CLINICAL ARTICLE

Direct Tubular Lumbar Microdiscectomy for Far Lateral Disc Herniation: A Modified Approach

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Objective: The concept of minimally invasive tubular discectomy is based on precise placement of the retractor over the surgical target to minimize collateral tissue trauma. For far lateral disc herniation, the junction between the pars and the transverse process has generally been adopted as the target for facilitating early nerve root exposure; however, this may limit access to the disc space and increase the risks of iatrogenic neuralgia. An alternative approach to help address these issues involving docking the retractor caudally directly over the disc space with the aid of a microscope is here proposed. The purpose of this study was to evaluate the safety and efficacy of such an approach.

Methods: Nineteen patients in whom the modified approach was performed over a 35-month period were identified. Direct access to the disc space was attained by directing the retractor against the lateral margin of the facet joint and following the inferior transverse process medially towards the foramen with minimal exposure of the nerve root. Clinical outcomes were assessed by the Oswestry Disability Index, visual analogue scale scores for leg and back pain, Short Form 36 physical functioning (SF36-PF) and bodily pain (SF36-BP) scores and sciatica bothersomeness and frequency indexes (SBI & SFI) and obtained from a prospective patient database. Follow-up data in the first 6 months were compared with preoperative baseline data.

Results: All procedures were successfully completed with the modified approach. Contained disc herniation without sequestered fragments was found in all but four cases. No perioperative complications or reoperation were recorded and no postoperative dysesthesia was noted. Clinically significant reductions in mean Oswestry Disability Index (32; 95% CI, 21–43) and visual analogue scale scores for leg pain (38 mm; 95% CI, 23–54 mm) and back pain (35 mm; 95% CI, 21–48 mm) scores were noted in the first 6 months. Significant improvements in SF36-PF (40; 95% CI, 30–51) and SF36-BP (35; 95% CI, 26–43), SBI (9; 95% CI, 6–11) and SFI (11; 95% CI, 8–13) were also recorded.

Conclusions: A modified direct tubular approach is safe and effective for treating far lateral lumbar disc herniation. Our early results suggest that this approach helps safeguard adequate decompression and reduce the risk of postoperative dysesthesia.

Key words: Discectomy; Herniated disc; Minimally invasive surgery

Introduction

Far lateral disc herniation is an infrequent cause of sciatica, accounting for 0.7%–11.7% of all lumbar disc herniations^{1,2}. Despite the varied terminology used in published reports, such as lateral, extreme lateral, foraminal and extraforaminal, this clinical entity is characterized by the development of disc herniation lateral to the more commonly encountered posterolateral location, resulting in compression of the exiting nerve root and dorsal root ganglion at the level

of the disc herniation^{3,4}. The traditional operative management for this condition utilizes a midline subperiosteal approach and entails resection of the facet joint to reach the pathology in the foraminal and extraforaminal space lateral to the spinal canal^{4,5}. In the last three decades, the development of a paraspinous muscle splitting approach has allowed facet sparing access to the far lateral compartment through the intertransverse extraforaminal corridor^{6,7}. This approach, which is characterized by a transmuscular oblique angle of

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attack, allows visualization of the foraminal and extraforaminal spaces without disruption of the facet joint or pars². However, collateral injury to the paraspinal musculature is an inevitable trade-off⁸.

The recent advent of minimally invasive tubular surgery has heralded a new operative paradigm in minimizing access trauma in spinal surgery. Pioneered by Foley and colleagues in the 1990s, the approach is based on the tenet of highly selective targeting and minimization of collateral tissue trauma by using tubular retractors, generally less than 20 mm in diameter, together with specialized long, tapered instruments to facilitate operating through a long narrow channel⁹. These techniques were originally designed for endoscopic surgery; however, the added infrastructure cost, disadvantages of monoscopic vision, wide availability of operating microscopes and their familiarity to most surgeons have prompted modifications in favor of microscopes^{10–15}. In particular, the tubular approach offers clear advantages in treatment of far lateral disc herniation through the paraspinal corridor, enabling minimization of soft tissue trauma compared with a conventional open approach^{9,11}.

The techniques for performing minimally invasive tubular surgery for far lateral disc herniation have been described by several authors^{8–10,12,14,15}. Despite variations in their techniques, one principle that underscores all of them is early identification of the nerve root by adopting a cranial trajectory to expose the superior aspect of the intertransverse space

rather than targeting the disc space caudally (Fig. 1A). Tissue dissection is advanced to define the pars, superior transverse process and exiting nerve root at the pars–transverse process junction ventral to the intertransverse ligament^{10,14,15}. The herniated disc or osteophytes caudal to the exposed nerve root is then identified at the edge of the surgical field by mobilizing and retracting the nerve root cephalad (Fig. 1C)^{7,11,12}.

However, our experience has led us to favor an alternative technique that entails directly targeting the intervertebral disc by docking a retractor caudally over the facet joint and then trimming the lateral edge of the articular process of the lower vertebra to gain access to the extraforaminal space (Fig. 1B). The inferior transverse process then serves as a key landmark: by following it medially, the annulus can be located immediately cephalad. Discectomy and foraminal decompression can then be performed without actively exposing the exiting nerve root (Fig. 1D).

Whilst departing from the traditional strategy of early nerve root exposure, our approach potentially offers several distinct advantages over a conventional approach. First, the centering of the working channel at the level of the disc space rather than of the nerve root may reduce the risks of postoperative dysesthesia associating with nerve root and dorsal ganglion manipulation. Second, having the surgical field directly over the disc herniation may help to maximize access to and decompression of the targeted pathology.

Fig. 1 (A, B) The tip of the first muscle dilator is positioned at the operative target and (C, D) a 18 mm tubular retractor is placed over the intertransverse region on a lumbar spine model. (A, C) The junction of the pars and the superior transverse process is generally used to allow early identification of the exiting nerve root. (B, D) The proposed approach targeting the facet joint provides direct access to the intervertebral disc.

In this retrospective study, our objective was to evaluate the safety and efficacy of this modified approach by reviewing a cohort of patients who had undergone this procedure. We investigated the rate of iatrogenic neural injury, postoperative neuralgic pain and reoperation because of insufficient decompression as the primary measures of safety and efficacy. Secondly, we assessed patient-reported outcome with standardized instruments and compare our results with those of other minimally invasive techniques.

Materials and Methods

The authors identified 19 patients (ten men, nine women) who had undergone tubular microdiscectomy for far lateral lumbar disc herniation from January 2012 to November 2014. All procedures were performed by the first author (TS), who used a caudal extraforaminal approach using a tubular retractor system (Metrx; Medtronic, Memphis, TN, USA). Only patients who had no prior surgery at the index lumbar disc level were included and patients who required concomitant instrumentation or more than single level treatment were excluded. Oswestry Disability Index (ODI), Short Form-36 physical functioning (SF36-PF) and bodily pain (SF36-BP) scores, visual analogue scale (VAS) scores for back and leg pain, and sciatica bothersomeness (SBI) and frequency (SFI) index scores¹⁶ were prospectively collected in a patient database (Keops; Smaio, Lyon, France) according to local human research ethics guidelines.

Treatment Protocol

Patients who presented with sciatica with significant motor deficits (grade 3/5 power or less) or failed conservative treatment of at least 6 weeks duration and whose symptoms were attributable to far lateral lumbar disc herniation, proven on MRI, were offered surgery. Conservative treatment consisted of non-steroidal anti-inflammatory drugs and physiotherapy. Imaging-guided steroid injections were routinely discussed with all patients and were carried out on request.

Surgical Techniques

Anesthesia and Position

Surgery was performed under general anesthesia. A prophylactic antibiotic (cefazolin) was administered prior to skin incision. The patient was placed in a prone position on a Jackson table.

Localization and Approach

The surface projection of the intervertebral disc and lateral margin of the adjacent facet joint were marked with fluoroscopy with lateral and anteroposterior views. A 2 cm skin incision was then made 1–2 cm lateral to the projected lateral margin of the facet joint, centering at the level of the disc space, typically about 4–5 cm from the midline. After the deep fascia had been pierced by a guidewire, serial muscle dilation was achieved using serial dilators of increasing diameter (Metrx; Medtronic). A tubular retractor (18 or

20 mm diameter) was inserted over the dilators, with the medial edge docking at the lateral margin of the facet joint. A retractor extending 1 cm above the skin level was selected to allow advancement of the retractor deeper towards the intervertebral foramen later in the procedure. In our experience this is an important step in allowing the tip of the retractor to reach the extraforaminal fat plane, thus maximally displacing the paraspinal muscle out of the surgical field. This maneuver drastically reduces the degree of muscle clearance required and minimizes associated postoperative pain.

Exposure

After securing the retractor to the operating table through an arm assembly and verifying the correct spinal level with fluoroscopy, the remainder of the procedure was carried out under an operating microscope (OPMI Pentero; Carl Zeiss, Jena, Germany). The lateral margin of the facet joint was first trimmed back for about 2 mm medially and towards the inferior transverse process. With L₅S₁, the extraforaminal window was obstructed by the sacral alar inferiorly, requiring shaving down of the superior portion of the sacral alar to maximize access to the disc space. With these bony structures cleared from the periphery of the retractor, the retractor was then advanced towards the extraforaminal fat plane, displacing the paraspinal muscles out of the surgical field (Fig. 2). The intertransverse ligament was then identified and resected with Kerrison rongeurs. The dorsal branches of the segmental neurovascular bundles were sacrificed to improve access if required.

Discectomy and Decompression

First, the intervertebral disc was identified by following the transverse process of the lower vertebra (or the sacral ala for L₅S₁) medially and cephalad. The inferior edge of the exiting nerve root was sometimes visualized superiorly; however, no attempt was made to expose the nerve if it was displaced outside the surgical channel. Once the annulus of the disc had been clearly defined, discectomy was performed in a standard fashion (Fig. 3). The facet joint was undercut with Kerrison rongeurs to address foraminal stenosis caused by ligamentum hypertrophy and facet arthritis and osteophytes debulked with an osteotome if required (Fig. 4).

Closure

After securing hemostasis, the tubular retractor was removed and the fascia closed with interrupted absorbable sutures. Skin closure was achieved with an absorbable subcuticular continuous suture.

Postoperative Management

Patients were mobilized on the first postoperative day. Narcotic analgesia was prescribed on an as-needed basis. Patients were routinely discharged 1–2 days after surgery.

Fig. 2 Intraoperative fluoroscopic lateral images of the lumbar spine. (A) The tubular retractor is docked at the facet joint. (B) The retractor has been advanced towards the foramen after trimming of the lateral edge of the facet joint.

Fig. 3 Patient with a left L₃₋₄ far lateral disc herniation. (A) Axial T2 MRI showing far lateral disc herniation with both foraminal and extraforaminal components causing lateral displacement of the exiting nerve root. Note the signal change in the nerve root. (B) Intraoperative photograph showing the annulus of the herniated disc. The exiting nerve root is visible at the superior margin of the surgical field (arrowheads).

Fig. 4 (A) Axial CT of a right L₅S₁ extraforaminal disc/osteophyte complex. (B) Postoperative CT showing that the superior margin of the sacral alar and lateral margin of the facet joint have been trimmed and the osteophytes debulked.

Statistical Analysis

Postoperative outcome scores were compared with preoperative values using repeated measures analysis of variance (ANOVA) with Greenhouse–Geisser correction. *Post hoc* analysis was carried out with the Bonferroni test. SPSS version 16 was used for all statistical calculations. A *P* value of less than 0.05 was considered statistically significant.

Results

Patient Characteristics

The patients' mean age was 58.4 years (range, 22.5–75.1 years). The most common spinal level operated on was L₃₋₄ (seven cases), followed by L₅S₁ (six cases), L₄₋₅ (four cases), L₁₋₂ and L₂₋₃ (one each). Preoperatively, only two of

the study subjects had lower extremity weakness on physical examination, both having grade 4/5 weakness of knee extension secondary to L₃₋₄ disc herniation.

Operative Findings

At surgery, contained discs were identified in all but four cases. Sequestered disc fragments were found in two cases and disc/osteophyte complexes were the offending pathology in two (both at L₅S₁). There were no intraoperative complications, including dural injury.

Postoperative Complications

There were no postoperative adverse events. No postoperative dysesthesia were noted or reoperations required.

Follow-up and Outcome

All patients were followed up for 6 months. The two patients who had preoperative motor deficits recovered fully following surgery. Figure 5 summarizes patient outcomes. Treatment effects were assessed by repeated measures ANOVA with Greenhouse–Geisser correction to identify statistically significant differences in mean scores between time points for all outcome instruments used ($P < 0.05$). *Post hoc* tests using the Bonferroni correction revealed significant improvement over the preoperative baseline by 6 weeks; these effects were sustained at 3 and 6 months ($P < 0.05$).

Mean ODI scores decreased by 32 points (95% confidence interval [CI], 21–43) by 6 months. Similarly, VAS scores for severity of pain improved by 38 mm (23–54) and 35 mm (21–48) for leg and back pain, respectively. This improvement exceeds the thresholds for clinically meaningful differences as suggested in published reports (20 mm for VAS and 10 points for ODI)¹⁷. Significant improvements in SF36-PF (40; 95% CI, 30–51) and SF36-BP (35; 95% CI, 26–43), SBI (9; 95% CI, 6–11) and SFI (11; 95% CI, 8–13) were also recorded. Overall, the greatest improvement was noted in indices for pain and leg symptoms—the mean SBI and VAS leg pain scores decreased by 81% ($P < 0.01$) and 82% ($P = 0.003$), respectively, and the mean SF36 bodily pain score improved by 152% ($P < 0.01$) at 6 months.

Discussion

Overview of Study Rationale and Results

First reported by Watkins in 1953 and subsequently modified by Wiltse in 1968, the paraspinal approach is a direct transmuscular approach to the foraminal and extraforaminal regions, thus circumventing the drawback of the extensive facetectomy that is required with standard midline subperiosteal surgery^{18,19}. In the past two decades, an increase in awareness of motion segment instability and chronic low back pain attributable to lumbar facetectomy has catalyzed a growing interest in use of the paraspinal approach for treating far lateral disc herniation^{20–22}. The recent advent of minimally invasive spinal surgery, which embraces the use of tubular retractors and biplanar fluoroscopy, has enabled

further minimization of tissue trauma associated with these techniques^{8,9}. However, one important trade off of such a minimally invasive approach is that it is not possible to achieve the panoramic survey of the entire intertransverse region that is generally afforded by an open approach. Thus, various authors have advocated a strategy for facilitating early exposure of the exiting nerve root by targeting the transverse process–pars junction where the exiting nerve root courses just lateral and deep to the lateral margin of the pars^{8–10,14,15}. Our study has shown that modifying this approach by targeting the facet joint and inferior transverse process is technically feasible and effective. Contrary to the conventional principle of early nerve exposure, our techniques focus on direct access to the disc space and decompression of the offending pathology with minimal or no nerve exposure. Despite this, our results show that safety and treatment outcome is not compromised—the use of multiple independent health-related quality of life instruments in this study having provided robust data in support of this conclusion. The major limitations of our study include small sample size, relatively short follow-up and retrospective design; however, recall bias and loss to follow up are reduced by prospective data collection.

Anatomical Considerations Concerning the Direct Caudal Approach

When assessing the safety and feasibility of this modified approach, one important consideration is the constant relationship between the nerve and disc in the far lateral location. The anatomical constraints of the intervertebral foramen mean that, in contrast with posterolateral disc herniation, far lateral disc herniation uniformly has a caudad–cephalad relationship with the exiting nerve root. Thus, unlike interlaminar surgery for posterolateral disc herniation where exposure and mobilization of the nerve root is fundamental to access and neural protection, decompression in the far lateral compartment can be accomplished safely without this because the exiting nerve root is safeguarded by its constant and predictable location in the surgical field and the herniated disc, being caudal to the exiting nerve root, can be reached and effectively debulked without mobilizing it. We have exploited these anatomical characteristics by adopting a direct caudal approach, thus maximizing exposure of the disc space, rather than the nerve root, and gaining a direct line of access that facilitates removal of calcified disc and osteophytes. The latter is particularly important because two previous large surgical series (each with more than 100 patients) of far lateral disc herniation have found that most far lateral disc pathology consists of contained disc or stenosis from disc/osteophyte complexes rather than sequestered disc fragments^{23,24}; these findings were echoed in the present study. Adequate access to the vertebral interspace is thus critical for achieving full decompression. Correspondingly, incomplete decompression rather than recurrent disc herniation has been found to be the most common reason for residual postoperative leg pain after discectomy for far lateral disc

Fig. 5 Treatment outcomes over time. (A) ODI: the scale ranges from 0 to 100, higher scores indicating worse functional status. (B) Short Form 36 physical functioning and bodily pain scales range from 0 to 100, higher scores indicating less severe symptoms. (C) VAS scores range from 0 (no pain) to 100 mm (worst pain ever). Patients were asked to rate their pain on two separate horizontal bars, one for low back pain and the other for leg pain. (D) Sciatica index scores range from 0 to 24. The SBI assesses the severity of sciatic symptoms, including numbness, tingling and weakness, higher scores meaning more severe symptoms. The SFI assesses how often the symptoms are present, from not at all to always. The error bars represent the standard deviations.

herniation²³. By providing a direct line of surgical access to the disc space, our approach helps secure satisfactory decompression and ensures treatment success.

Comparison with Other Minimally Invasive Techniques

The minimization of nerve manipulation with the caudal approach in contrast with the standard pars-transverse technique has important clinical implications. In the past, development of postoperative neuralgic pain and dysesthesia following surgical treatment of far lateral disc herniation has often been noted^{22,25}. The rates of such complications in patients undergoing conventional paraspinal surgery reportedly range from 7% to 38%^{1,2,23,26,27}. This propensity is generally thought to be attributable to traction on the nerve, particularly the dorsal root ganglion, during its identification

and exposure^{22,25}. It is conceivable that the conventional pars-transverse process approach would increase the risk of such morbidity. On the other hand, our technique would have the opposite impact because no or minimal retraction of the nerve is generally required. The absence of such complications in the current series corroborates this contention.

One of the major challenges in adopting the paraspinal approach for treating far lateral disc herniation is that the anatomy of the paraspinal region is unfamiliar to many surgeons^{22,25} and the use of minimally invasive techniques further compounds this difficulty. It is conceivable that the pars-transverse process approach, which entails early survey of important anatomical landmarks, namely the lateral pars and the exiting nerve root, would facilitate orientation by surgeons. Thus, it may be advisable for those in the initial

phase of adopting the techniques to follow the standard approach before transitioning to the direct approach. In our experience, the use of fluoroscopy is an invaluable adjunct for anatomical localization and we recommend its generous application to help circumvent the difficulties of orientation through a tubular retractor.

Purely percutaneous techniques assisted by thin endoscopes have recently been advocated by several authors, the aim being to further minimize the collateral soft tissue trauma associated with a transmuscular approach for treatment of far lateral disc herniation^{28–31}. These techniques differ significantly from tubular or open discectomy in that access to the disc space is established purely percutaneously with fluoroscopic vision and decompression is achieved endoscopically by removal of any soft disc fragments encountered or by indirect decompression through debulking of the nucleus pulposus. Because it utilizes a working channel of only several millimeters, such an approach is by far the least invasive. However, several studies have highlighted the complexity of the techniques and the drawback of a steep learning curve^{32,33}. In particular, adverse outcome such as bowel and ureteric injuries^{34–36}, retroperitoneal haematoma³⁷, dural injury³⁸, postoperative dysesthesia^{39,40} and conversion to open surgery⁴⁰ are found specifically associated with these procedures, underscoring the challenges of such a

minimalist approach. By comparison, microscopic tubular discectomy retains the conventional microscope-based approach and shares the fundamental characteristics of direct visualization of surgical landmarks and open access to targeted pathology common to all open techniques. The proven safety and treatment efficacy of such a time-honored operative paradigm strikes an important note of caution when adopting any minimally invasive approach that departs from these principles.

Conclusion

The results of our study confirm previous data that microscopic tubular discectomy is highly effective in improving sciatic pain secondary to far lateral lumbar disc herniation^{10,12,14,15}. Our caudal approach offers a safe alternative to the standard pars-transverse process approach. It involves less nerve manipulation and provides direct access to the disc space, thus potentially lowering the risks of iatrogenic neuralgia and inadequate decompression.

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