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Technical Note

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A Modified Endoscopic Access for Lumbar Foraminal Pathologies; Posterolateral "Intertransverse" Endoscopic Approach to Minimize Postoperative Dysesthesia Following Transforaminal Approach

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Objective: To present an innovative, modified endoscopic approach for foraminal/extraforaminal pathologies, to reduce postoperative dysesthesia (POD) following the conventional transforaminal endoscopic approach (the access angle more than 45° from the midline), since POD is one of the major documented disadvantages that may compromise patient satisfaction.
Methods: We introduce a modified posterolateral technique, termed the intertransverse approach, utilizing a steeper access angle less than 25° through the intertransversarii muscle and the intertransverse space with expanding Kambin triangle via lateral facetectomy/foraminoplasty, to reduce dorsal root ganglion/exiting nerve root irritation under direct visualization and lower the incidence of POD. Consecutive patients undergoing endoscopic spine surgery via the intertransverse approach for foraminal and/or extraforaminal disc herniations or bony stenosis were retrospectively reviewed. Clinical outcomes were reviewed with the primary outcome being POD.
Results: Twenty-two patients were included in the review. Patients showed significantly improved clinical outcomes (visual analogue scale leg and back pain and Oswestry Disability Index) postoperatively. There was a low rate of dorsal root ganglion (DRG)-related POD (9.1%, 2 of 22) that was minimal and resolved soon.
Conclusion: The inter-transverse endoscopic approach is feasible for lumbosacral foraminal and extraforaminal decompression with significantly improved clinical outcomes and the added advantage of a low rate of DRG-related POD compared to traditionally reported rates in the literature for the conventional transforaminal approach.

Keywords: Endoscopic lumbar discectomy, Decompression, Transforaminal approach, Intertransverse approach, Postoperative dysesthesia, Dysesthetic pain

INTRODUCTION

Full endoscopic lumbar discectomy is an established minimally invasive surgical technique providing adequate access and excellent visualization of lower lumbar herniated discs while causing less soft tissue trauma than traditional open discectomies with favorable outcomes compared to open discectomies. Conventional mainstay approaches for full endoscopic lumbar discectomy include the transforaminal and interlaminar approaches. The transforaminal approach, which is the most traditional endoscopic approach for lumbar disc herniations, allows for decompression of extraforaminal, foraminal, and lateral recess pathologies. However, a transformational approach utilizes access through Kambin triangle, which is close to the nerve root and dorsal root ganglion (DRG).

One main disadvantage of the transforaminal approach includes postoperative dysesthesia (POD), with a reported incidence in the literature ranging from 9.3% to 26%.[1-7] The cause of POD is still unclear but is thought to be a result of nerve root or DRG irritation from the endoscopic working sleeve.

We herein present a modification of the transforaminal approach to address foraminal and some extraforaminal pathologies, termed the 'intertransverse approach' with an advantage of decreased exiting nerve root and/or DRG irritation and easier access to the foraminal and extraforaminal area compared with the conventional transforaminal approach.

MATERIALS AND METHODS

Consecutive patients undergoing endoscopic spine surgery that included the intertransverse approach were retrospectively reviewed from March 2021 to August 2022. The study was approved by the Institutional Review Board (IRB) of Johns Hopkins University (IRB No. 00135145) with a waiver of patient consent. The inclusion criteria were foraminal and/or extraforaminal disc herniations or bony stenosis causing exiting nerve root compression and compatible radiculopathy. We excluded spondylolisthesis, history of prior lumbar surgeries, patients with spinal deformity, infection, trauma, or neoplastic disease processes. We also excluded patients who underwent a concomitant intertransverse and ipsilateral transforaminal approaches as it would be difficult to identify the cause of any POD. Demographics, perioperative and outcomes data were collected by query of our electronic medical record database. A total of 22 patients were included in the study cohort. Outcomes collected were age, sex, body mass index (BMI), operative time, length of stay, Oswestry Disability Index (ODI) and visual analogue scale (VAS) back and leg pain scores preoperatively, at 2–4 weeks, 6 weeks, 3 months, 6 months, 1 year. and at last follow-up. In addition, the incidence of POD and perioperative complications including reoperation during the follow-up period were collected.

POD was defined whenever there was pain which is different than the preoperative symptoms, uncomfortable sensation that could be described as burning, icy-hot, prickly, itchy-prickly, and intensely creepy-crawly at a proper DRG innervated region, as previously defined and used in the literature.[3]

Continuous variables were expressed as mean ± standard deviation or as median with range. Categorical variables were expressed as frequencies and percentages. Continuous outcomes were compared with the t-test for means. Significance was set at 0.05. Statistical Analysis was performed using Microsoft Excel v16.65 (Microsoft, Redmond, WA, USA).

1. Surgical Technique

1) Positioning of the patient and preparation

Under general anesthesia, the patient is positioned prone over a radiolucent operative table. Electromyographic neuromonitoring is optional. The lumbar area is prepped and draped in a sterile fashion and a C-arm is positioned such that true anteroposterior (AP), lateral and 25° oblique views are available.

2) Entry portal and trajectory angle

On the AP view, the entry is located at the line connecting the tips of transverse processes above and below, and a line parallel to the intervertebral disc space (Fig. 1A). The entry point is located over the lateral aspect of the superior articular process on a 25° oblique view (Fig. 1B). Usually, the portal is located about 5–7 cm from the midline and at a 15°–25° angle from the vertical line (Fig. 2A, B). A 7-mm-sized transverse skin incision is made over the entry point. A discography needle is advanced until the tip of the needle touches the lateral aspect of the facet joint. Then a 6-mm obturator is placed after sequential dilation on a guide wire. Finally, a beveled working cannula is placed over the obturator, positioning the bevel towards the medial side (Fig. 3A, B).

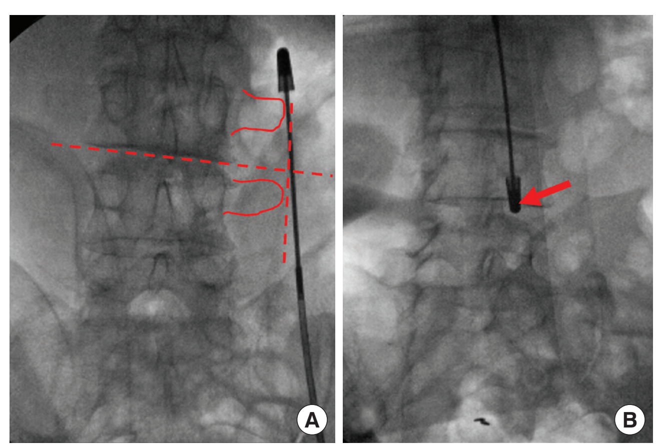

Fig. 1. Intraoperative fluoroscopic anteroposterior (A) and oblique (B) views show the location of the portal. (A) The entry is on the crossing point between the vertical line connecting the lateral borders of transverse processes and the intervertebral disc space. (B) On a 25° oblique view, the entry is over the lateral aspect of the facet joint and the disc space.

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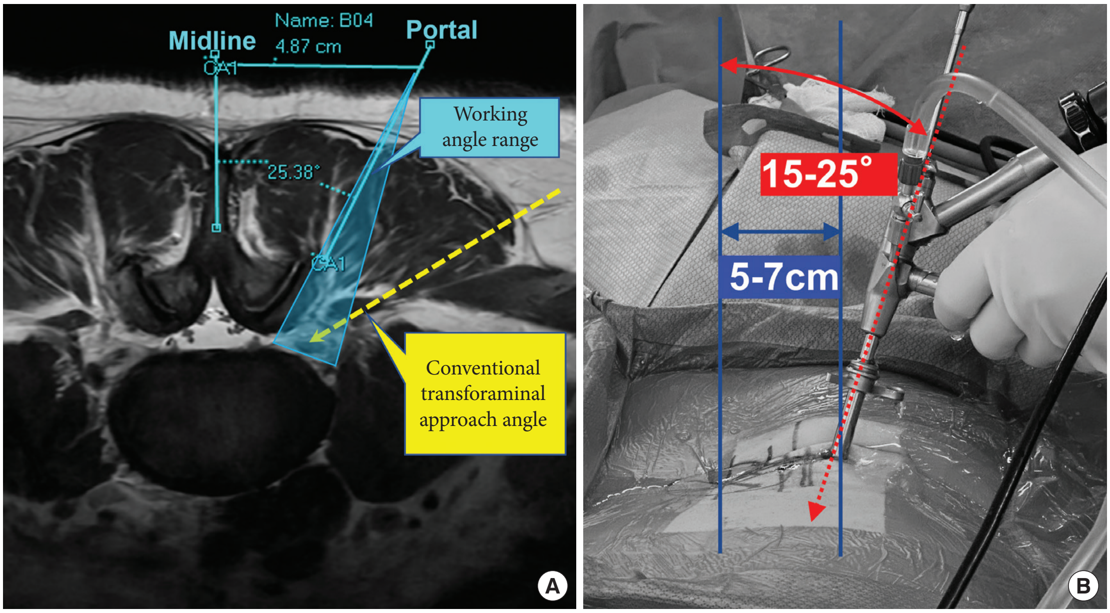

Fig. 2. (A) An axial magnetic resonance imaging view of an L4/5 level, showing the location of the portal (about 5 cm from the midline) and the access angle in the axial plane (15°–25° from the midline, blue lines and triangle). The conventional transforaminal access angle is demonstrated (the yellow line). (B) An intraoperative picture showing the access angle. To access the lateral recess, the angle can be increased more than 25°–30° via a same portal, but less than a conventional transforaminal access angle which is 45° or more.

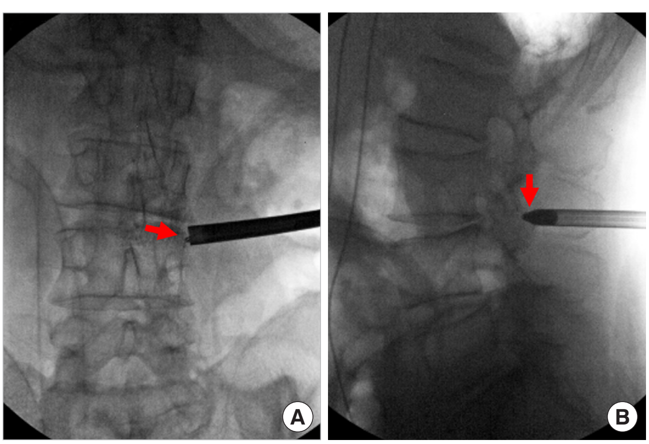

Fig. 3. Intraoperative anteroposterior (AP) and lateral images showing the docking point of the intertransverse approach (red arrows). The obturator or working cannula should touch the posterolateral corner of the facet on AP (A) and lateral aspect of the facet on lateral view (B).

3) Lateral facetectomy/foraminoplasty; expanding the medial aspect of Kambin triangle

A 7-mm interlaminar spinal endoscope is introduced and the water inflow is opened. The posterolateral aspect of the facet joint capsule and attachment of longissimus muscle at the lateral aspect of the facet are dissected with a radiofrequency (RF) tip (Fig. 4A). Using a 3.5-mm endoscopic burr, the lateral aspect of the facet is drilled (i.e., superior articular process of the lower vertebra) to expand Kambin triangle. In cases with bony foraminal stenosis, the lateral aspect of the superior articular process is resected including the tip of superior articular process until the facet joint is exposed (i.e., lateral facetectomy). For soft disc herniation cases, the lateral aspect of the superior articular process is drilled to expand Kambin triangle without resection to the facet joint (i.e., foraminoplasty). The depth of drilling is usually 3–5 mm (1 to 1.5 times of drill diameter) but may vary depends on the hypertrophy of superior articular process (Fig. 4B, C).

4) Exposure of posterolateral annulus and exiting nerve root

Gradually, the beveled working cannula is advanced through the expanded Kambin triangle, until the posterolateral annulus is visible. Before exposing the annulus, the lateral facet capsule, foraminal ligament and intertransverse membrane are resected and shrunken using the RF tip. To make identification of the location of the disc or ruptured disc fragment easier, injection of diluted methylene blue in the disc space could be considered. The working cannula is still not touching the DRG or exiting nerve root. After cleaning the soft tissues at the foramen and extraforaminal area using an RF tip, the caudal aspect of DRG/

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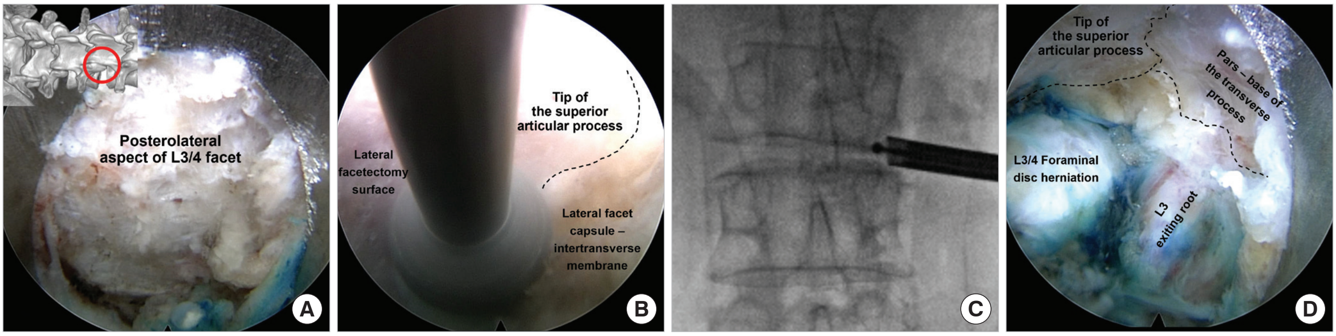

Fig. 4. Sequential steps of a L3/4 right side intertransverse approach to expose the foramen (a water mark at the superolateral corner of the panel A, with the red circle outlining the L3/4 right facet joint on the model for orientation), posterolateral aspect of the foraminal disc herniation and exiting nerve root, from the posterior aspect of the foramen. (A) Exposure of the posterolateral aspect of the facet joint capsule with a radiofrequency tip (the blue stain is from the methylene blue discography). (B) Lateral facetectomy can expose the lateral facet capsule and the intertransverse membrane, finally expanding Kambin triangle for safer foraminal access. (C) A fluoroscopic image of lateral facetectomy with a 3.5-mm endoscopic drill. (D) After final lateral facetectomy with drilling of the tip of superior articular process and pars, and removal of the intertransverse membrane, the endoscopic field provides good exposure of exiting nerve root and lateral aspect of the lateral recess as well as foraminal discs.

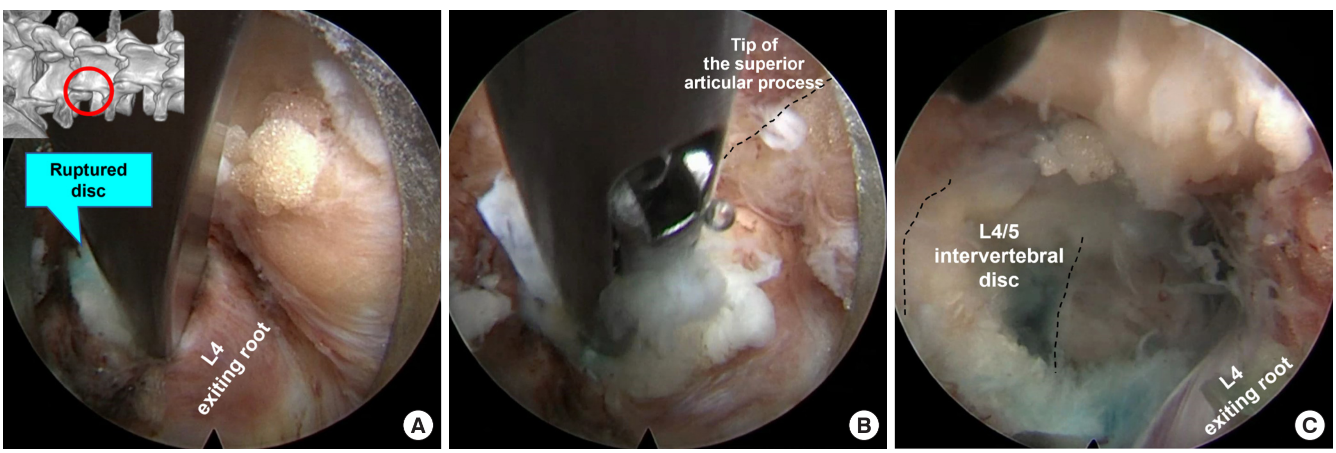

Fig. 5. An intertransverse approach for a L4/5 extraforaminal disc herniation on right side. The red circle outlines the L4/5 right facet joint on the model for orientation. (A) Before discectomy, the exiting nerve root shows engorged perineural vein with severe tension. (B) The ruptured disc fragments can be removed safely under clear visualization of the exiting nerve roots. (C) After the disc removal, exploration of the foramen, ventral aspect of the exiting nerve root and lateral recess is possible without any traction of the exiting nerve root or dorsal root ganglion with the working cannula.

exiting nerve root can be visualized without any root retraction or compression (Fig. 4D).

5) Discectomy and/or foraminotomy

After exposure of the posterolateral annulus, discectomy or additional foraminotomy is doable with variable sized endoscopic instruments, including pituitary rongeurs, Kerrison rongeurs and osteotomes. The additional foraminotomy can be performed for any ventral bony spurs arising from the endplates or the ventral aspect of the superior articular process which can cause compression of the exiting nerve root. After completion of the foraminal discectomy, exploration of the foramen, area under the exiting nerve root and the lateral recess is possible by changing the angle of the working cannula (Figs. 5–7).

RESULTS

Twenty-two patients (12 men, 10 women) with a mean age of 62 ± 10 and mean BMI of 30.4 ± 6.0 kg/m^2 underwent endoscopic surgery that included the intertransverse approach. Indications for the intertransverse approach were foraminal/extraforaminal disc herniation in 14 patients (64%), bony foraminal

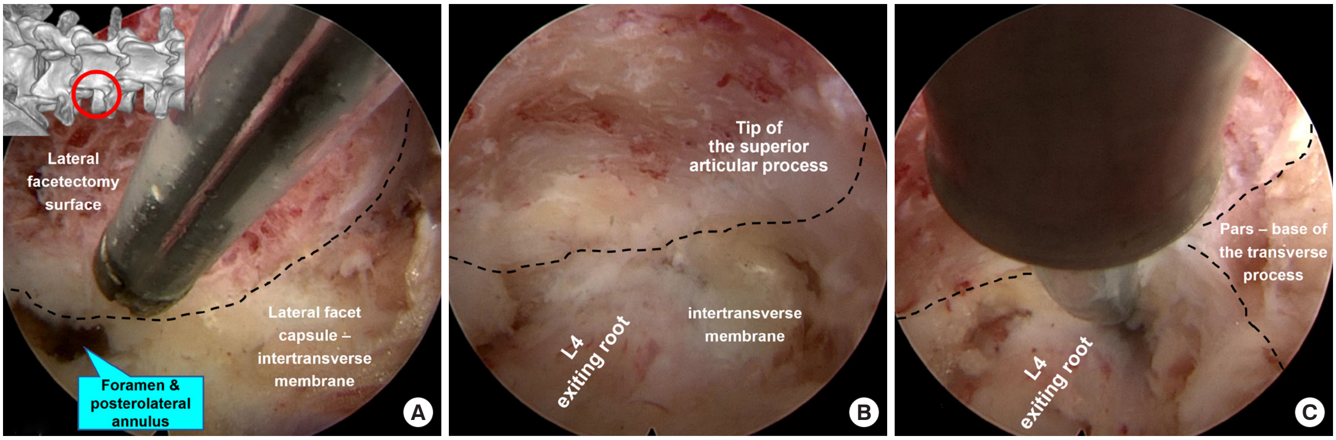

Fig. 6. Foraminal stenosis at L3/4 with right sided decompression using an intertransverse approach. The red circle outlines the L4/5 right facet joint on the model for orientation. (A) Lateral facetectomy demonstrates the entry of the foramen at the disc level, lateral facet capsule and intertransverse membrane. (B) After removal of the intertransverse membrane and facet capsule the exiting nerve root can be visualized. (C) More foraminal decompression was achieved with drilling of the tip of the superior articular process, pars, and ligamentum flavum at the lateral recess.

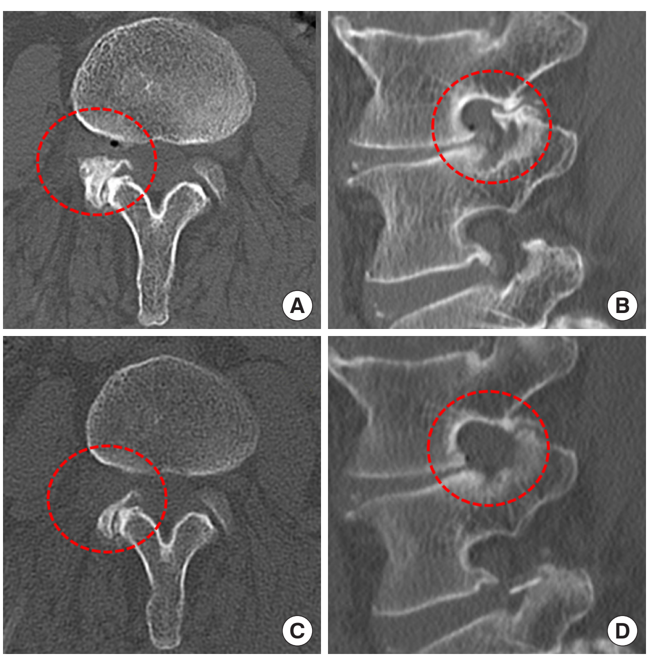

Fig. 7. The preoperative (A, B) and the postoperative computed tomography (C, D) images of the patient in Fig. 6. The foraminal stenosis from osteophytes and disc was decompressed on both axial (C) and sagittal (D) images as seen in the area outlined in red (the target foramen).

Table 1. Demographic and perioperative data

Variable	Value
Age (yr)	62 ± 10
Male sex	12/22 (55)
BMI (kg/m^2)	30 ± 6.0
Indication	
Foraminal/extraforaminal disc herniation	14/22 (64)
Bony foraminal stenosis	4/22 (18)
Both	4/22 (18)
Intertransverse approach level	
L2/3	3/26 (12)
L3/4	7/26 (27)
L4/5	14/26 (54)
L5/S1	2/26 (8)
Operative time (min)	154 (59–286)
Operative time/level (min)	82 (59–129)
Length of stay (day)	0.5 ± 0.6

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

stenosis in 4 patients (18%), and concomitant disc herniation and bony foraminal stenosis in 4 patients (18%). Twelve patients underwent stand-alone intertransverse approach (55%), with 10 cases involving single level and 2 cases involving 2 levels. The other 10 patients (45%) underwent a combination of intertransverse approach and concomitant interlaminar approach for a different level with intraspinal disc herniation or stenosis. The most common levels for the intertransverse approach in descending order are L4/5 (54%, n = 14/26), L3/4 (27%; n = 7/26), L2/3 (12%; n = 3/26), and L5/S1 (8%; n = 2/26).

Median operative time was 154 minutes (range, 59–286 minutes), and median operative time per level or approach was 82 minutes (range 59–129 minutes). Mean length of stay was 0.5

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± 0.6 days (median, 0 days; range, 0–2 days) (Table 1).

The mean VAS leg pain score was as follows: preoperative, 6.9 ± 2.0; at 2-4 weeks, 2.3 ± 3.1; at 6 weeks, 3.0 ± 3.2; at 3 months, 1.6 ± 2.1; at 6 months, 1.9 ± 2.1; at 1 year, 2.0 ± 3.4; at last follow-up, 2.0 ± 2.8 ($p < 0.001$, preoperative vs. at last follow-up).

The mean VAS back pain score was as follows: preoperative, 4.1 ± 3.5; at 2–4 weeks, 1.4 ± 3.1; at 6 weeks, 3.6 ± 2.9; at 3 months, 2.0 ± 2.5; at 6 months, 2.6 ± 2.3; at 1 year, 2.4 ± 2.4; at last follow-up, 1.5 ± 2.0 ($p < 0.01$, preoperative vs. at last follow-up).

The mean ODI was as follows: preoperative, 42.7 ± 20; at 2–4 weeks, 12 ± 7.3; at 6 weeks, 19 ± 11; at 3 months, 4.7 ± 3.1; at 6 months, 3 ± 4.2; at 1 year, 12 ± 2.8; at last follow-up, 11 ± 8.2 ($p < 0.01$ preoperative vs. at last follow-up). Mean time to last follow-up was 4.5 ± 5.1 months.

POD occurred in 2 cases (9.1%). One in a patient who underwent a left sided L4/5 discectomy for a foraminal herniated disc using an intertransverse approach. The patient reported new onset "nerve pain" radiating down her left lower leg that began 4 days postoperatively and was associated with mild numbness in her left lateral calf. Her symptoms resolved after 2–3 weeks. The other was in a patient who underwent a right sided L3/4 discectomy for a foraminal herniated disc using an intertransverse approach, the patient had burning medial thigh dysesthetic pain that began 3–4 days after surgery that was very mild and did not require any additional medication or other treatment and resolved in 4–5 weeks.

DISCUSSION

Although conventional transforminal endoscopic discectomy has demonstrated favorable clinical outcomes in the literature for the management of foraminal/extraforaminal disc herniations as well as paracentral disc herniations, the POD is not an uncommon complication that compromises patients' satisfaction.[1-7] This POD has been frequently reported in the literature as one of the main disadvantages of the transforaminal approach.

During a transforaminal access to the epidural space, the working cannula in Kambin triangle can compress, irritate or injure the DRG or exiting nerve root sheath during the endoscopic procedure. Unlike the central and peripheral nervous systems which are protected by blood-brain and blood-nerve barriers respectively, the DRG lacks such a protective barrier. As such, it is more susceptible to the inflammatory mechanisms.[8] Irritation of the DRG can lead to POD, which manifests as either spontaneous or evoked burning pain at a proper DRG innervated region, without motor weakness which differentiates it from nerve root injury.[9]

The reported incidence is highly variable from 9.3% to 29%, but generally it is considered to be underreported given the lack of established diagnosis criteria. Several prior studies reported on the incidence of DRG-related dysesthesia after transforaminal approach. Lewandrowski et al.[1] reported 451 consecutive patients undergoing transforaminal endoscopic decompression and found an incidence of 21.5% of dysesthetic leg pain which they report typically developed 5 to 10 days postsurgically, occurred at the same frequency in the different lumbar levels and without a predilection to 1- versus 2-level cases. The same author also showed that DRG-related dysesthesia leads to delayed return to work by a mean of almost 19 days.[2] Kim et al.[3] compared patients who underwent transforaminal foraminotomy and discectomy with patients who underwent contralateral interlaminar foraminotomy and discectomy and found a significant different between the incidence of postoperative dysesthesias, with 26% in the transforaminal group compared to 14% in the contralateral interlaminar group.

Because of this well-known complication following conventional transforaminal approaches, there has been an effort to minimize the incidence of POD with modified transforaminal approaches in the literature.[10-14] Cho et al.[14] reported a 'floating retraction technique' specifically aimed at reducing postoperative DRG-related dysesthesia with good outcomes. They modified the transforaminal approach via targeting the upper part of the pedicle of the lower lumbar vertebra and retracted the exiting nerve root towards the cranial part of the foramen to access the lateral recess.

Although a conventional transforaminal approach could provide a good access to the lateral recess and epidural space either with inside-out or outside-in technique, direct visualization of the exiting nerve root and DRG at the foraminal/extraforaminal area could be limited because the working cannula is located through Kambin triangle.

There have been reports on posterolateral approaches to foraminal and extraforaminal pathologies in the literature with favorable outcomes.[7,15-17] However, the access angles were about 45°–60° from the midline, which is similar to conventional transforaminal approaches. In this study, we introduced a modified technique from the transforaminal approach to reduce DRG/exiting nerve root irritation and lower the incidence of postoperative dysesthetic pain with better access to the foraminal and extraforaminal area. To accomplish that, we utilized a steeper access angle less than 25°, with the endoscopic portal being about 5–6 cm from the midline. Expansion of Kambin triangle could provide wide exposure of the DRG and exiting nerve root as well as the foraminal-extraforaminal area. Detailed exploration of the foramen for remaining soft disc herniation was possible with variable endoscopic hooks or dissectors and removal of osteophyte is doable using endoscopic burrs or osteotomes.

We termed this approach as "intertransverse" since the access is through intertransversarii muscle and the intertransverse space unlike a conventional transforaminal approach, which is through the quadratus lumborum muscle, lateral to the tip of the transverse process. The docking point of obturator and working cannula of intertransverse approach is at the posterolateral aspect of the facet, which is different than that of a transforaminal approach which is usually at the distal foramen under the transverse process (Fig. 2).

In our case series, patients had significantly improved clinical outcomes postoperatively but more importantly had a relatively low rate of POD (9.1%) compared to the literature regarding the transforaminal approach.[1-7] We postulate that the dysesthetic pain could be avoided because of better visualization of the DRG and exiting nerve root from the posterior aspect like in an interlaminar approach, without contacting or irritation by the working cannula. It was unclear if the POD experienced by the 2 patients in our series were due to irritation of DRG by the procedure or due to postdecompression symptom that can also be seen similarly to open decompression surgeries. However, the intensity and duration were relatively mild and not disabling in nature. The disadvantages of the author's technique should be less extent of access to the central part of the epidural space, unlike a conventional transforaminal approach because of the steeper access angle. The authors generally prefer an interlaminar approach for centrally located disc herniations to avoid the risk of dysesthetic pain from passing the working cannula through the foramen. But in most cases, lateral recess could be visible and disc fragment can be removed if it is not located too far centrally.

Limitations of this study include its retrospective nature. In addition, the presence of concomitant interlaminar approaches along with the intertransverse approach for different levels or sides further complicated the analysis of patient symptoms. However, in those patients who had postoperative pain, we were able to generally correlate the patient's symptoms with the side or level of the approach to ascertain whether this constituted a DRG-related dysesthetic symptom. Thirdly, while the incidence of POD was low in our series relative to literature figures, we were unable to compare this in statistical fashion. Future work could compare a cohort of patients with stand-alone intertransverse approach versus stand-alone transforaminal approach.

CONCLUSION

The intertransverse endoscopic approach is feasible for lumbosacral foraminal and extraforaminal decompression with improved clinical outcomes and the added advantage of a low rate of DRG-related postoperative dysesthetic pain.

NOTES

Conflict of Interest: The authors have nothing to disclose.

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Author Contribution: Conceptualization: SHL; Data curation: FNM, SHL; Formal analysis: FNM; Methodology: FNM; Project administration: SHL; Visualization: SHL; Writing - original draft: FNM, SHL; Writing - review & editing: FNM, SHL.

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