Transtubular microsurgical approach to treating extraforaminal lumbar disc herniations

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Object. Approaches to treating extraforaminal lumbar disc herniations can be challenging due to the unique anatomy and the need to prevent spinal instability. Numerous approaches, including conventional midline, paramedian, minimally invasive, and full endoscopic approaches, have been described. The purposes of this study were to point out the outcome and clinical advantages of a transtubular microsurgical approach and to describe and illustrate this technique.

Methods. Between 2009 and 2012, a series of 51 patients underwent a minimally invasive dilative transtubular microsurgical approach for the treatment of extraforaminal lumbar disc herniations. All patients were clinically evaluated using the visual analog scale (VAS) and Oswestry Disability Index preoperatively and 6 months postoperatively.

Results. Both pain scores and functional status showed significant improvement after surgery ($p < 0.001$): radicular pain decreased from VAS score of 7.9 to one of 1.3, lower back pain from VAS score of 2.4 to 1.4, and the Oswestry Disability Index from 42.0 to 12.3. Subgroup analyses revealed no differences in outcome regarding obesity or timing of surgery (early vs late intervention). Highly significant was the correlation between preoperative radicular pain activity and timing of surgical intervention ($p < 0.001$).

Conclusions. The dilative transtubular microsurgical approach combines the advantages of the conventional open muscle-splitting approach and the endoscopic approach. The technique is easy to use with a steep learning curve. Less muscle trauma and the absence of bony resection prevent facet pain and instability, thereby contributing to a rapid recovery. Patients in this series improved excellently in the short-term follow-up.

**Key Words** • extraforaminal disc herniation • minimally invasive approach • tubular approach • tube system

Extrarofaminal lumbar disc herniations represent 7%–12% of all lumbar disc herniations. They are defined as dislocated disc material in the area lateral to the superior and inferior pedicles (Fig. 1 left). Purely extraforaminal lesions are less frequent than extraforaminal lesions that also extend into the intraforaminal space. Compression of the superior exiting nerve root and the ganglion causes the clinical symptoms.

One of the preferred approaches for treating ELDH is the posterior lateral muscle-splitting approach, which spares the articular facets. The transtubular microsurgical approach is a modification involving the use of a tubular working canal with integrated illumination, which results in reduction of surgical trauma, especially in obese patients, and prevention of instability. We present a series of 51 patients and discuss the advantages of the dilative transtubular microsurgical approach in comparison with conventional lateral muscle-splitting, far lateral full endoscopic, and midline approaches.

**Methods**

**Patient Population**

Between October 2009 and October 2012, a group of 51 patients underwent a minimally invasive transtubular microsurgical approach for the treatment of ELDH. All patients were clinically monitored for radicular and low-back pain using the VAS and for functional status using the ODI, before and 6 months after surgery.

Inclusion criteria were as follows: 1) unilateral radiating leg pain with or without back pain; 2) corresponding imaging findings with single-level extraforaminal soft-disc herniation; 3) absence of bony foraminal or central
stenosis; 4) absence of intraspinal pathologies corresponding to the clinical presentation; 5) absence of instability in the involved segment; and 6) failure of conservative treatment, including periradicular infiltration therapy.

Preoperative Diagnostics

All patients underwent preoperative axial, sagittal, and coronal T1- and T2-weighted MRI of the lumbar spine. In addition, CT was performed in selected cases to evaluate possible bony foraminal or central stenosis (Figs. 1 left and 2A and B).

Surgical Technique

General anesthesia was induced, and the patient was placed in the prone position on a Hall frame. After an 18-gauge spinal needle was inserted contralateral to the pathology, the positioning of the tip with respect to the neural foramen was verified by a lateral radiograph. A skin incision measuring 1.8–2.0 cm was made 3–6 cm lateral to the spinous process centered around the spinal needle. After the muscle fascia was sharply perforated, the initial dilatator was inserted and advanced in a 15°–30° angle medially toward the nerve root exit at the outer part of the neural foramen (Fig. 1). The dilatator was inserted until it reached the depth of the facet joint and the transverse processes, which are bony landmarks within the weak muscle tissue. The facet joint marks the medial border of exploration, and the transverse processes mark the superior and inferior borders. After this muscle dilative approach was completed using second and third sequential dilators, a tubular retractor with a diameter of 14–18 mm and a length of 60–110 mm (SPOTLIGHT, DePuy Spine) was inserted. Fixation was obtained using a table-mounted flexible arm to secure the tubular retractor in place, and optical fiber cable was connected to the retractor. This process allows the surgeon to perform the surgical procedure using medical loupes; however, the following steps were performed using a surgical microscope (Pentero, Carl Zeiss Surgical GmbH) in our series.

The nerve root usually exits the outer neural foramals in the upper medial aspect of the exploration, in the angle between the lateral facet and the superior costal process (Fig. 3A). It is usually packed in fat tissue and radiates laterally and caudally at an angle of 30°–60° to the lower lateral aspect of the exploration. The annulus of the disc and, accordingly, the herniated disc material are usually located caudal to and/or below the nerve root. Safe identification of the nerve is crucial. Gentle mobilization cranially allows an unrestricted view of the herniated disc (Fig. 3B). In cases with partially intraforaminal sequestered disc fragments, an undercutting of parts of the lateral facet joint (outer foraminotomy) with the punch was required. The herniated disc fragments were mobilized with a hook and resected (Fig. 3C and D). Afterward, the sequester pseudocapsule (sequester bag, Fig. 3E) and the area around the nerve root were irrigated using a syringe. After sufficient decompression of the nerve root was verified (Fig. 3F), the tubular system was slowly removed, with special attention to bleeds originating from the muscle tissue. No drains were inserted. The fascia was closed with 1 suture, and the wound was closed with 2 subcutaneous sutures.

Results

Fifty-one patients (29 men, 22 women) with a mean age of 56.6 years (range 31–79 years) met the inclusion criteria and were subjected to the minimally invasive transtubular approach for the treatment of ELDH. Seven patients (13.7%) had ELDH at the L5–S1 level, 26 (51.0%) at the L4–5 level, and 18 (35.3%) at the L3–4 level. Whereas 45 patients (88.2%) presented with pure extraforaminal disc herniation, 6 patients (11.8%) had additional
Approach to extraforaminal lumbar disc herniation

Patients had an average VAS score of 7.9 (range 3–10) for radicular pain and 2.4 (range 0–7) for low-back pain before surgery. At the final follow-up at 6 months, the VAS score had decreased to 1.3 (range 0–4) for radicular pain and 1.4 (range 0–7) for low-back pain. The improvements in radicular and low-back pain were statistically significant (both p < 0.001, t-test). Regarding the patients’ functional status, there was a significant improvement in the mean ODI values, from 42.0 preoperatively to 12.3 postoperatively (p < 0.001, t-test).

Analysis of the acute and chronic subgroups (early vs late surgery) revealed no significant differences in the improvement of VAS and ODI scores between the 2 subgroups. This result indicates that the timing of surgery (early vs late intervention) did not correlate with patients’ outcome and that “late” surgery was not associated with less patient satisfaction or with more chronic complaints.

There was, however, a significant difference between the acute and chronic subgroups in pretreatment VAS scores for radicular pain (8.6 vs 7.0, respectively, p < 0.001, t-test). No significant differences between the 2 subgroups could be detected in presurgery VAS score for back pain, presurgery ODI score, postsurgery VAS scores for back pain and radicular pain, or postsurgery ODI score. These results simply reflect the daily clinical experience that patients with massive radicular pain who do not improve under conservative treatment, including periradicular infiltrations, usually undergo surgery earlier than do patients with low to moderate pain.

Comparing the obese subgroup with the normal-weight patients, no significant differences could be detected in terms of pre- and posttreatment VAS or ODI scores. Like the normal-weight patients, the obese subgroup showed the same highly significant improvement in VAS and ODI score after surgery (p < 0.001, t-test).

Discussion

This study demonstrates that the dilative transtubular microsurgical approach for treating ELDH in a minimally invasive fashion combines the advantages of the commonly used paramedian muscle-splitting approach and the endoscopic approach. The often-used term “microendoscopic” is misleading, as gaining tubular access is not an endoscopic procedure. Thus, we use the term “transtubular microsurgical approach,” which describes the procedure better.

Besides the more and more commonly used transtubular approaches, there is a wide range of published options for treating ELDH, including conservative treatment, open techniques, and endoscopic techniques.\(^\text{2,4,5,7,8,10, 13,15,17,18,20,21,23,25}\) Combining the advantages of the often used paramedian muscle-splitting approach and the endoscopic far-lateral approach, Greiner-Perth and coworkers described a minimally invasive variant of the paraspinous muscle-splitting approach and introduced a tubular working channel.\(^\text{9}\) The technique was called the microscope-assisted technique. Doi and coworkers used the same technique but called it the “endoscopic-technique.”\(^\text{3}\) We prefer the term “transtubular microsurgical approach,” which describes the procedure unambiguously.
One advantage of the transtubular microsurgical approach over the midline approaches is that it leads to safe lateral exposure of the nerve and adequate extraforaminal decompression without compromising the facet joints. Less muscle trauma (Fig. 2C and D) and the absence of bony resection prevent facet pain and degeneration of the disc due to transferred load, instability, and the need for fusion.5,10 Furthermore, the transtubular microsurgical approach contributes to rapid mobilization and short hospital stays.

This approach also has advantages over the conventional paramedian muscle-splitting approach. One essential advantage is that it involves using sequential dilators and ultimately a tubular retractor, which allow it to be as fast and easy in obese patients as in thin ones. In this study, the 34% of patients who had a BMI greater than 30 required the use of tubular retractors of 10 cm or more in length. Open muscle-splitting approaches in these patients are more challenging and require enlargement of the skin incision. Another advantage of the transtubular microsurgical approach is that the tubular retractor is equipped with lighting at its tip, which provides excellent illumination and allows the surgeon to perform the surgical procedure even with medical loupes (although we used a surgical microscope).

Like the transtubular microsurgical approach, the full endoscopic approach to treating ELDH should not be affected by obesity. In skilled hands, the endoscopic technique is very elegant and efficient.2,19,21 The surgical trauma is minimal, and even intraforaminal disc material can be removed. Furthermore, patients can be mobilized immediately. However, there are a few disadvantages. First, the 2D technique and the exceptional endoscopic view implicate a shallow learning curve.21 A demanding technique and a shallow learning curve for the treatment of a rare disease (ELDH comprises 7%–12% of all disc herniations) allow for good clinical results only in experienced hands and in a few specially trained centers that have a high frequency of suitable patients. The endoscopic technique is not a problem in skilled hands, but the difficulty is in reaching this expert level. Accordingly, inadequate exposure of the herniated disc, incomplete decompression, and poor outcome are sometimes reported.11,12 Furthermore, with the endoscopic technique, reaching the neural foramen and extraforaminal disc herniation at the lumbosacral junction is hindered by the iliac bone wings. In contrast, transtubular microsurgical approaches at this difficult L5–S1 level are safe and efficient.14,16

One essential part of a learning curve is reflected in the operating time. Postacchini and coworkers reported an operating time of 68 minutes using an interlaminar approach,17 and Lew and coworkers reported an operating time of 60–120 minutes using an endoscopic approach.12

![Intraoperative photographs. The 18-mm tube is in place (A). The L-3 nerve root (yellow arrow) exits the outer neural foramen in the angle between the lateral facet (medial) and the superior costal process (cranial) (B). The herniated disc material (red arrow) is located caudal to and/or below the nerve root. After gentle mobilization of the nerve in the cranial direction, the herniated disc fragments can be mobilized with a hook (C) and resected in one large piece (D). The empty sequester bag is inspected (E), and complete decompression of the nerve root is verified (F).](image-url)

**Fig. 3.** Intraoperative photographs. The 18-mm tube is in place (A). The L-3 nerve root (yellow arrow) exits the outer neural foramen in the angle between the lateral facet (medial) and the superior costal process (cranial) (B). The herniated disc material (red arrow) is located caudal to and/or below the nerve root. After gentle mobilization of the nerve in the cranial direction, the herniated disc fragments can be mobilized with a hook (C) and resected in one large piece (D). The empty sequester bag is inspected (E), and complete decompression of the nerve root is verified (F).

**Fig. 4.** Learning curve for the dilative transtubular microsurgical approach for treating ELDH. There was improvement in the pooled operating time of the 4 involved surgeons (S.O.E., S.R., J.H., F.W.F.), who treated 51 cases over a period of 3 years.
Approach to extraforaminal lumbar disc herniation

Over the course of our study, the mean operating time among our 4 surgeons was 67.5 minutes for the transtubular microsurgical approach. At the end of the inclusion interval, the mean operating time was 42 minutes (Fig. 4). Greiner-Perth and coworkers had an average operation time of 43 minutes for the same approach as described in our study. Their overall operating time was clearly faster than ours, which might be a result of the low number of lumbosacral pathologies (1 patient in their study compared with 7 patients in our study). Approaching the L5–S1 level, with its narrow oblique passage descending toward the outer L5 neural foramen, took considerably longer in our patients (on average 91.8 minutes).

The clinical results in our short-term follow-up 6 months after surgery showed excellent outcome based on pain relief measured by VAS and ODI classification. Individual residual symptoms were classified as not severe in a patient satisfaction survey. Leg pain relief especially was regarded as a major benefit, which might be attributed to the extraordinary pain caused by compression of both the exiting nerve root and the spinal ganglion. These findings are in line with long-term results analyzed by Marquardt and coworkers; they found a high level of patient satisfaction in an ultra-long-term follow-up (mean 12.2 years) after a conventional muscle-splitting lateral approach, despite residual symptoms, namely sensory deficits and mild paresis, in some cases.

The procedural advantages of the transtubular microsurgical approach over other techniques in terms of patient outcome were not examined in this study. Brock and coworkers investigated this question for medial or mediolateral disc herniations. They found no difference in VAS or ODI score when they compared a conventional subperiosteal retractor-based approach with a tubular approach on the day of discharge. However, they did find a higher level of pain medication usage in the conventional approach group than in the tubular approach group during the hospital stay. This difference was statistically significant (p = 0.03).

In the subgroup analyses in our study, the difference between the acute subgroup and the chronic subgroup could be clearly pointed out. Although pre- and postoperative back pain and ODI showed no significant differences, the VAS score for radiating leg pain was significantly higher in the acute subgroup (8.6 vs 7.0, p < 0.001), despite conservative treatment. High radiating leg pain leads to early surgical decompression therapy.

Our data emphasize that patients’ weight had no influence on the duration of the procedure or on the clinical outcome. Compared with the normal-weight patients, the obese subgroup showed the same highly significant improvement in VAS and ODI scores after surgery (p < 0.001, t-test). This result is surely attributed to the soft-tissue–protecting tubular approach.

Conclusions

Extraforaminal lumbar disc herniation is a rare but clinically highly significant pathology with a low rate of conservative treatment success. For this reason, the surgical procedure has to be standardized even in anatomically complex ELDH at the lumbosacral junction. The transtubular microsurgical approach combines advantages of the conventional muscle-splitting approach and the endoscopic approaches. The easy table-mounted fixation, excellent illumination due to an integrated light source, and low maintenance are the technical advantages of this tubular system.

The technique is easy to use with a steep learning curve. Less muscle trauma due to dilation and the absence of bony resection prevent facet pain and instability, thereby contributing to rapid mobilization and recovery. Patients in this series improved excellently, as discovered in the short-term follow-up at 6 months.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: Eicker. Acquisition of data: Eicker, Rhee, Herdmann, Floeth. Analysis and interpretation of data: Eicker. Drafting the article: Eicker. Critically revising the article: Rhee, Steiger, Herdmann, Floeth. Reviewed submitted version of manuscript: Floeth. Approved the final version of the manuscript on behalf of all authors: Eicker. Statistical analysis: Eicker.

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