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Clinical Outcome of Minimally Invasive Spine Surgery (MIS) Discectomy Using a Tubular Retractor System

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ABSTRACT

Background: Lumbar disc herniation is one of the most common conditions affecting the lumbar spine, often causing severe radicular pain and neurological deficits. Traditional open discectomy involves significant paraspinal muscle disruption, leading to postoperative pain and prolonged recovery. Minimally invasive spine surgery (MIS) with a tubular retractor system offers a muscle-splitting "key-hole" approach, potentially reducing soft-tissue trauma, blood loss, and hospital stay.

Aim: To evaluate the clinical outcomes of MIS discectomy using a tubular system in patients presenting to our tertiary care centre.

Methodology: This retrospective study included all patients who underwent tubular-system MIS discectomy between January 2023 and March 2024. Thirty-one patients (any age, socioeconomic status, or symptom duration) with single-level disc prolapse confirmed on MRI were enrolled. Exclusion criteria were prior lumbar surgery, scoliosis, multilevel herniation, canal stenosis, or spondylolisthesis. Outcomes were assessed by pre- and postoperative Visual Analogue Scale (VAS), Oswestry Disability Index (ODI), and modified Macnab score, with follow-up ranging from 6 to 12 months. Intraoperative metrics (blood loss, operative time), hospital stay, analgesic use, and complications were recorded. Statistical analysis used paired t-tests (SPSS v27.0), with $p < 0.05$ considered significant.

Results: Mean age group of patients in our study was 53 with male preponderance. Clinical outcome was determined by VAS, ODI, and Modified Macnab Score. Mean pre-operative VAS score was 8.5 which reduced to 2.03 postoperatively (p value < 0.001, t = 47.17). Mean pre-operative and post-operative ODI scores were 77 and 11.8 respectively (p value < 0.001, t = 27.752). Post-operative Modified Macnab Score was excellent in 51.6%, good in 45%, and poor in 1 (3%). Mean blood loss was 40 ml. The mean operative time was 210 mins. We had an overall complication rate of 6.5%, with a durotomy rate of 6.5% seen in two patients. Re-operation rate was 3.2% [1].

Conclusion: Tubular-system MIS discectomy yields excellent to good clinical outcomes in 97% of cases, with significant pain and disability reduction, minimal blood loss, and early return to work. Although operative times are longer—reflecting the learning curve—MIS provides a muscle-sparing, infection-reducing approach that matches conventional outcomes and enhances patient satisfaction.

Keywords: *Minimally invasive spine surgery; tubular system; discectomy; clinical outcome*

1. INTRODUCTION

Lumbar disc disease (LDD) is one of the most common conditions affecting the lumbar spine in individuals aged 30–50 years [1]. Lumbar disc herniation causing severe radicular pain or neurological deficits often requires discectomy, which has a reported success rate ranging from 50% to 98% [2]. In 1932, Mixter and Barr performed laminectomy and removed the disc via a transdural approach. Between 1937 and 1939, Love introduced the intralaminar extradural approach for discectomy. In 1977, Caspar and Yasargil introduced microdiscectomy, which became the gold standard treatment for lumbar disc herniation [3]. However, this procedure involved separation of the paraspinal muscles from the lamina and spinous process, leading to postoperative pain and morbidity.

In 1997, Foley and Smith introduced endoscopic discectomy, a technique utilizing an operative endoscope with a tubular system. Over time, the tubular retractors were modified to incorporate a microscope instead of an endoscope [3]. The advantages of using a tubular system include a muscle-splitting approach that causes less tissue damage, leading to faster recovery and earlier return to work [4,5]. Additionally, the tubular system prevents direct contact between the surgical field and the skin, reducing the risk of infection [6].

By minimizing incision size and sparing paraspinal structures through a smaller, more targeted surgical exposure, the approach aims to lower surgery-related morbidity while maintaining surgical efficacy. These principles continue to define the goals of all minimally invasive spine surgeries.

2. MATERIALS AND METHODS

This is a retrospective study including all patients who underwent minimally invasive spine (MIS) discectomy using a tubular system at our hospital from January 2023 to March 2024.

All patients, irrespective of age, socioeconomic status, or duration of symptoms, who presented with lumbar radicular pain, sensory or motor deficits, and radiologically documented single-level intervertebral disc prolapse on magnetic resonance imaging (MRI) were included and treated with MIS discectomy using a tubular system.

Exclusion criteria included patients who had undergone prior lumbar spine surgery, had scoliosis, multilevel disc herniation, lumbar canal stenosis, or Grade 1 spondylolisthesis. All MIS procedures were performed using a 22 mm tubular retractor system under the ZEISS KINEVO 900 operating microscope.

Patient Evaluation and Indications for Surgery

Preoperative imaging included MRI and dynamic lumbar spine X-rays. Pain and functional disability were evaluated using the Visual Analogue Scale (VAS), Oswestry Disability Index (ODI), and Modified Macnab score.

The following parameters were assessed and analyzed:

- Operating time
- Intraoperative blood loss
- Pre- and postoperative VAS scores
- Pre- and postoperative ODI
- Duration of hospital stay
- Use of analgesia
- Postoperative complications

Surgical Technique

All procedures were performed under general anesthesia. Patients were positioned prone on a Wilson frame, ensuring a lax abdomen to facilitate venous drainage and minimize blood loss. Pressure points were adequately padded, and special precautions were taken to protect the eyes.

The midline was identified by palpation of the spinous processes, and the target level was confirmed using C-arm fluoroscopy. A spinal needle was used to confirm the correct disc space.

A 22 mm vertical skin incision was made approximately 1.5 cm lateral to the midline, centered over the affected disc level. The incision was made on the same side as the disc herniation. In cases of central disc herniation, the incision site was based on the side of radicular pain.

After incising the dorsolumbar fascia, the paraspinal muscles were dissected off the lamina and spinous process using monopolar cautery. The smallest serial dilator was inserted into the dissected plane, and docking was performed at the spinolaminar junction. Subsequent dilators were inserted sequentially. After the fourth dilator, the skin marking was used to determine the appropriate tube length. Muscle was cleared from the lamina before introducing the tubular retractor system.

The tubular retractor was positioned to expose the lower one-third of the upper lamina, interlaminar space, and spinolaminar junction. Placement and trajectory were confirmed under fluoroscopy. The retractor was then fixed to a flexible arm attached to the operating table, and soft tissue was cleared under the operating microscope.

Laminotomy of the superior lamina was performed using a high-speed drill (3–4 mm cutting and diamond drill bit). The extent of laminotomy depended on the disc bulge location. Medially, the laminotomy extended to the spinolaminar junction. In central disc herniations, over-the-top decompression and partial medial facetectomy were performed to mobilize the dural sac and minimize nerve root retraction.

Bone removal was carried out using 45° Kerrison rongeurs (starting from 1 mm to 3 mm). The ligamentum flavum was excised using 45° Kerrison rongeurs (1–2 mm). The nerve root was gently retracted medially using a nerve root retractor or suction cannula, and the disc bulge was identified.

The annulus was incised using a No. 15 blade, and the disc material was removed using curved and straight disc forceps. Following discectomy, the nerve root and dura were confirmed to be free (Figure 1).

Figure 1: Free nerve root and dura visualized through the operating microscope using a tubular system.

Statistical Analysis

Data analysis was performed using SPSS version 27.0 (IBM Corp., Armonk, NY). A paired *t*-test was used for statistical comparisons. A p-value < 0.05 was considered statistically significant.

The mean age of patients in the study was 53 years, with a male predominance. Based on the work of Palmer et al. [10], 78.8% of patients were expected to return to work within 6 weeks. Based on this, a minimum of 30 patients was deemed necessary for inclusion in the study.

Clinical outcomes were assessed using VAS, ODI, and Modified Macnab score.

- **VAS Score**: The mean preoperative VAS score was 8.5, which reduced to 2.03 postoperatively ($p < 0.001$, $t = 47.17$).
- **ODI Score**: The mean preoperative ODI was 77, which improved to 11.8 postoperatively ($p < 0.001$, $t = 27.752$).
- **Macnab Score**: Postoperative Macnab scores were excellent in 51.6% of patients, good in 45%, and poor in 1 patient (3%).
- **Blood Loss**: Mean intraoperative blood loss was 40 ml.
- **Operative Time**: The mean operative time was 210 minutes.

All patients received postoperative pain management, which included intravenous NSAIDs for the first two days. Opioids were administered as needed for breakthrough pain.

The overall complication rate was 6.5%. Intraoperative durotomy occurred in two patients (6.5%) and was managed conservatively. The re-operation rate was 3.2%, with one patient requiring a second surgery due to recurrent disc herniation.

Table; Pre and perioperative outcomes

Outcome	Preoperative	Postoperative	p-value
VAS (mean ± SD)	8.5 ± 0.7	2.03 ± 0.66	< 0.001
ODI (%) (mean ± SD)	77.6 ± 12.9	11.9 ± 8.6	< 0.001
Modified Macnab (Excellent/Good/Poor)	—	51.6% / 45% / 3%	—
Blood loss (mL) (mean ± SD)	—	40 ± 11	—
Operative time (min)	—	210	—
Complication rate	—	6.5% (durotomy ×2)	—

Outcome	Preoperative	Postoperative	p-value
Re-operation rate	—	3.2% (n = 1)	—
Return to work at 4 weeks	—	97%	—

3. DISCUSSION

Minimally invasive techniques have demonstrated superiority in reducing infection rates, intraoperative blood loss, postoperative pain, hospital stay duration, time to return to work, and overall hospital costs [7]. These advantages contribute to faster recovery in patients undergoing MIS discectomy [8].

Foley and Smith first described micro-endoscopic discectomy (MED) in 1997, utilizing a muscle-splitting approach that results in less denervation and soft tissue damage compared to conventional open surgery [8]. Sasaoka et al. reported significantly lower postoperative levels of interleukin-6 in patients undergoing MED compared to those undergoing conventional microdiscectomy, supporting the reduced inflammatory response with MIS techniques [9].

In our study, the mean age of patients was 53 years, with a male predominance. Clinical outcomes were assessed using VAS, ODI, and Macnab scores. The mean preoperative VAS score was 8.5, which significantly reduced to 2.03 postoperatively—comparable to results reported by Palmer S [10] (7.3 to 1.9) and Asati S et al. [3] (7.2 to 1.7). Similarly, the mean ODI score improved from 77.55 ± 12.95 to 11.8, in line with findings by Sonawane D et al. [8] (54.4 ± 17.69 to 4.98 ± 3.97) and Asati et al. [3] (40 to 14).

Postoperative Macnab scores were excellent in 51.6%, good in 45%, and poor in 3% (1 patient), closely matching results from Kunert et al. [9] (66% excellent, 34% good).

In our study, 97% of patients returned to work by the 4th week, with 51.2% resuming full duties and 45% returning with modifications. This aligns with Bookwalter et al. [11], who observed a 40% return-to-work rate within 5 weeks. In contrast, Caspar et al. and Foley & Smith reported average return-to-work durations of 18.6 weeks and 17.6 days, respectively.

The mean blood loss was 40 mL, consistent with values reported by Arts et al. (50 mL) and German et al. (59 mL). The mean operative time in our study was 210 minutes, slightly longer than German et al.'s [13] 165.5 ± 5.75 minutes. This extended duration is likely attributable to the learning curve associated with MIS techniques.

No opioids were administered postoperatively; patients received IV NSAIDs for two days. Muramatsu et al. [14] reported that 52% of MIS discectomy patients required opioids, while Brock et al. [14] noted significantly lower postoperative analgesic use in patients treated with tubular systems.

The mean hospital stay was 3.25 days, comparable to findings by Lyson et al. [9] (2–3 days) and Kunert P et al. (1–2 days). Reduced blood loss, decreased need for postoperative analgesics, and faster return to work all contribute to the appeal of MIS discectomy using tubular retractors.

Complications

The overall complication rate in our study was 6.5%, consistent with Overdevest GM et al. [15], who reported a rate of 6.45%. No surgical site infections were noted in our series. Palmer S et al. reported 0.8% wound infection and discitis, while other studies documented complication rates as follows: Williams et al. and Ebling et al. (0%, 3.3%), Caspar et al. (0.7%), and Pappas et al. (7.2%).

The reoperation rate was 3.2% (1 patient), similar to the 4% reported by Palmer et al. [10]. Our reoperated patient experienced inadequate pain relief initially but had a favorable outcome post-reoperation based on the modified Macnab criteria.

Durotomy is the most common intraoperative complication, with rates ranging from 7–10% [13]. We observed two cases (6.5%) of dural injury, consistent with findings from Ebling et al. (3.9%) and Caspar et al. (6.7%) [10]. Both patients were managed conservatively with fat graft and Surgicel placement, followed by three days of bed rest. No fibrin glue was used. After retractor removal, the tissue collapse closed the defect sufficiently to prevent CSF accumulation [8].

The overall success rate was 97%, which is in line with literature. Studies by Williams et al., Ebling et al., Caspar et al., and Findlay et al. have reported success rates between 73–86% [10].

4. LIMITATIONS

This study was limited by its retrospective design, small sample size, and short follow-up duration. Future research should include prospective comparative studies with larger sample sizes. Comparative analysis between MIS, open discectomy, and endoscopic discectomy would offer deeper insights into efficacy, patient satisfaction, and cost-effectiveness.

5. CONCLUSION

Our study, though retrospective and limited in scope, demonstrates that MIS discectomy using a tubular system offers excellent clinical outcomes, a high success rate (97%), shorter hospital stays, minimal analgesic use, and faster recovery—making it a promising alternative to traditional open techniques. While the longer operative time reflects the steep learning curve, the muscle-sparing keyhole approach of MIS surgery improves patient satisfaction and can potentially become the preferred standard for lumbar disc herniation treatment

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