generally, this bony structure is the facet joint. The operating microscope is used for visualization. The remaining muscle fibers within the operation field are cauterized and removed. A diamond drill is then used to remove part of the bone on the medial aspect of the facet joint. The drilling direction is along a plane between the facet joint and the lateral dural sac, which is usually affected by scar tissue. Thus, the lateral recess is decompressed, and the nerve root and the disc fragment can be identified. Using this technique the recurrent LDH can be removed, the coexisting lateral recess stenosis can be decompressed, and the segmental stability should be maintained. Bone removal is minimal. Occasionally, when the disc fragment has migrated cranially, a more cranial approach is performed. The remaining lamina is drilled cranially until virgin dural sac, unaffected from scar tissue, is reached. Then, depending on the underlying pathology, mobilization of the dural sac, adhesiolysis, removal of the recurrent LDH, and foraminotomy through drilling or removal of bone using Kerrison rongeurs at the pars interarticularis and foraminal roof is performed. All of the surgical maneuvers used in a standard open microdiscectomy can be performed through the tubular retractor under microscopic view. Moving the tubular retractor at various angles allows the surgeon to reach various areas of the spine, a process known as wandering.³³ When the goals of the operation are fulfilled and adequate hemostasis within the spinal canal and the entire operating field is obtained, the tube is smoothly withdrawn and microbleeding of muscle fibers in the different layers of the paravertebral musculature should be microscopically identified and cauterized. This procedure is a mandatory precaution to be taken to avoid rehemorrhage. Subfascial drainage is not necessary. The 2-cm skin incision is then closed with subcutaneous sutures and skin glue.

Data Collection

The medical records, visual analog scale (VAS) scores for pain, complications, and clinical outcome according to modified Macnab criteria (Table 2) were analyzed retrospectively. The VAS data for pain pre- and postoperatively had been collected prospectively. The postoperative VAS scores were assessed during hospital stay. All patients were interviewed and examined at 6–12 weeks as well as 12 months after the operation. The outcome according to Macnab criteria was also assessed at these times. In addition to the 12-month follow-up, we performed follow-up telephone interviews to exclude deterioration of symptoms

FIG. 1. Intraoperative lateral (left) and anteroposterior (right) radio-graphs showing the optimal position of the transmuscular working channel. Important landmarks are the facet joint indicated by the red line (left), the pedicles marked with red circles (right), the midline, and the expected nerve courses indicated by the blue lines (right). Figure is available in color online only.

or occurrence of delayed complications like re-recurrence or instability. Thus, the minimum follow-up was 1.5 years.

Statistical Analysis

For the statistical comparison of the pre- and postop-erative VAS scores for pain, the Student t-test with paired samples was used. Prism 6 statistical software for Mac (GraphPad Software Inc.) was used for data processing. A p value < 0.05 was considered to be statistically signifi-cant.

Results

The mean operating time was 90 ± 35 minutes. The segments operated on were: L4–5 (16 of 30), L5–S1 (12 of 30), L2–3 (1 of 30), and L3–4 (1 of 30) levels. The VAS score for leg pain (Fig. 2) was significantly reduced from 5.9 ± 2.1 preoperatively to 1.7 ± 1.3 postoperatively (p < 0.001). The clinical outcome was assessed as excellent for 18 patients (60%), good for 9 patients (30%), fair for 1 pa-tient (3.3%), and poor for 2 patients (6.7%).

In 21 patients no complication was reported. Re-recur-rence rate was nil. Incidental durotomy occurred in 5 pa-tients (16.7%) and was repaired with only a fibrin sealant

FIG. 2. Box-and-whisker plot showing the preoperative and postopera-tive VAS scores for leg pain. Boxes represent the interquartile range, the horizontal line represents the median values, and the whiskers represent the minimum and maximum values. Student t-test with paired samples showed a statistically significant reduction of leg pain (*p < 0.001).

patch (FSP) in 4 patients and by primary closure with an additional FSP in 1 patient. These 5 patients suffered no additional neurological deficits, and the outcome was ex-cellent for 4 of them and good for 1. A postoperative CSF fistula did not occur.

Two patients (6.7%) with postoperative instability re-quired fusion. The affected segment was L4–5. These patients had poor outcomes according to Macnab crite-ria, as an additional intervention was needed. We studied these cases carefully to identify potential risk factors for the instability. One patient underwent a bilateral partial laminectomy during revision surgery because of bilateral symptoms; the other patient underwent revision surgery for rebleeding and early recurrence only 2 days after the primary surgery. The extension of the partial laminecto-my and facetectomy, as well as redisection, were clear risk factors for developing instability in this patient.

Lastly, 2 patients had a facet joint syndrome that could easily be treated with a facet joint block. The overall suc-cess rate (excellent or good outcome according to Macnab criteria) was 90%. The mean length of hospital stay was 5 ± 1.8 days.

Discussion

Our technique with the use of a minimally invasive transmuscular approach in combination with the operating microscope has a relatively short learning curve. The fa-miliarity of neurosurgeons with the operating microscope is a decisive factor. The operations in our study were suc-cessfully performed by several surgeons at different stages of their neurosurgical career. Thus, ease in mastering this procedure is a major advantage compared with the long learning curve of the ETD^{14,37,39} and MED^{33,52} techniques, where familiarity with the endoscope must be acquired. ETD and MED are also more demanding to perform due to the absence of 3D visualization. Our technique requires

TABLE 2. Modified Macnab criteria for assessment of clinical outcome after minimally invasive tubular microdiscectomy

Outcome	Characteristic
Excellent	No pain; no restriction of mobility; return to normal work and level of activity
Good	Occasional nonradicular pain; relief of presenting symp-toms; able to return to modified work
Fair	Some improved functional capacity; still handicapped and/or unemployed
Poor	Continued objective symptoms of root involvement; additional operative intervention needed at index level irrespective of length of postoperative follow-up

no special training in endoscope use. This factor could be decisive and enable the wide applicability of the technique among neurosurgeons, who are more familiar with the microscope than with the endoscope.³³

The overall success rate of 90% in our series is comparable to reported success rates of MED and ETD in the literature.^{1,7,14,15,24,25,32,39,43} The mean operative time of 90 ± 35 minutes is comparable to other series using MED (98–102 minutes).^{15,24,25}

The instability/fusion rate in our series was 6.7%. In another series of 16 patients⁴³ and in two 10-patient series described by Le et al.²⁴ and Isaacs et al.¹⁵ in 2003, no case of instability and fusion was reported. In our series, we report an incidental durotomy rate of 16.7%. This incidence is in the midrange of values (13%–27%) reported in the literature concerning revision microdiscectomy via open or tubular approach.^{6,18,43,48} Our reported incidence is clearly higher than in the ETD (nil)^{1,14,39} and slightly higher than in MED (7.4%–12.5%).^{15,24,32,43} Compared with a series of patients that were treated with open revision microdiscectomy in our clinic (data not shown), the durotomy incidence rate is not significantly higher. Thus, we do not regard working through the minimally invasive access tube and the use of longer instruments as limiting factors that may increase the durotomy incidence rate. In our opinion, the bottom line is that durotomy was not associated to additional morbidity. Neurological deficits did not occur, and no CSF fistula was reported. The outcome of these patients according to Macnab criteria was excellent (n = 4) or good (n = 1). Our results were in general comparable to the reported MED series in terms of clinical outcome.

Compared with ETD, our technique has a higher rate of dural tear. Dural tear rate in ETD is reported to be nil.^{1,14,39} However, the continuous saline flow in the operating field during endoscopy could account for underdiagnosed intraoperative dural tears. Postoperative CSF fistulas after small dural tears in minimal access surgery are rare;^{33,49,52} therefore, in these cases small dural tears can be easily missed. The reported success rates of ETD are not better compared with our series (80%–85% vs 90%, respectively).^{1,7,14,15,24,25,32,39,43} Additionally, the ETD technique has a markedly long learning curve, is inadequate for use in cases with a coexisting lateral recess stenosis, and may be difficult or even impossible to use for the resection of a dislocated herniated fragment within the spinal canal.^{16,27,36,37,39,40} Difficulties in recognizing and removing small dislocated fragments also sometimes occur in MED.⁵²

In our technique, as in MED, wandering of the tubular retractor allows the surgeon to move to various areas, cranially, caudally, laterally, or contralaterally, to reach and remove dislocated disc fragments.³³ With our technique, every recurrent LDH can be treated. In this respect, we believe that a slightly smaller working channel (e.g., 16 mm vs 20 mm) could be advantageous, since it allows for more effective wandering. The slightly more limited view is overcome by this means.

Bone removal is not effective in ETD. This is the reason why in the series reported by Ahn et al.¹ the coexistence of lateral recess stenosis was identified as a negative prognostic factor affecting the outcome. The same reason

accounts for the nil rates of instability and fusion in this series,¹ and the very low rate of 1 patient out of 238 in the series presented by Hoogland et al.¹⁴ In this prospective cohort study with a 2-year follow-up, the re-recurrence rate is reported to be 4.62%.¹⁴

In minimally invasive tubular microdiscectomy, the coexistence of lateral recess stenosis does not affect the outcome, because bone decompression is very effective with this technique. Also, bone decompression does not seem to correlate to a significantly higher fusion rate, whereas the re-recurrence rate in our series is nil.

Limitations of the Study

We acknowledge the retrospective nature and the small cohort of 30 patients of the study as methodological drawbacks.

Conclusions

Minimally invasive tubular microdiscectomy is a safe treatment option for recurrent LDH and is equally effective compared with the other available minimally invasive techniques (MED, ETD).

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Disclosure

Dr. Hubbe reports being a consultant for Medtronic.

Author Contributions

Conception and design: Kogias, Hubbe. Acquisition of data: Vasilikos, Scholz. Analysis and interpretation of data: Kogias, Klingler. Critically revising the article: Hubbe, Franco-Jimenez, Klingler. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Kogias. Statistical analysis: Klingler. Administrative/technical/material support: Franco-Jimenez.

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