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Review and Technical Note

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Contralateral Keyhole Biportal Endoscopic Surgery for Ruptured Lumbar Herniated Disc: A Technical Feasibility and Early Clinical Outcomes

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Objective: Spinal endoscopic surgery is increasingly adapted as a minimal invasive technique, however, significant facet joint violation may be developed after ipsilateral laminectomy. The aim of this study is to introduce surgical technique of contralateral keyhole biportal endoscopic surgery (CKES) for ruptured lumbar disc and report it is early surgical outcomes with facet joint violation.
Methods: Between January to December 2019, 27 patients with ruptured lumbar disc were underwent CKES. Simple radiographs were obtained to investigate development of iatrogenic instability or spondylolisthesis. Magnetic resonance imaging scan was checked about 8 hours after surgery to evaluate successful removal of ruptured disc and existence of facet joint violation. Clinical outcomes were assessed by modified MacNab criteria, visual analogue scale (VAS) scores of back and radicular pain.
Results: The mean age of the patients was 62.8 ± 12.48 years. The average operative time and mean follow-up period were 57.1 ± 21.36 minutes and 8.1 ± 3.78 months, respectively. Compared to preoperative scores, the VAS scores of back and radicular pain were significantly improved. Modified MacNab outcome grade was *good* to *excellent* in 96.3% (26 out of 27 patients) of patients. The reduction rate of facet joint plane was about 4.9% after contralateral approach.
Conclusion: CKES may be considered as an excellent surgical option to treat ruptured lumbar disc without the development of iatrogenic instability. Low rate of facet joint reduction, good visualization of lateral recess, and identification of accurate midline of central spinal canal are advantages of the procedure.

Keywords: Biportal endoscopy, Ruptured disc, Lumbar, Migrated, Contralateral approach, Keyhole

INTRODUCTION

Lumbar herniated disc is one of the most common causes of low back and radiating leg pain. Approximately 70%–85% of people suffer with low back pain due to herniated lumbar disc.[1] Microdiscectomy is considered as a gold standard surgical procedure for lumbar herniated disc which does not respond to conservative treatments such as medications, physiotherapies, selective epidural root blocks, and bed rest. But microdiscectomy has some disadvantages such as paraspinal muscle injury, leading to persistent postoperative back pain and iatrogenic instability or spondylolisthesis due to extensive removal of lamina and facet joint, which may be needed a fusion surgery.[2-4]

Recently, there has been a rapid development in minimally

invasive endoscopic surgery with better visualized endoscopes and specialized instruments including reamer kits, high-speed endoscopic drills, well designed probes, and forceps.[5,6] Firstly, full endoscopic spine surgery has been performed for herniated lumbar disc or stenosis, but there still remains some difficulty for learning curve.[7] Biportal endoscopic spine surgery has been the hot issue with relatively short learning curve and favorable surgical outcomes for degenerative lumbar disease from several years ago. Many studies have reported that comparative clinical results of the biportal endoscopic technique are equal to those of the microsurgical technique.[2,8,9]

Although endoscopic spine surgery has been developed with minimal paraspinal tissue damage, and reducing the possibility of iatrogenic instability after lumbar laminectomy and facetectomy, it still remains as a possible complication. Already, contralateral approach had been introduced with reducing bone work and preservation of facet joint during spinal canal decompression in microsurgery.[10] The purpose of this study is to introduce the operative technique of contralateral keyhole biportal endoscopic surgery (CKES) for the treatment of lumbar herniated disc and report preliminary results of this technique.

MATERIALS AND METHODS

From January to December 2019, the single surgeon performed 315 surgical procedures of lumbar herniated disc. Among the total 315 patients, only 37 patients were performed with CKES for ruptured lumbar disc. Nine of 37 patients with contralateral interlaminar approach had failed to minimum follow-up, and 1 patient had mainly stenotic symptoms without symptoms of acute lumbar herniated disc. Therefore, a total 27 patients treated via CKES for ruptured lumbar disc were finally included in this study. All enrolled patients have suffered from sudden onset back and radiating leg pain without neurogenic claudication and preoperatively failed the improvement of symptoms through conservative treatments including medications, physiotherapies, selective epidural root blocks, and bed rest. The inclusion criteria were unilateral radicular pain with backache, corresponding lesion on magnetic resonance imaging (MRI) images such as ipsilateral migrated disc herniations, and postoperative follow-up of more than 3 months. The exclusion criteria were central and extraforaminal ruptured disc, multilevel lumbar herniated disc, history of previous spine surgery at same level, more than grade 2 degenerative spondylolisthesis, lytic spondylolisthesis, and index level spinal instability. Demographic characteristics, operative time, and mean follow-up period were investigated. The highly migrated disc was defined by migration disc with the extension which is larger than the measured height of the posterior marginal disc space.[11]

1. Indications and Relatively Contraindications

The suitable indications of CKES are listed below: (1) Down-migrated ruptured disc on paracentral and foraminal area; (2) no or temporary response after conservative management including medication and spinal injections; (3) advantage for upper lumbar level, which has more vulnerable facet joint from ipsilateral laminectomy and has narrow and more acute angle of lamina.

The followings are contraindications of CKES: (1) central ruptured disc, which is difficult to remove central disc without excessive retraction of thecal sac and nerve root; (2) extraforaminal ruptured disc, which is also difficult to successful removal of ruptured fragments due to inability of the instruments to reach the extraforaminal area; (3) segmental instability, presence of spondylolysis at treated level, or more than grade 2 spondylolisthesis (Table 1).

2. Surgical Procedures

1) Anesthesia and patient position

This technique was performed mainly under general anesthesia (21 in 27 patients) or epidural anesthesia (6 in 27 patients) in prone position with flexion to reduce abdominal pressure. The discography was performed before starting the operation in all patients using a contrast mixture with indigo carmine for identifying the ruptured site. After discography, a waterproof surgical drape was applied for endoscopic surgery.

2) Skin Incision and Making Keyhole

Surgeon should stand on the opposite side of lesion. Contralateral side means the opposite side of ruptured disc. If patient has a left sided disc, procedure should be performed from right (contralateral) to left (ipsilateral) side via sublaminar space after

Table 1. Indication and contraindication

Indications
Paracentral to foraminal disc
Down migrated disc > up migrated disc
Higher level > lower level
Absolute contraindications
Central disc
Extra-foraminal disc

making keyhole. If patient has a right sided disc, procedure was started from left (contralateral) to right (ipsilateral) side and operating surgeon stand on contralateral side of lesion.

Preoperative planning on plain films and MRI should be done to determine skin entry point and portal trajectory which is dependent on the location and extension of ruptured disc. If operating surgeon stands on the left side of patient, distal point of skin incision for working port should be made around the upper third of pedicle of distal vertebra on C-arm lateral view. This makes removal of upper margin of lower lamina and dissect ligamentum flavum much easier with use of instrument such as Kerrison punch and up-curved curettes. Proximal point for endoscopic view port is made on 1.5 to 2 cm superiorly from working port (Fig. 1).

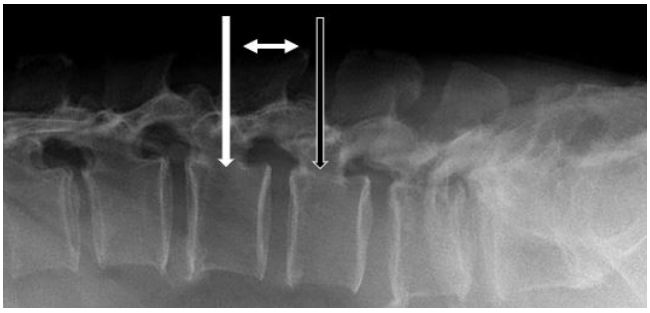

Fig. 1. Preoperative measurement of skin entry point. If surgeon stand on left side of patient, distal point of skin incision for working port (black arrow) is made on upper third area of lower pedicle on C-arm lateral view. Proximal skin incision for endoscopic view port (white arrow) is made on 1.5–2 cm superiorly.

Two spinal needles were advanced with a guiding C-arm fluoroscopy and then landed and joined at the target point. Both incisions were made transversely. Soft tissues overlying the lamina of the cranial and caudal vertebra and the ligamentum flavum are ablated to expose bone edge to make working space. The operated level is double-confirmed under C-arm fluoroscopy. A contralateral spinolaminar junction is drilled out on the upper and lower border of the lamina for undercutting the base of spinous process by using a 4-mm drill burr. This step of procedure is called the making keyhole. The important tip of this procedure is not to drill out on the contralateral side of the lamina to preserve facet joint and joint capsule. Try to make the keyhole wide enough in base of spinous process enough for easier handling of endoscopic instruments.

3) Contralateral sublaminoplasty

The fat tissue can be identified initially during making a keyhole, that point is center of spinal canal, which is located in the central fissure of ligamentum flavum (Fig. 2A). After identifying the central fissure of ligament flavum, the sublaminoplasty is performed by using 4-mm drill burr toward the opposite side (the side of the lesion), which means that working space for procedure are made beneath the lamina with drilling of inner cortex and partially cancellous bone. This procedure is very important, because it allowed to more freely use the spinal endoscope and instruments without neural structure damages. The proximal origin of ligamentum flavum is Y-shaped, and inserts cranio-laterally up to neuroforamen containing exiting nerve root, sublaminoplasty should be extended more cranially

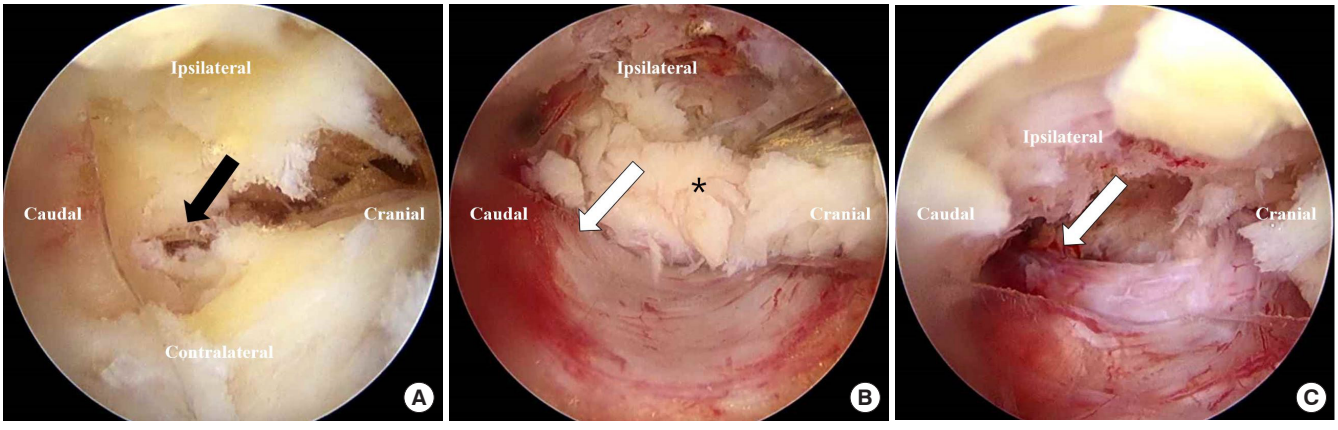

Fig. 2. Intraoperative endoscopic images of right approach. (A) Intraoperative endoscopic images of right approach. After making keyhole, central fissure (black arrow) of ligamentum flavum was identified at first. (B) Removal of ruptured disc material (black asterisk) can be performed safely using specialized hand-made retractor with pituitary forceps during retraction of traversing nerve root (white arrow). (C) The procedure is done when the full decompression of the dura and nerve roots (white arrow) are confirmed.

on the lateral border, when till the flavum edge is freed. The cutting side of the burr should be faced away from dura and nerve root to prevent unintended injury of dura and nerve root. Sublaminoplasty should be extended caudally to the superior articular process with optimal decompression of lateral recess. Optimal decompression of lateral recess is important in achieving good outcomes and reduced risk of operative failure.[12]

4) Flavectomy and sequestrectomy

The edge of ligamentum flavum was dissected off from bone margin with blunt dissectors and up-curved curettes. Flavectomy starts from midline towards ipsilateral side of ruptured disc. During the excision of ligamentum flavum, the plain between flavum and dura should be defined carefully. Additional drilling and punching can be needed for sublaminoplasty. Direct decompression could prevent inadvertent nerve root injury after traversing nerve roots is identified. Ruptured disc should be removed carefully without excessive nerve root retraction by observing the midline of ligamentum flavum and thecal sac. Removal of ruptured disc material can be performed safely using specialized hand-made retractor with pituitary forceps (Fig. 2B). The procedure was performed till the full decompression was achieved with 2-mm free margin from lateral border of dura. After decompression, freed traversing or exiting nerve roots, and unroofing of lateral recess were confirmed (Fig. 2C). Active bleeding points were controlled by the saline irrigation, and radiofrequency (RF) coagulation.

5) Wound closure

A drainage catheter was inserted through the working port for prevention of postoperative hematoma. After the subcutaneous layers were approximated with absorbable suture material, the skin was sutured with nonabsorbable material. Then the drainage catheter was secured in its place with a suture.

3. Clinical and Radiological Assessments

1) Clinical outcomes

Clinical outcomes were assessed by VAS score for back and radicular pain, and modified MacNab criteria. VAS scores were checked at preoperatively, time of discharge, 1, 3 months after surgery and final follow-up. We defined that *excellent* and *good* grades on modified MacNab criteria was favorable outcomes and the *fair* and *poor* grades was unfavorable outcomes.

2) Radiological assessment

Simple plain lumbar radiographs including flexion and extension view were obtained before and immediately after surgery, and at the final follow-up. The development of segmental instability or progression of iatrogenic spondylolisthesis were observed during follow-up period. Postoperative MRI was performed about 8 hours after the surgery to check the presence of any postoperative complications such as insufficient neural decompression, residual disc materials, facet joint violation, and postoperative hematoma. We measured the length of facet joint plane and calculated the ratio of ipsilateral/contralateral the

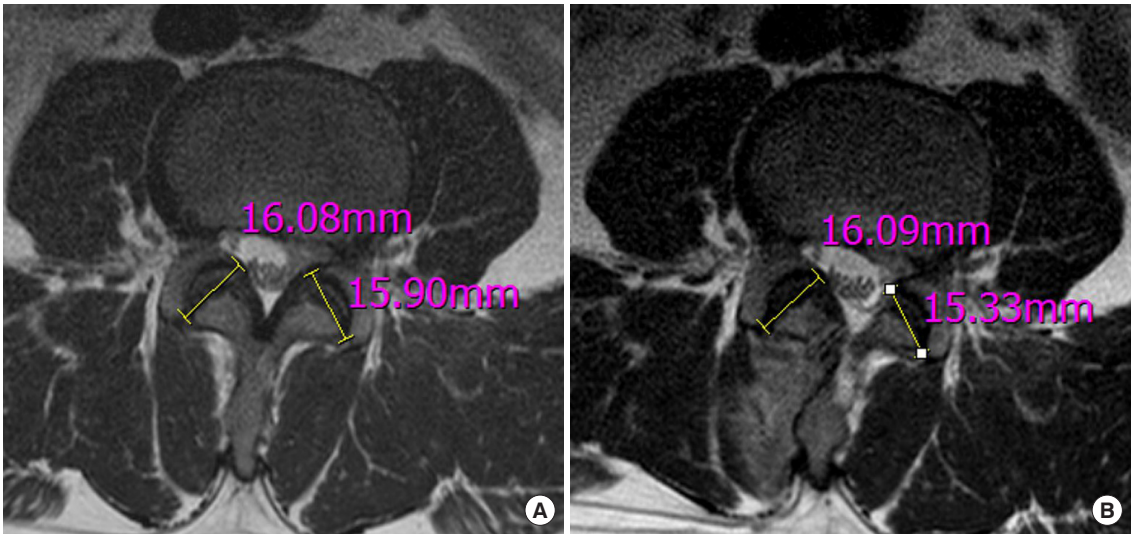

Fig. 3. Measuring the length of facet joint plane and calculated the ratio of ipsilateral/contralateral the length of facet joint plane in preoperative (A) and postoperative axial T2 magnetic resonance imaging images (B). Preoperative ratio is 0.99 (=16.08 [contralateral]:15.90 [ipsilateral]). Postoperative ratio is 0.95 (=16.09:15.33). Reduction rate is 4.04% ([0.99-0.95/0.99]×100).

length of facet joint plane in preoperative and postoperative axial T2 MRI images (Fig. 3A, B). The percent of difference between preoperative ratio and postoperative ratio of facet joint plane was investigated as the reduction rate of the facet joint.

4. Statistical Analyses

The Kolmogorov-Smirnov test was used to confirm the normality of all variables. The differences of preoperative and postoperative VAS were analyzed with paired t-test and Wilcoxon signed-rank test. All analyses were done using IBM SPSS Statistics ver. 25.0 (IBM Co., Armonk, NY, USA). p-values less than 0.05 were considered statistically significant.

RESULTS

From January to December 2019, 27 patients were included in our study, which was performed with CKES with minimum 3 months of follow-up period. The mean age of the patients was 62.80 ± 12.48 years (36–87 years) and the mean duration of conservative treatment was 11.60 ± 11.35 weeks (1–52 weeks). Fifteen patients were male, and 20 were female. All patients suffered from intolerable back or leg radicular pain preoperatively, and 1 of 27 patients complained foot drop. The L4–5 was involved the most (19 cases, 70.3%), followed by L3–4 (5 cases, 18.6%), L5–S1 (2 cases, 7.4%), and L2–3 (1 case, 3.7%). The down migrated disc were 7 cases, highly down migrated disc were 4 cases and up migrated disc were 3 cases. The average operative time and mean follow-up period were 57.10 ± 21.36 minutes (25–105 minutes) and 8.10 ± 3.78 months (3–14 months), respectively (Table 2).

Table 2. Patient demographics (n = 27)

Characteristic	Value
Sex, male:female	15:12
Age (yr)	62.8 ± 12.48 (36–87)
Level	
L2–3	1
L3–4	5
L4–5	19
L5–S1	2
Side	
Right	20
Left	7
Disc	
Highly upmigrated	1
Upmigrated	3
Intervertebral	12
Down migrated	7
Highly downmigrated	4
Anesthesia	
General	21
Epidural	6
Duration of conservative treatment (wk)	11.60 ± 11.35 (1–52)
Operative time (min)	57.10 ± 21.36 (25–105)
Final follow-up period (mo)	8.10 ± 3.78 (3–14)

Values are presented as number or mean ± standard deviation (range).

1. Radiological Outcomes

The ruptured disc materials were successfully removed and confirmed by MRI about 8 hours postoperatively (Fig. 4). There were no observed the significant occurrence of facet joint violation and postoperative epidural hematoma on MRI scan. The preoperative mean ratio of ipsilateral/contralateral facet joint plane was 1.03 ± 0.27 (1.15–0.92), and the postoperative mean ratio was 0.98 ± 0.22 (1.14–0.90). There was no statistical significance between preoperative ratio of facet join plane and postoperative value ($p > 0.05$). The reduction rate of facet joint plane was about 4.9%. During follow-up period, there was no newly developing segmental instability or spondylolisthesis on plain flexion/extension films.

2. Clinical Outcomes

Compared to preoperative values, VAS scores for back and

Table 3. Descriptive statistics of preoperative and postoperative VAS score

VAS	Back	p-value	Leg	p-value
Preoperative	4.5 ± 1.70 (2–7)	-	6.9 ± 0.46 (6–8)	-
Discharge	1.9 ± 0.51 (1–3)	-	1.7 ± 0.45 (1–2)	-
1 Month	1.6 ± 2.44 (0–10)	-	1.5 ± 2.29 (0–10)	-
3 Months	0.8 ± 1.12 (0–4)	-	1.0 ± 1.51 (0–5)	-
Final follow-up	0.5 ± 0.64 (0–2)	0.001	0.9 ± 1.23 (0–5)	0.001*

Values are presented as mean ± standard deviation (range).
VAS, visual analogue scale.
*Wilcoxon signed rank test.

Table 4. Modified MacNab score of enrolled patients

Follow-up	Excellent	Good	Fair	Poor
1 Month	10	14	1	2
3 Months	13	13	0	1
Final follow-up	19	7	0	1

Fig. 4. Preoperative and postoperative magnetic resonance (MR) and computed tomography (CT) images. L3/4 down migrated disc (white arrow) shown in preoperative T2-weighted sagittal magnetic resonance imaging in sagittal (A) and axial views (B). Complete removal of ruptured disc without remnant disc material (white arrow) in postoperative MR images in sagittal (C) and axial views (D). (E) Keyhole (black arrow) in contralateral spinolaminar junction without violation of lamina and facet joint (white arrowheads) shown in postoperative CT image.

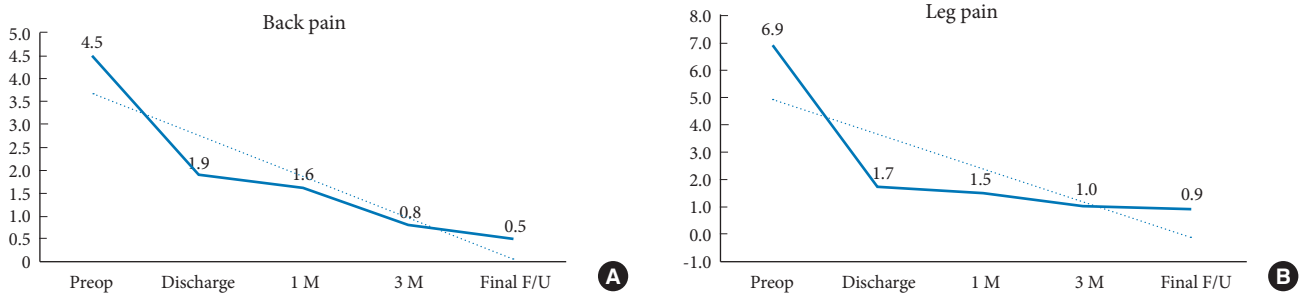

Fig. 5. Visual analogue scale (VAS) score of back and leg pain. The VAS score of back pain (A) and leg pain (B) reduced at discharge day, 1/3 months later after operation and final follow-up (F/U) respectively. The differences in the preoperative scores and final follow-up scores were statistically significant ($p < 0.001$).

leg were significantly reduced at each time-point of follow-up. VAS score for back reduced from 4.5 ± 1.70 (2–7) preoperatively to 1.9 ± 0.51 (1–3), 1.6 ± 2.44 (0–10), 0.8 ± 1.12 (0–4), and 0.5 ± 0.64 (0–2) at discharge day, 1, 3 months later after operation, and final follow-up respectively (Fig. 5A). Similarly, VAS score for leg pain reduced from 6.9 ± 0.46 (6–8) preoperatively to 1.7 ± 0.45 (1–2), 1.5 ± 2.29 (0–10), 1.0 ± 1.51 (0–5), and 0.9 ± 1.23 (0–5) at discharge day, 1, 3 months later after operation, and final follow-up respectively (Fig. 5B). The differences in the preoperative scores and final follow-up scores were statistically significant ($p < 0.001$) (Table 3). On the final follow-up, there were 19 patients with *excellent* grade and 7 patients with *good* grade. Twenty-six of 27 patients were with favorable outcomes by modified MacNab criteria. One of 27 patients suffered residual leg pain at final follow-up, which was evaluated as *poor* grade, leading to an unfavorable outcome (Table 4). There was no dura tear or direct root injury intraoperatively, thus no need for additional unintended revision surgery.

3. Case Presentation

A 51-year-old male presented sudden intolerable left radicular pain with backache. Back and radicular pain in VAS score were 7 and 8, respectively. The straight leg raising test on the left side was positive at 30° and free on right side. On MRI at our hospital, left highly down migrated ruptured disc was confirmed. The plain film did not show segmental instability in flexion and extension and spondylolysis. Conservative treatment was performed including medications, selective root blocks, and physiotherapy for 12 weeks. The patient underwent contralateral keyhole ipsilateral biportal endoscopic surgery after failed conservative treatment. Routine laboratory data showed unremarkable findings. Ruptured disc with root compression was confirmed intraoperatively and removed (Fig. 2). Back and leg radicular pain scores were decreased remarkably from 7 and

8 preoperatively to 1 and 2 after the operation. Compared to preoperative MRI, the ruptured disc materials were successfully removed (Fig. 4). The patient was satisfied and evaluated as *excellent* grade on modified MacNab criteria.

DISCUSSION

Endoscopic spine surgery has been introduced and developed with increasing demand for minimal invasive spine surgery and emerging endoscopic technology.[2,5-7] The benefits of endoscopic spine surgery are lesser paraspinal muscle injury, reduced blood loss, decreased postoperative back pain, risk of infection, and dura injury with good visualization of neural structures.

Biportal spine surgery using arthroscopy was firstly reported by De Antoni et al.[13] in 1996, however the clinical trials had been actively initiated by Korean spinal surgeons and it's results have been reported with successful clinical and radiological outcomes.[2,9,14] The surgical anatomy of biportal endoscopic spine surgery is similar as those of conventional lumbar microdiscectomy, which is familiar with spine surgeons to convert from microsurgery to biportal surgery. Magnification of pathologic lesion via 4-mm biportal endoscope and clean operative field through continuous saline irrigation can allow visualization of details of surgical anatomy.[15,16] Basically all microsurgical instruments such as high-speed drill, pituitary forceps, and Kerrison punches can be also utilized in biportal endoscopic surgery.[14] Therefore, biportal endoscopic surgery is considered as the minimal invasive technique with relatively shorter learning curve compared to any other minimal invasive spine surgery including the full endoscopic surgery.[17,18]

Despite spinal endoscopic surgical procedures and associated instruments have been continuously developing for a couple of decades, there are still challenges to overcome such as iatrogenic instability due to violation of facet joint.[15,19] The violation of medial facet joint is inevitable for adequate exposure of surgical field in ipsilateral approach. It was reported that the facet joints were lesser violated on the contralateral side than on the ipsilateral approach side in unilateral laminotomy bilateral lumbar decompression.[20] The reduction rate of facet joint area via ipsilateral approach was reported about 22.6%. Moreover, the fracture of inferior articular process was also reported to 6% in ipsilateral approach. The possibility of facet joint injury during decompression has been highly reported in patients with upper lumbar level lesion, narrow lamina, and sagittal plane joint morphology.[10] To overcome the iatrogenic instability due to laminectomy with facet violation, contralateral endoscopic approach had been attempted and it's good clinical and surgical outcomes were also reported.[7,8,21-23] In our radiological results, the reduction rate of facet joint plane was calculated about 4.9%, which was lower than that of early reported reduction rate of facet joint after ipsilateral approach. This fact indicates that contralateral approach may be effective tools for removal of ruptured disc with facet joint preservation. Lesser violation of facet joint are the 2 ultimate goals in minimally invasive endoscopic surgery, even though less than one third violated facet joints can withstand the vertebral shearing forces in our daily lives.[4,24]

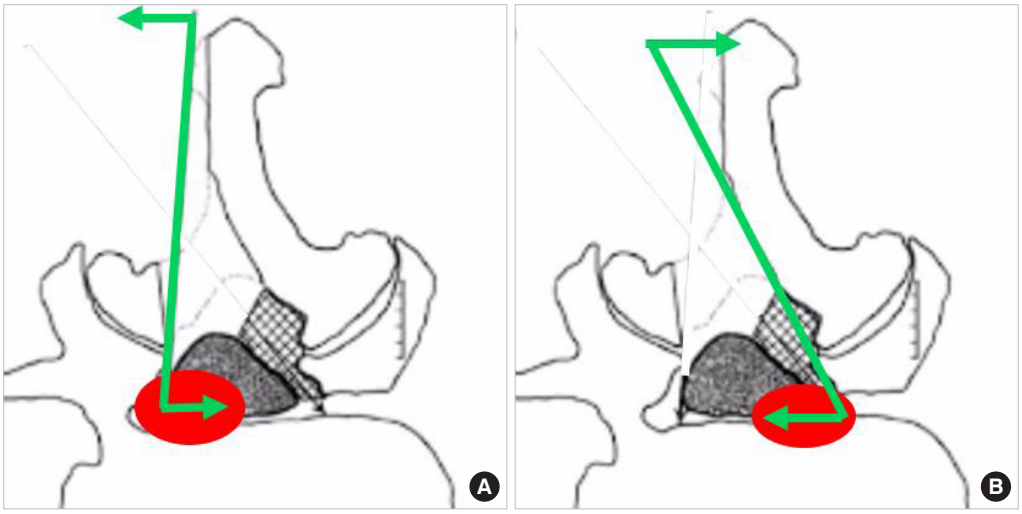

Fig. 6. The difference of nerve retraction between ipsilateral (A) and contralateral approaches (B). Midline of central spinal canal can be identified accurately during retraction of thecal sac and nerve root via performing contralateral approach (green arrow in red circle), which is named over-the top-retraction.

Microscopic contralateral approach using tubular system can be attempted as the minimal invasive technique. However, the advantage of endoscopic contralateral approach is that surgeon can perform operation in clean surgical field via continuous irrigation and in magnified vision compared to microscope. Hydrostatic pressure on epidural space can reduce bleeding and offer the working epidural space for endoscope and surgical instruments via reduction of dura mater.[16] Good visualization of surgical field can be possible optimal decompression of lateral recess, which is significant factor of clinical outcomes.[14] Especially, the free usage of pituitary forceps, osteotomes, and Kerrison punches via working channel in biportal endoscopic surgery is very helpful to perform the decompression of spinal canal and removal of ruptured disc. These advantages could be able to achieve the favorable outcomes for lumbar ruptured disc by performing CKES with less violation of facet joint and successful removal of ruptured disc. Additional merit of CKES is that accurate midline of central spinal canal can be identified during retraction of thecal sac and nerve root via performing contralateral approach, which is named the over-the top-retraction (Fig. 6).

We reported 1 case of unfavorable outcome in MacNab criteria. Ruptured disc fragment was successfully removed and other complications were not seen in postoperative MRI scan. The preoperative and postoperative ratio of ipsilateral/contralateral facet joint plane were 1.05 and 1.01, respectively. The symptom duration was about 5 months. Most of patients were received the operation within 6 weeks from the time of initial symptom development. Relatively long-term compression of neural structure might be associated with unfavorable outcome. However, there were some severe adhesions between nerve root and ruptured fragment, and we tried to detach hardly using specially designed hook and RF probe. During the detach the adhesions, neural structure damage might be occurred, especially due to RF coagulation. We thought that RF should be very carefully used with free margin from neural structures. The excessive use of RF can cause of raising epidural temperature, therefore, maintenance of continuous irrigation is important to reduce thermal injury of neural structure.

There are some technical points of contralateral keyhole endoscopic surgery. If operating surgeon stands on left side of patient with a ruptured disc on right side, a skin incision for the working port is made on upper third pedicle of lower vertebra. This let instrument to lies vertical to the upper margin of lower vertebra creating the optimum angle to remove and dissect the upper margin of lower vertebra. If skin incision is made other than the said area, the angle made between the instrument and upper margin of lower vertebra is acute or obtuse making it difficult to remove and to dissect the upper margin of lower vertebra. If operating surgeon stands on right side of patient with a ruptured disc, skin incision is made on lower margin of upper lamina. And this may be adjusted based on individual patient's anatomy and the location of the ruptured disc. And keyhole should be made wide enough to work easily with endoscopic instrument such as dissector, pituitary forceps, Kerrison punches because there is a risk of unintended injury of thecal sac and exiting/traversing nerve root in small working space. During sublaminoplasty, as the proximal origin of ligamentum flavum is Y-shaped, inserting cranio-laterally up to neuroforamen containing exiting nerve root, sublaminoplasty should be extended more cranially on the lateral border and caudally to the superior articular process with optimal decompression of lateral recess and performed with removal of only the inner cortex and the partial cancellous bone for working space and the outer cortex should be preserved. During removal of disc material, midline of central spinal canal can be identified accurately during retraction of thecal sac and nerve root via performing contralateral approach.

There are several limitations to this study. First was retrospective study design. Second, this study involved a small sample size and relatively short follow-up duration, which prevented detection of complications such as recurred disc herniation, and development of segmental instability. Third, measurement of reduction rate may be inaccuracy to reflect facet joint violation with bias. Lastly, biportal endoscopic surgery is more invasive procedure compared to one-portal endoscopic approach. However, free handling of surgical instruments and usage of zero degree endoscopy with high resolution are the advantages of biportal endoscopic surgery to reach good clinical outcomes.

CONCLUSION

CKES may be considered as an excellent surgical option to treat ruptured lumbar disc without the development of iatrogenic instability. Low rate of facet joint reduction, minimal soft tissue injury, and identification of accurate midline of central spinal canal during retraction of thecal sac and nerve root are advantages of the procedure.

CONFLICT OF INTEREST

The authors have nothing to disclose.

SUPPLEMENTARY MATERIAL

Supplementary video clip 1 can be found via https://doi.org/10.14245/ns.2040224.112.v.1.

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