Technical Consideration of Transforaminal Endoscopic Spine Surgery for Central Herniation

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Abstract

Introduction: Lumbar disc prolapse is most common between 30 and 50 years of age and is associated with severe disability and pain. It commonly occurs at L4/5 and L5/S1. Transforaminal endoscopic discectomy is an emerging technique for treatment of degenerative disc disease. Literature has shown clinical outcomes, comparable to classical open and micro lumbar discectomy. Central disc herniations in lumbar spine pose technical challenge for transforaminal endoscopic decompression due to its location. Existing techniques to access central herniations and ventral epidural space have trajectory related challenges due to the proximity of the retroperitoneal space and abdominal organs and technically difficult for the less experienced surgeon. Materials and Methods: Thirty patients – 19 males and 11 females – with central, multifocal, central-paracentral disc herniations in the lumbar spine operated in 2015 and 2016 were considered in this study. All patients underwent selective endoscopic discectomy under monitored care anesthesia and local anesthesia with modification of the classical technique, medialization of annulotomy, undercutting the nonarticular part of superior articular process (foraminotomy) and use of articulating and long jaw instruments either alone or in combination. Results: In all the thirty patients, we were able to achieve adequate decompression with neurological recovery. All patients improved in their neurological status. Postoperatively, visual analog scale dropped from 7.8 to 1.8 and ODI dropped from 73.46% to 32.90% of the patients reported excellent and good results. One patient had recurrent herniation and was treated with transforaminal surgery. One patient had persistent back pain and reported poor outcome. Three patients underwent medial branch block for facet joint pain followed by medial branch rhizotomy and reported excellent and good results. Conclusion: Transforaminal endoscopic spine surgery with modifications as described above to reach the dorsal part of the disc in the midline and to access ventral epidural space is safe and effective.

Keywords: Central herniation, foraminotomy, selective endoscopic discectomy, transforaminal endoscopy

Introduction

The annual incidence of low back pain is estimated at 5%, but only 1% develops radiculopathy. Lumbar disc prolapse is a disease most common between 30 and 50 years of age and is associated with severe disability and pain.[1] It may occur at any level but commonly occurs at L4/5 and L5/S1. In the older population, with chronically degenerated discs, compression of the nerve root is more likely to be due to stenosis. Disc herniation primarily can occur in four locations: central, paracentral, foraminal and extraforaminal, or far lateral [Figure 1]. Most patients with central herniation present with low back pain, often of long duration, with a more recent onset of acute pain radiating into the lower limbs.[3] Frequently, the pain may be accompanied by numbness, paraesthesia, or weakness. The dermatomal distribution of the pain may give an indication of the level of the pathology, but frequently the pain is myotomal being described as a severe, deep seated muscular ache associated with cramps. Awkward movements or Valsalva maneuvers often exacerbate the pain (e.g., sneezing). Sudden resolution of leg pain, accompanied by motor or sensory deficit, is more likely to represent nerve root infarction than disc resorption. Neurogenic claudication (from compression of the cauda equina) is usually intermittent paraesthesia, occasional bilateral leg pain or ache, unsteadiness or loss of balance on walking are presenting complaints in most of the patients with central herniation.

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Transforaminal endoscopic discectomy is an emerging technique for treatment of degenerative disc disease. Number of studies and articles in the literature has shown clinical outcomes comparable to classical open and micro lumbar discectomy.\[2\] Transforaminal endoscopic discectomy has the unique advantage of being done under local anesthesia, minimal blood loss, less collateral tissue destruction, minimal fibrosis and hence significantly shorter hospital stay compared to other surgical modalities. With the advent of technically improvised endoscopic instruments, shavers, burrs, larger working channel endoscopes, and laser the spectrum of indications to treat degenerative conditions of the lumbar spine have widely expanded.

Central disc herniations in lumbar spine pose technical challenge for transforaminal endoscopic decompression due to its location, proximity of retroperitoneal structures in the path of the trajectory and difficulty in accessing the herniation. To overcome these problems, here we describe technical options and modification of the classical technique to address central lumbar disc herniation.

**MATERIALS AND METHODS**

Thirty patients with central, central-para central disc herniation in the lumbar spine operated in 2015 and 2016 were considered in this study. All patients had minor neurodeficits preoperatively. There were 19 males and 11 females in the study. The average age was 43 years (maximum - 76 years and minimum - 22 years). There were 16 herniations at L4–L5, 12 at L5-S1, 01 at L2–L3 and 01 at L1–L2. All the patients were evaluated preoperatively by visual analog scale (VAS), ODI. All the patients underwent dynamic X-rays of the lumbar spine to rule out segmental instability. All patients underwent selective endoscopic discectomy under monitored care anesthesia and local anesthesia with 01% preservative free Xylocaine in prone position under image intensifier control. Average operative time was 55 min. Radiofrequency (Elliquence), Holmium YAG laser (Accutech), Trephines (Richard Wolf), Reamers (Maxmore), and Endoscopes (Richard Wolf, Euroline) was used during the surgery.

The classical technique for a paracentral herniation starts by choosing a skin entry point by measurement technique explained Yeung and Tsou. The first step is to dock the needle on the lateral aspect of the superior articular facet and then walk over the superior articular process (SAP) to reach the dorsal aspect of the disc on the lateral and at the mid or medial pedicular line on the posterioranterior (PA) view of the image intensifier.\[2\] Technically, at this point, the tip of the needle is in the Kambin’s triangle. After accessing the patient’s pain response, the needle was advanced in the disc till the midline on the PA and dorsal 25% of the disc on the lateral. At this point, a discogram is performed with radiopaque dye and methylene blue (0.1 cc) and the patients response noted. Disc morphology and dye leak was also noted to confirm the herniation. Sequentially, the needle is followed by a guide wire, dilator, working sleeve, and last the endoscope.

We follow the classical inside out YESS technique.\[2\] A sub-annular discectomy is primarily done to decompress the intradiscal component of the herniation. Most of the times, we can identify the annular rent through which the herniation has extruded. There can be evidence of granulation tissue at the junction of the herniation and annulus, and in chronic herniations evidence of neovascularization, neo neurolization, calcification, and osteophytic growth can be found which can be responsible for chronic low back pain.\[2\] 4.1 Radiofrequency (Elliquence Inc.,) with Trigger flex was used to ablate the granulation tissue intradiscally. Osteophytes are burred out with a diamond burr. The working sleeve is withdrawn out to see more of the ventral epidural space. If the extruded fragment is Grade 1\[3\] [Figure 2], medialization of annulotomy was performed and extruded fragment removed.

**Technique of medialization of annulotomy**

After subannular discectomy ventral to the extruded or prolapsed fragment (Grade 1), the sleeve is withdrawn out to
be half in and half out with annulus traversing in the middle of the endoscopic field. A punch or scissor is used to cut the part of the annulus to reach more medially. Incidentally, cutting the annulus in this area also decompresses the subarticular recess floor. Care is taken to achieve hemostasis in the epidural space before cutting the annulus, as this area is full of venous plexus and can bleed profusely if not taken care off. Reinserting the sleeve inside the disc over a conical dilator will shift the sleeve dorsally giving more medial and dorsal access to the disc and epidural space. This technique is called as medialization of the annulotomy [Figures 3-6].

Medialization of annulus was helpful in patients where the herniation was Grade 1 size and where there were minimal degenerative changes in the facet and the foramen. In herniations of Grades 2 and 3, narrow foramen due to lateral canal stenosis and hypertrophied SAP just medialization of annulotomy was not sufficient to gain medial and dorsal access to the extruded fragment and epidural space. In such situations, foraminotomy - undercutting the ventral aspect of nonarticular part of SAP was performed to gain medial and dorsal access to the extruded fragment and ventral epidural space.

**Technique of foraminotomy**

After subannular discectomy and RF modulation of the annulus, the working sleeve was withdrawn to see more of the SAP about 75% in the endoscopic view. Undercutting of the nonarticular part of the SAP was performed with Trephine (Richard Wolf) and or serial reamers (Maxmore) till ligament flavum curtain was seen. The ligament flavum can be excised with Punch, Kerrison, and Ho-YAG Laser (Accutech). Trephine was used under radiological control. The trephine was advanced with gentle tapping and rotatory movements till the trephine reached the medial pedicular border. Tapping with the mallet offers excellent control for the advancement of the trephine, and rotatory movements help in cutting the bone. Care was taken to watch for any neurological symptoms experienced by the patient and accordingly change in the direction of the working sleeve and trephine made till neurological symptoms disappeared. Beyond the medial pedicular border is the beginning of the spinal canal and hence further trephining was done after confirming the position of the trephine on the lateral fluoroscopic view. If the trephine was shallow and dorsal to the posterior vertebral line on the lateral view, a steeper trajectory was chosen to avoid inadvertent injury to the neurological structures especially the traversing root. Alternatively serial reamers (Maxmore 4–8 mm) can be used to perform the foraminotomy over a guide wire under radiological control. Endoscopic burr was used to fine sculpt the SAP under vision and to control bone bleeding. After getting oriented to the anatomy and securing all bleeders, the working sleeve was advanced till the midline over a conical dilator to gain medial and dorsal access to the extruded herniated fragment and Epidural space. More SAP was cut incrementally to achieve the desired location for easy removal of the herniated fragment. Strict principles with the technique, radiological control with image intensifier in PA and lateral view with the patient awake and aware is necessary for effective and safe foraminotomy [Figures 7-14].

After removal of the herniated fragment, time was taken to confirm decompression by direct and indirect evidences. Inspection of the decompressed traversing root, axilla and exiting root was performed with blunt probe under radiological and visual control and recorded for medicolegal purpose.

**Results**

In all the thirty patients, we were able to achieve adequate decompression. All patients improved in their preoperative neurological status. One patient had persistent extensor hallucis longus weakness - Grade 2. TheVAS in the series dropped from 7.8 preoperatively to 1.4 at 6 weeks and 1.8 at 6 months. Two patients had residual leg pain (VAS 2–3) with no restriction of activities of day-to-day living, which was controlled on medications (Pregabalin 75 mg 01 HS). The ODI dropped from 73.46 to 41.2 at 6 weeks to 32 at 6 months. Twenty-seven (90%) of the patients reported to have excellent to good results. Two (6.6%) patients reported to have fair results as one patient had a recurrent herniation at the same level after 2 months which was treated with transforaminal endoscopic spine surgery. The second patient had a restriction in sitting on the floor and reported fair outcome. One patient had persistent back pain though much less than the preoperative
status and was advised transforaminal lumbar interbody fusion, reported poor outcome. No patients in the study had discitis or diasthesia postoperatively. Three patients in the study underwent medial branch block followed by percutaneous medial branch rhizotomy with elliquence radiofrequency and reported excellent and good outcome after the rhizotomy.

**Examples**

- **Patient 1:** Right central – paracentral superiorly migrated disc herniation at L5–S1 [Figures 15-20]
- **Patient 2:** Central with B/L paracentral inferiorly migrated disc herniation at L4–L5 [Figures 21-26].

**DISCUSSION**

Central disc herniations in lumbar spine pose technical challenge for transforaminal endoscopic decompression due to its location, proximity of retroperitoneal structures in the path of the trajectory and difficulty in accessing the herniation. For a paracentral herniation, the standard posteriolateral trajectory and classical technique\(^2\) offers optimum position
of the working sleeve and endoscope for removal of the herniated fragment-intradiscal and epidural with confirmation of decompression by visualizing free epidural space and neurological structures. For central herniation with the same classical technique, the working sleeve lies too ventral in the disc with respect to the central herniation. The more medially one tries to go, the more ventral one goes. Large interpedicular distance makes the situation more worse especially at L5-S1 (level with the largest interpedicular distance) intradiscal component of the herniation can be decompressed, but herniation at the level of the annulus and epidural component
of the herniation are beyond the reach of the endoscope and instruments. From morphometric studies in lumbar spine, the interpedicular distance or the transverse diameter of the spinal canal at the level of the pedicles is approximately 23 mm at L1 and 30 mm at L5. Larger the interpedicular distance, difficult it will be to access the central herniated fragment. Second, the proximity of the retroperitoneal structures in thin and lean patients makes it difficult to choose shallow trajectory, and hypertrophied superior articular facet in the old makes access to central herniations difficult by blocking the foramen.

To overcome these problems and to gain direct access to the epidural space, Ruetten et al. described a far lateral entry. The entry point chosen is in line with the dorsal aspect of the facet joint. This gives a 10°–15° access to the foramen. The technical difficulty of this trajectory is, it can only be used at L4–L5 and sometimes at L5-S1 where the iliac crest is very
shallow. The trajectory traverses underneath the intertransverse ligament making the working sleeve and endoscope floating in the foramen as it is not anchored in the intertransverse ligament. This makes working in the foramen extremely difficult and tiresome for the less experienced. In the levels above L4–L5, far lateral trajectory cannot be used due to the very close proximity of the retroperitoneal structures especially kidneys and other abdominal organs. At L4–L5, in the thin and lean patients, far lateral entry is dangerous due to the proximity of retroperitoneal structures especially colon on the left side [Figure 27].

The working sleeve of the endoscopic system is anchored at three places the intertransverse ligament, SAP, and the annulus. This makes medialization of the working sleeve to reach the epidural space at the center almost impossible. Cutting medial collar of the annulus or cutting the ventral, nonarticular part of the SAP can allow medialization of the working sleeve to reach the ventral epidural space close to the mid line.

Outside-in technique targets the ventral epidural space by primarily reaming the ventral nonarticular part of SAP for direct targeted fragmentectomy. Reaming the SAP is a nonvisualized procedure performed under radiographic control to gain ventral epidural access. Lumbar foramen is a favorite site of anomalous pathoanatomy (conjoint roots, furcal nerves, and autonomous nerves). Nonvisualized reaming of the SAP in the foramen can cause potential injury to neurological structures especially in anomalous anatomy and jeopardies the safety of the procedure. Direct access to the ventral epidural space makes the endoscopic trajectory shallow and does not allow intradiscal decompression and annular modulation (annuloplasty). In this series, we used the inside-out technique by primarily decompressing the intradiscal component of the herniation and performed annular modulation (annuloplasty) followed by foraminotomy with serial reamers/trephines/burr after thorough endoscopic visualization of the foramen which ensures safety and a step by step methodology.

To overcome the technical issues with central herniations (all Grades 1, 2, and 3),[3] we use following options either alone or in combination. Medialization of annulotomy is usually
sufficient to gain access to Grade 1 central herniations. Foraminotomy with or without medialization of annulus can be used for medial and dorsal access to the extruded herniations (Grades 2 and 3) and the epidural space. Old and chronic herniations can have osteophytic growth from the either end plates and calcification within the herniation, which can be removed with a burr or osteotome under vision to ensure safety to the neurological structures. Larger herniations may sometimes need articulating rongers for complete removal. Confirmation of decompression is an important step after removal. Direct evidences-visual confirmation of decompression of the thecal sac and traversing root, free movement of the blunt probe in the epidural space under radiological control, free flotation of neurological structures and indirect evidences-free epidural oozing, cough impulse, relief of pain confirmation by the patient, free flowing epidural fat with epidural pulsations and Valsalva maneuvers.

In this study, no patient reported postoperative dysesthesia probably due to predominant involvement of the central thecal sac and relative sparing of dorsal root ganglion from chemical and mechanical injury due of the herniation.

**Conclusion**

Transforaminal endoscopic spine surgery with modifications as described above to reach the dorsal aspect of the central herniation in the midline and to access ventral epidural space is safe and effective technical modification of the existing classical technique. Medialization of annulotomy, undercutting the nonarticular part of SAP (foraminotomy) and use of articulating and long jaw instruments makes access to the central herniation and ventral epidural space possible. The use of radiologic control intraoperatively while using the trephine and reamer makes it safe and controlled. Study with larger sample size, longer duration of follow-up, and multicentric study would add more value to this technique.

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**Conflicts of interest**

There are no conflicts of interest.

**References**