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Radiographic and clinical outcomes of huge lumbar disc herniations treated by transforaminal endoscopic discectomy

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ABSTRACT

Objectives: Large Central disc herniations (occupying more than 50% of canal area) are notorious as they are generally associated with worse outcomes and are technically difficult to manage. Transforaminal endoscopy (TELD) has evolved to become an interesting alternative for lumbar disc herniations. The aim of the paper is to review our technique of transforaminal endoscopy in large central disc herniations and describe the clinical and radiographic results. We also describe an innovative technique of intraoperative epidurography to assess the adequacy of decompression in some cases with severe canal compromise.

Patients and methods: We performed a retrospective analysis of all the patients undergoing TELD from December 2012 to October 2018 for huge central lumbar disc herniations. The procedure was done under local anaesthesia and required a more horizontal approach angle, undercutting of superior articular process and posterior annular release to reach the herniated fragment in the epidural space. In severe cases, a radiopaque dye was introduced via transsacral catheter to check the adequacy of decompression. The disc height, lumbar lordosis, segmental lordotic angle on standing radiographs and Canal cross sectional area(CSA) on MRI were evaluated preoperatively and compared with postoperative images at the end of 1 year/final follow-up. The Visual analogue scale(VAS) for Back and Leg pain and Oswestry disability index (ODI), MacNab criteria, return to daily activities, return to work, patient satisfaction rate and recommendation to others were the clinical outcomes evaluated. The percentage of patients achieving the Minimal clinically important difference (MCID) of 3 points for VAS and 12 points for ODI was calculated.

Results: A total of 18 patients, with an average age of 35.1years (range 20–61), were operated. The mean VAS back improved from 5.7(± 1.77) to 1(± 0.77) and VAS leg improved from 7.3(± 1.37) to 1.1(± 1.09). The ODI improved from 49.88(± 11.42) to 13.88(± 7.28) at final follow-up. According to MacNab criteria, 17 patients had excellent and 1 had good outcome at final follow-up. The patient satisfaction rate was 90.5%, with 94% patient recommendation rate. All the patients returned to daily activities and work/modified work within a median of 5 weeks. There was 1 patient who required conversion to open surgery due to incidental dural tear, 1 patient who had a remnant disc required a revision tubular discectomy and 1 patient who had recurrence at 6 weeks and again at 2 years which was treated by repeat TELD. Five patients had impending cauda equina. All the patients achieved the MCID for VAS and ODI within a median period of 6 weeks and 3 months, respectively. The recovery rate was 90.1%. Five patients had grade 4 weakness of great toe/ankle dorsiflexion, one also had ankle flexion weakness preoperatively which improved after surgery. The CSA improved from a preoperative mean of 62.26(± 30.3)mm^2 to 122.16(± 56.5)mm^2 postoperatively. The CSA improved to 141.05(± 63.86)mm^2 at 1 year followup. The average disc height which was 9.71 mm(± 2.4) was maintained at follow-up of one year which was 9.21 mm(± 2.4). The lumbar lordosis and segmental lordotic angle changed from 27.08°(± 15.9) and 2.82°(± 5.7) to 35.8°(± 8.56) and 4.85°(± 4.39) respectively.

Conclusion: TELD may be considered as an alternative to microdiscectomy or fusion procedures for huge central disc herniations with favourable outcomes. However, sufficient expertise with the procedure is necessary.

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Intraoperative decompression may be confirmed with intraoperative epidurography. The patient acceptability of the procedure is good and causes minimal disruption of the normal anatomy.

1. Introduction

Transforaminal endoscopic lumbar discectomy (TELD), which is frequently termed as Percutaneous Endoscopic Discectomy (PELD), is rapidly evolving alternative for lumbar disc herniations [1–3]. The advantages of TELD are remarkable due to minimal bone resection, no damage to paravertebral muscles, rapid recovery, minimally procedure related morbidity, cost-effectiveness and high patient satisfaction rate [4,5]. Described by Kambin et al and Hajikata et al in the early 80 s, the technique of transforaminal discectomy has come a long way through numerous advancements in the field of optics and instrumentation [6,7]. Initial cases of discectomy were limited to soft paracentral disc herniations. However, with time, numerous literatures have been published describing the efficacy of TELD for central disc herniations, highly migrated discs, foraminal and extraforaminal discs etc [8–11]. TELD has been reported to be efficacious in almost every form of disc herniations. Central disc herniations, in particular, have been notorious to be associated with worse outcomes compared to other varieties in various studies [12–15]. This is partly due to the internal disc derangement that already exists on presentation and partly due to the technical difficulty in addressing these conditions. According to our knowledge, there are few published literatures on the feasibility of TELD for “large” or “huge” lumbar central disc herniations which occupy more than fifty percent of the canal cross sectional area.

The principal set back of TELD procedure for central disc herniations is the accessibility to the herniated fragment. Secondly, the adequacy of canal decompression achieved may be difficult to assess intraoperatively. The former issue can be addressed by using articulating instruments and foraminoplasty. The latter can be assessed using the technique of intraoperative epidurogram described in this paper below. Hence, goals of our study were to describe the technique of TELD for huge central lumbar disc herniations and assess the feasibility of the technique and analyze the outcomes in 18 patients presenting with huge central disc herniations.

2. Patients and methods

We obtained permission from the institutional review board of the hospital for this study.

A central disc herniation is defined as one in which the apex of the herniation is located in the center of the spinal canal with deviation of about 10% of the spinal canal diameter. MSU classification of lumbar disc herniations on MRI was described by Mysliwiec et al in 2008 which defined the objective criteria for classifying LDH [16]. They used the intrafacetal line joining the medial ends of both facet joints and classified into 3 grades; grade 1, 2 and 3. In the author’s experience, all LDH that are grade 3 are classified as “huge” and require special attention due to two reasons. First, the access to such herniations via transforaminal approach is difficult requiring specialized instruments and techniques. Secondly, in huge disc herniations, it is difficult to judge the adequacy of canal decompression. Furthermore, some grade 3 LDHs, may present with a cauda equina syndrome complicating the clinical scenario.

We retrospectively analyzed 18 patients operated in our hospital from December 2012 to October 2018 from the hospital records. Inclusion criteria were patients with radicular pain in one or both lower limbs with MRI evidence of large disc herniation and failed conservative treatment. Exclusion criteria were patients with grade 2 or less central disc herniations, those operated with other methods, patients with spondylodiscitis, instability etc.

The procedure is similar to the TELD described earlier in other reports [17,18]. We use a standard transforaminal endoscope (RIWO Spine Wolf), radiofrequency probe, articulating forceps, tip control drill (RIWO Spine) and reamers (Maxmore) as the standard set for discectomy [Fig. 1] [Video I]. The procedure is done under local anaesthesia. There are two ways of addressing the herniation. First is the “Central discectomy first” or “inside-out” method and second is the “foraminoplasty first” or “outside-in” method. In central discectomy first method, the patient is positioned prone on a radiolucent table with proper padding. The level is confirmed under C-arm. We mark the following details on the skin: the midline and the disc space on anteroposterior view and the posterior facet line on lateral view. A line is drawn transversely from the center of the disc space to the posterior facet line. Another line is draw making an angle of approximately 10-15° with the previous line starting from the disc space. The second line defines the entry point of the needle; a slight oblique trajectory provides an easier access to the foramen and requires less bony resection [Fig. 2]. After infiltration of local anaesthetic, an 18 G long needle is introduced and guided under C-arm to reach the target disc space. When the location of the needle is at medial pedicular wall in AP view, it should be at the posterior vertebral body margin of caudal vertebrae in lateral view. After confirming this, the needle is advanced to the center of the disc in AP view underneath the disc herniation. In lateral view, the needle should be in the dorsal one-fourth of the disc space. A discography is done and the needle is replaced with guide wire, then obturator and finally the working sleeve positioned followed by the endoscope. Under endoscopic visualization, the portion of the disc

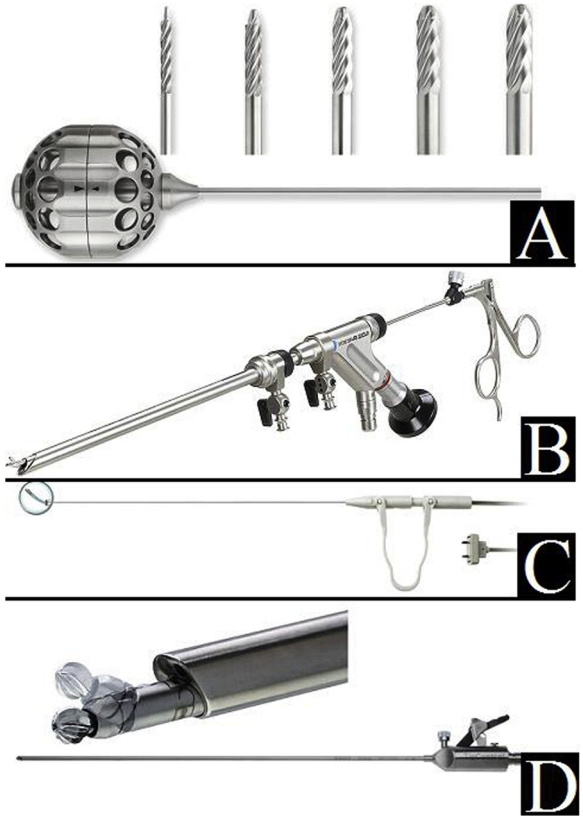

Fig. 1. Endoscopy instruments. A) Foraminoplasty reamers B) Endoscope with working sleeve and Endoscopic Rongeur C) Radiofrequency probe and D) Tip control burr.

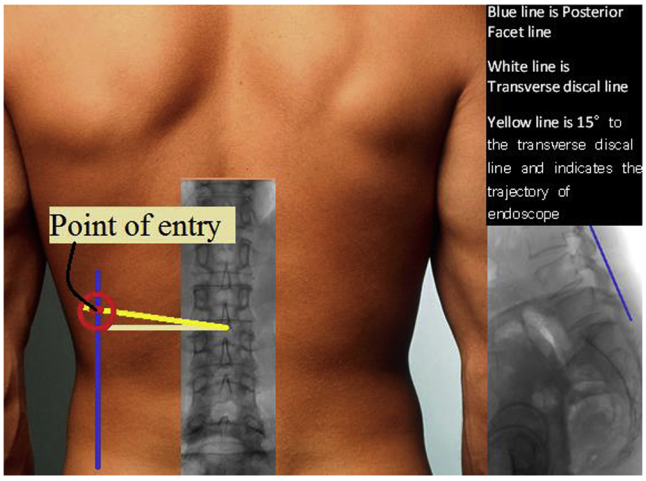

Fig. 2. Entry point marking for transforaminal endoscopy.

under the herniation is removed to create a working cavity. The working cavity serves as a room to pull down the uncontained fragment from the spinal canal and prevents the rise in the intracanal pressure in the already narrowed canal during manipulation of the herniated fragment. The breach in the annulus can be visualized at 12o-clock position on the screen. After this is done, the endoscope and the working cannula are withdrawn to visualize the superior articular process (SAP). The positioning is such that almost three fourths of the field is occupied by the SAP. Then with an endoscopic tip-control drill, the ventral portion of the SAP is resected under endoscopic visualization and C-arm control. The SAP is drilled till the lateral portion of the ligamentum flavum is visualized. Drilling of the SAP provides a more horizontal entry into the spinal canal which enables access to the herniated fragment. The lateral portion of the flavum is cut with punches or scissors and the annulus is exposed. At this point, half of the endoscopic view in the disc and half is in the spinal canal; thus called "half and half" position. Now, using RF probe and endoscopic scissors, the annulus is cut from the lateral to medial side, taking care to control the bleeding from the epidural venous plexus. This is reffered to as "annular release". The working cannula and endoscope may be advance further after the annulotomy. In foraminoplasty first method, the approach angle is more horizontal and the working channel is docked under the ventral surface of SAP. The SAP is drilled first, followed by other steps similar to described above. The choice of central discectomy first or foraminoplasty first depends upon the size of the neuroforamen. If the foramen is large enough, the working cannula can be pushed directly upto the central portion of the disc to perform central decompression. In case of narrow foramen, the foraminoplasty is required to negotiate the working cannula. Of the 18 patients, 10 (55%) had foraminoplasty first technique.

Using a combination of disc forceps and nerve hook, the herniated fragments are removed until the ventral dura and the traversing nerve root is visible. Often, in grade 3 cases, it is difficult to assess the adequacy of decompression and hence we propose the technique of intraoperative epidurography. Before the procedure is started, we suggest the placement of a transacral epidural catheter. The catheter is inserted under local anaesthesia from the sacral hiatus into the spinal canal. A radiopaque dye Iobrix® is flushed through the catheter to obtain an epidurogram. In some cases, we also use the O-arm to obtain a 3D image of the epidurogram. Comparison between pre-discectomy and post-discectomy epidurogram enables the surgeon to judge the adequacy of discectomy and canal clearance achieved. A free flow of the dye above the affected disc space and into the involved nerve root suggests adequate decompression. The free passage of catheter across the disc space may also be visualized with the endoscope.

Visual analogue scale for back and leg, Oswestry Disability Index were recorded preoperatively and postoperatively at regular follow-ups at 1 week, 6 weeks, 3 months, 6 months and 1 year. MacNab criteria were used to assess the outcome at final follow-up. The percentage of patient achieving the Minimal clinically important difference (MCID) of 3 points for VAS and 12 points for ODI was calculated. In addition to this, a detailed neurological examination of the patient in terms of power and sensation of the lower extremities were recorded and changes noted in the post-operative period were documented. The patient's return to work/daily activities, satisfaction rate and recommendation for surgery were also noted at final follow-up. All the patients were evaluated preoperatively by X-rays, CT scan and MRI. Postoperatively, the canal decompression and discectomy were confirmed by an MRI done within 2–3 weeks of surgery. The postoperative MRI was analyzed to find out the improvement in the canal cross-sectional area at the herniated level within 4 weeks of surgery and again at 1 year/final follow-up.

The quantitative variables were compared using *t*-test and the qualitative variables were compared using chi-square test. A p-value of $< .05$ was considered significant.

3. Results

3.1. Demographic data

Eighteen patients were included in the study, with 11 males and 7 females and an average age of 35.1 [range 20–61] years. The demographic data is described in Table 1. All the patients had a grade 3 disc herniation, five had impending CES. The average follow-up duration was 33.11(± 21.59) months.

3.2. Clinical data

The mean VAS back improved from 5.7(± 1.77) to 1(± 0.77) and VAS leg improved from 7.3(± 1.37) to 1.1(± 1.09). The ODI improved from 49.88(± 11.42) to 13.88(± 7.28) at final follow-up. According to MacNab criteria, 17 patients had excellent and 1 had good outcome at final follow-up. The patient satisfaction rate was 90.5%, with 94% patient recommendation rate. All the patients returned to daily activities and work/modified work within a median of 5 weeks. There were 3 complications, one incidental dural tear, one residual disc and one recurrent disc. The dural tear patient required conversion to tubular surgery for repair. One patient who had a residual disc required a revision tubular discectomy at 2 weeks when conservative treatment and blocks failed to provide relief. One patient had recurrence at 6 weeks and again at 2 years which was treated by repeat TELD.

Five patients had impending cauda equina syndrome in which decompression was confirmed via intraoperative epidurography. All the patients reached the MCID of 3 points for VAS Back and Leg and 12 points for ODI at 6 weeks and 3 months follow-up respectively. Five patients had grade 4 weakness of great toe/ankle dorsiflexion, one also

Table 1
Demographic data of patient population.

Parameter	Variable
Age	35.1(± 12.63) years
Sex ratio (M:F)	11:7
Cauda Equina syndrome	2
Levels involved	
L5S1	1
L4L5	17
Blood Loss	20.27(16.8)ml
Operative time	100.65(43.2) minutes
Complications	
Dural tear	1
Residual Disc	1
Recurrent disc	1

had ankle flexion weakness preoperatively which improved after surgery.

3.3. Radiographic data

Postoperative MRI revealed successful discectomy in all patients with the canal cross sectional area improving from a preoperative mean of 62.26(± 30.3) mm^2 to 122.16(± 56.5)mm^2 postoperatively. The CSA improved to 141.05(± 63.86)mm^2 at 1 year follow-up. The average disc height which was 9.71 mm (± 2.4) was maintained at follow-up of one year which was 9.21 mm (± 2.4). The lumbar lordosis and segmental lordotic angle changed from 27.08° (± 15.9) and 2.82° (± 5.7) to 35.8° (± 8.56) and 4.85° (± 4.39) respectively. The clinical and radiographic data is summarized in Table 2. A case example is described in Fig. 3.

4. Discussion

A central disc herniation is defined as one in which the apex of the herniation is located in the center of the spinal canal with deviation on either sides of about 10% of the spinal canal diameter [19]. According to Bärlochar et al, a huge central disc herniation is defined as the one in which there is more than 50% canal compromise on midsagittal MRI. However, we used the MSU classification, and considered grade 3 herniations as huge central disc herniations. The management of huge lumbar disc herniations has been associated with worse outcomes at long term follow-up. The internal disc derangement caused by the massive loss of nucleosus pulposus accompanied by a big annular tear play a significant role in chronic back pain [20].

Open Microdiscectomy and microendoscopic procedures using tubular retractor and microscope/endoscope are considered to be gold standard procedures for this condition [21]. However, these traditional surgeries are also associated deteriorating results at long term followup [22]. There are two issues with traditional approaches. First is the iatrogenic damage to the posterior back musculature and the posterior elements of the spine. Since huge lumbar disc herniations occupy a greater spinal canal diameter, the extent of laminotomy is more lateral in order to reach the lateral border of the thecal sac. Hence there is a possibility of excess facet resection. In some cases, even a bilateral approach may be required for complete disc removal [23]. Secondly, access to the central disc requires excessive thecal sac retraction. Considering that canal diameter is already compromised in this condition, excess retraction may cause iatrogenic nerve root injury [24,25]. In contrast, none of the patients in our series suffered a new onset neurological deficit. This may be because the decompression is performed without entering into the spinal canal and without retracting the thecal sac. Also, none of the patients had exiting nerve root injury, which is a concern with transforaminal procedures. Thus, the combination of the intrinsic characteristic of the pathology itself combined with iatrogenic tissue damage caused by traditional surgical approaches play a role in producing unfavorable. Minimally invasive transforaminal Lumbar interbody fusion may also be considered for these conditions. However, compared with discectomy alone, the procedure is associated with greater tissue damage, blood loss, postoperative back pain, costs, implant related complications, adjacent segment disease and probably greater post-operative morbidity [26,27].

The ideal management of such condition is one in which a complete removal of the pathologic fragment is possible with minimal damage to the normal disc and the normal anatomic structures. Transforaminal endoscopy has gained tremendous popularity because of the advantages in terms of minimal morbidity to the patient, high patient acceptance rate, feasibility under local anaesthesia, no damage to the posterior elements of the spine and minimal scarring. However, the technique of TELD for huge lumbar disc herniation differs from that for paramedian discs. In principle, the success of TELD depends upon proper localization of the endoscope near the herniation based on preoperative MRI. As described above, after an initial “inside-out” approach for creating a working cavity, withdrawal of the cannula up to the facet joint followed by foraminoplasty, and a more horizontal approach through the annulus to reach the herniated fragment is necessary.

Our technique of intraoperative epidurogram is useful in cases of severe canal compromise to check the adequacy of decompression. Through a transacral catheter with the tip located caudal to the affected level, a radiopaque dye is injected before and after the discectomy procedure. With preoperative and postoperative fluoroscopy images, the extent of decompression can be checked. In our cases with impending CES where the preoperative epidurogram image showed block of dye at the herniated level, post-discectomy image revealed resolution of the block and free flow of dye. The passage of the catheter from caudal to cranial direction after discectomy can be visualized under the endoscope. We also, did an O-arm scan in these cases to obtain a 3D epidurogram which provides better information that 2D epidurogram.

In our study, the VAS for back and leg as well as the ODI improved significantly. All the patients achieved the MCID of 3 points for VAS Back and Leg and 12 points for ODI at 6 weeks and 3 months follow-up respectively. All the patients had favorable outcome according to MacNab criteria (excellent and good). The patient satisfaction rate with the procedure was high (90.5%), with 94% patient recommendation rate. All the patients returned to daily activities and work/modified work within a median of 5 weeks. There was only one case of residual disc which required revision microtubular discectomy. Only one patient of revision discectomy required conversion to open procedure which was due to incidental dural tear. Dorsal approach in this patient revealed adhesions due to previous procedure. There was one case of recurrence at 6 weeks and again at two year which was treated by TELD in both scenarios. The higher BMI of the patient may have been a contributing factor for recurrence. The disc height was relatively well maintained at final follow-up in all patients. The lumbar lordosis and segmental lumbar lordosis was also improved after surgery and maintained at final follow-up. None of the patients had subsequent instability in form of collapsed disc height or listhesis. Our study had better outcomes compared to previous studies, with fewer complications. This may be due to multiple reasons including a relatively smaller sample size, development of newer instruments such as articulating forceps and drills, use of intra-operative epidurogram for confirming adequate decompression etc. Also, the technique of foraminoplasty first increases the available working space and provides better accessibility to the herniation. No patient complained of chronic back pain at follow-up. This may be due to multiple reasons, including selective

Table 2
Clinical and Radiographic Outcomes.

Variable	Preoperative	Final follow-up	Percentage improvement	p-value
Clinical				
VAS Back	5.7(± 1.77)	1(± 0.77)		p < .001
VAS Leg	7.3(± 1.37)	1.16(± 1.09)		p < .001
ODI	49.88(± 11.42)	13.3(± 7.28)		p < .001
Mac Nab				
Excellent	17			
Good	1			
Fair	0			
Poor	0			
Radiographic				
Disc height (mm)	9.7(± 2.4)	9.2(± 2.4)	5.15%	p > .05
Segmental lordotic angle	2.8(± 5.72)	4.85(± 4.39)	73.2%	p < .05
Lumbar lordosis	27(± 15.9)	35.8(± 8.56)	32.6%	p < .05
Canal cross sectional area	62.6(± 30.3)	141(± 63.8)	125%	p < .05

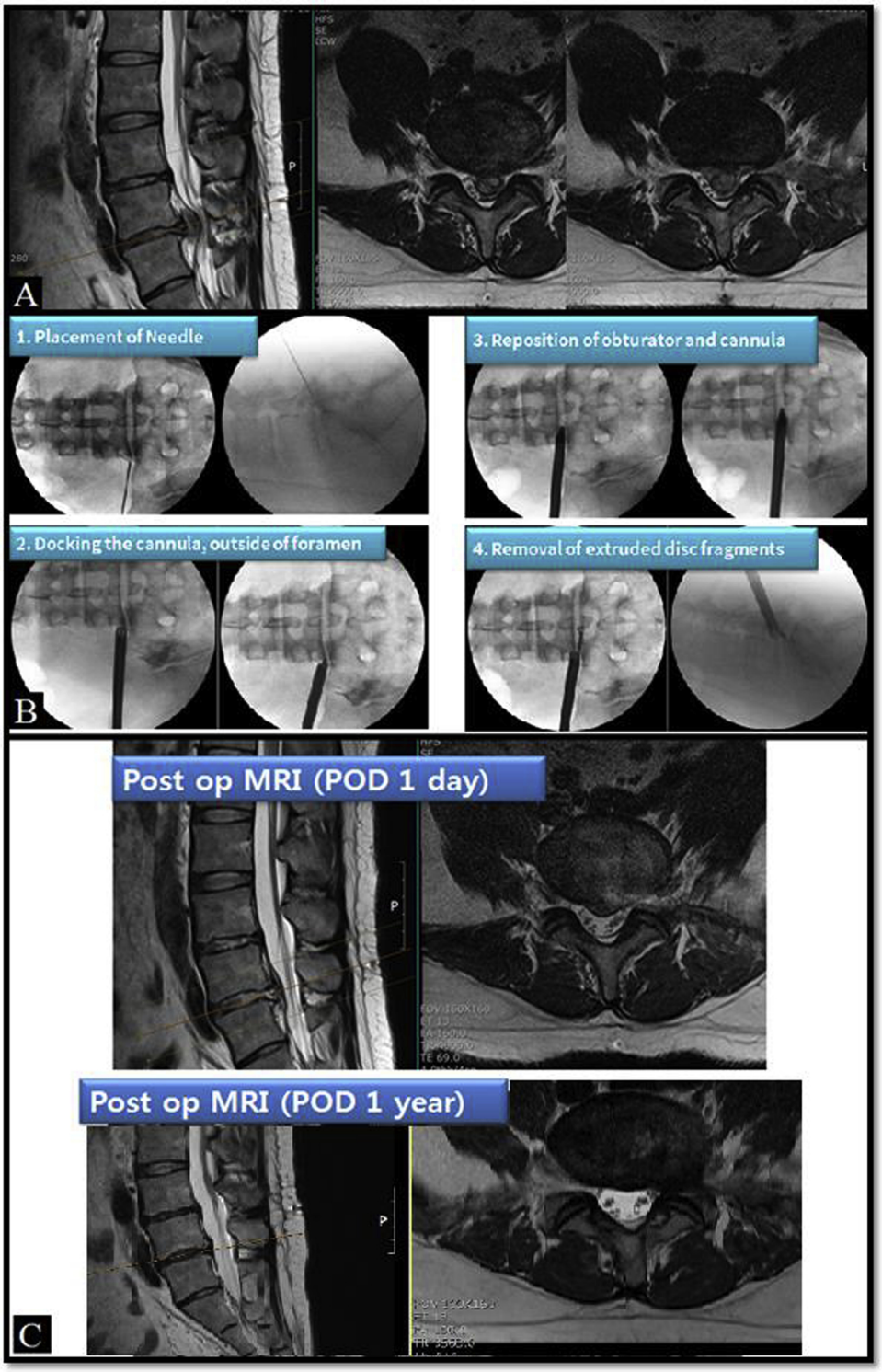

Fig. 3. Case example. M/37, pain in both legs, left > right. A) Preoperative MRI showing huge central disc herniation at L4L5 B) Intraoperative images C) Postoperative MRI at day 1 and at 1 year follow-up.

fragmentectomy which preserves the rest of the nucleus, annuloplasty procedure done after the fragmentectomy and minimal damage to the posterior structures.

Choi KC et al have described the advantages of TELD over open microdiscectomy [23]. They have shown that TELD is associated with less back pain at follow-up compared to microdiscectomy. However, it should be noted that the technique is technically difficult for huge central disc herniations and is suitable in expert hands. Choi et al described their results of unsuccessful transforaminal endoscopic discectomy for lumbar disc herniations and proposed that central disc herniations are associated with worst outcomes and highest reoperations. Incomplete removal was commonest with central disc herniations, the percentage of patients requiring reoperation being 30.2% [13]. Lee SH et al. in his study also described central non-migrated disc herniations to be associated with maximum failure, the percentage of reoperations being 15% for central variety [12]. However, in our study

and in Choi KC's study, the incidence of residual disc was less. Still, caution needs to be advised while performing TELD for such cases. Our technique of intraoperative epidurogram may play a role in assessing the decompression intraoperatively.

This study has its limitations. Firstly, it was a retrospective analysis with no control group. The sample size is relatively small, although it is similar to other studies in literature. The follow-up period is too short to comment on the subsequent degeneration of the disc and its outcomes.

5. Conclusion

TELD can be considered as a feasible option for huge central disc herniations in expert hands. The technique of intraoperative radiography can be utilized in severe cases to confirm decompression. In short term follow-up, TELD may be beneficial in improving not only leg pain, but also back pain. The disc height is usually well maintained at follow-up. The patient acceptability of the procedure is good and causes minimal disruption of the normal anatomy.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.clineuro.2019.105485.

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