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Percutaneous Endoscopic Interlaminar Discectomy for L5-S1 Disc Herniation : Axillary Approach and Preliminary Results

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Objective : The purpose of this study was to describe a surgical technique of axillary approach of percutaneous endoscopic interlaminar discectomy for L5-S1 disc herniation and its preliminary results.

Methods : From July 2002 to September 2003, 101 patients with lumbar radiculopathy due to L5-S1 disc herniation, who were treated by percutaneous interlaminar endoscopic discectomy, were retrospectively reviewed. There were 57 males and 44 females with a mean age of 44.8 years (range, 18 to 62 years). The surgery consisted of needle insertion into the epidural space via the interlaminar space, sequential dilatation, and endoscopic discectomy through the axillary area of the S1 root.

Results : The mean follow-up period was 14.5 months and the average surgical time was 41 min. According to the modified Macnab criteria, 44 patients (43.6%) had excellent outcomes, 49 (48.5%) had good results and only 8 (7.8%) had fair or poor outcomes. Four patients had a revision microdiscectomy due to incomplete removal of disc fragment. There were no major complications related to this surgical approach.

Conclusion : Axillary approach of percutaneous endoscopic interlaminar discectomy is safe and effective procedure for the treatment of L5-S1 disc herniation. It combines the advantages of MED and conventional percutaneous endoscopic discectomy.

KEY WORDS : Interlaminar approach · L5-S1 disc herniation · Percutaneous endoscopic discectomy.

Introduction

In 1978, Williams first described microdiscectomy[14]. Since then, the concept of a minimally invasive approach to disc surgery, which led to less iatrogenic skeletal injury, has been further developed. The reported success rate of microdiscectomy varies from 46% to 96%, which is comparable to the traditional open approach[6]. Most surgeons will use the least invasive approach when possible, assuming that the results are similar with the older traditional approach[4]. The less invasive procedures have also resulted in a decrease of the average size of the wound site.

Microendoscopic discectomy(MED) uses a muscle splitting technique[3], and although this is less traumatic than the traditional approach which takes the muscle off the spinous process and lamina using periosteal elevator and electrocautery, it can still lead to post operative instability and back pain, the same as incurred when using this procedure for partial laminectomy. And it has the same risks of microdiscectomy, such as partial laminectomy and facet joint violation. The percutaneous transforaminal endoscopic approach is less invasive than MED in that it avoids any bone dissection[7,15]. The herniated discs at L3/4 and L4/5 are easily reached via the intervertebral foramen. However, due to occasional anatomical obstacles such as a high iliac crest or sacral ala, access to the L5-S1 disc space may be difficult.

Based on the anatomic findings, there are two small safe triangular zones at the L5-S1 level for the interlaminar app-

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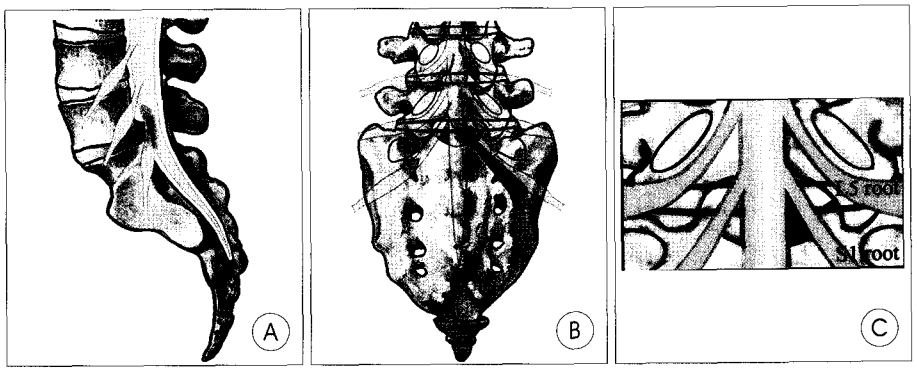

Fig. 1. Anatomical characteristics of L5–S1 area (A : The axilla of the S1 root is located at the L5–S1 disc level, while the L5 axilla is inferior to the L5 pedicle. B : The L5–S1 interlaminar space is the largest space in the lumbosacral region. C : The L5–S1 interlaminar space provides the proper trajectory for an approach to the disc space through the axillary portion).

roach. Some of L5/S1 disc herniations, which can be removed through the shoulder of the S1 nerve root, can also be removed by the transforaminal approach. In this study, we describe a new percutaneous endoscopic interlaminar discectomy technique for L5/S1 disc herniation through the axilla of the S1 root (Fig. 1).

Materials and Methods

Patient population

From July 2002 to September 2003, 332 patients at our hospital were operated on for disc herniations at L5-S1; 101 of these patients who satisfied the inclusion criteria of our study, and so they underwent percutaneous interlaminar endoscopic discectomy. The mean age of these 101 patients was 44.8 years, and their ages ranged from 18 to 62 years. The inclusion criteria were as follows : 1) neurological signs including S1 radiculopathy, sensory changes or motor weakness; 2) symptoms corresponding with the magnetic resonance image (MRI) and computed tomography (CT) scan findings; 3) unsuccessful conservative treatment including nerve root blocks and analgesics for at least four weeks; and 4) no past history of back surgery at the same level.

The exclusion criteria were as follows : 1) central stenosis (less than 10mm), lateral recess stenosis (less than 3mm) or facet joint hypertrophy as confirmed by MRI and CT scan; 2) too small an interlaminar space (less than 7.5 mm in the vertical or horizontal planes); 3) a low lying axilla as shown by the preoperative CT or MRI; 4) an upwardly migrated disc, foraminal or far lateral disc herniation; 5) segmental instability on dynamic radiographs; and 6) previous back surgery at the same level.

Interlaminar space dimensions were measured at the CT slice showing the root diversion. Three-dimensional reconstruction of the CT scan using the Rapidia® software (INFINITT, Seoul, Korea) was very helpful for evaluation, assessment and planning of an appropriate trajectory (Fig. 2). The software allowed for an accurate assessment of the size of the interlaminar space, and thus, it facilitated a precise placement of the endoscope.

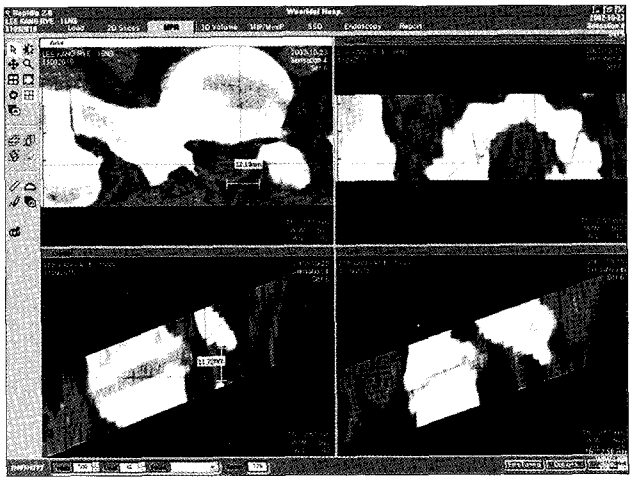

Fig. 2. Three-dimensional reconstruction of the computed tomography scan using the Rapidia® software was very helpful for the evaluation, assessment and planning of an appropriate trajectory. The reconstructed view shows the location of axilla and disc fragment, and we could also measure the size of the interlaminar space.

Surgical techniques

All procedures were performed with the patient under light sedation. Dormicum 0.5cc and prophylactic antibiotics were given pre-operatively. The patient was placed in the kneeling position on a radiolucent operating table. The incision site, which was 1cm lateral to the midline and in the lower portion of the L5-S1 interlaminar space, was anesthetized with 2% lidocain. An 18G needle was passed through the ligamentum flavum. The anteroposterior and lateral fluoroscopic views were taken to confirm the proper position of the needle. A loss-of-resistance technique and an epidurogram were used to identify the epidural space, and the epidurogram clearly showed a triangle made by the S1 and S2 nerve roots (Fig. 3A). The needle should be located at the widest part of the axilla. 2cc of 0.5% lidocaine was injected into the epidural space at this point of the procedure, which was useful for controlling pain. The guide wire was then inserted through the needle, and increasingly larger dilators were passed over the guidewire, splitting and widening the ligamentum flavum. The 7mm diameter working sheath (Fig. 3B) was eventually placed. A YESS® 20° endoscope (Richard Wolf Surgical Ins-

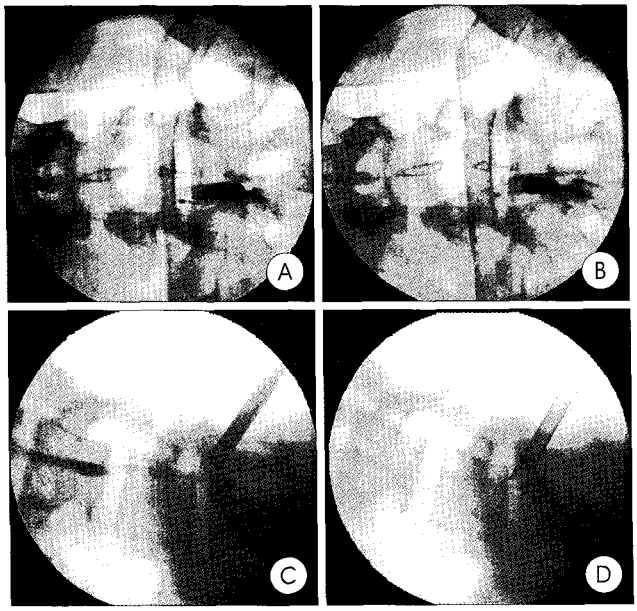

Fig. 3. Intraoperative C-arm views (A : This epidurogram was taken after insertion of the needle into the epidural space. It shows the accurate location of nerve roots and axillary portion. B : The 7mm size-working sheath was finally introduced by sequential dilatation. C : Final position of the working sheath from the lateral view. It just faced the disc fragment. D : The working sheath could be advanced into the disc space).

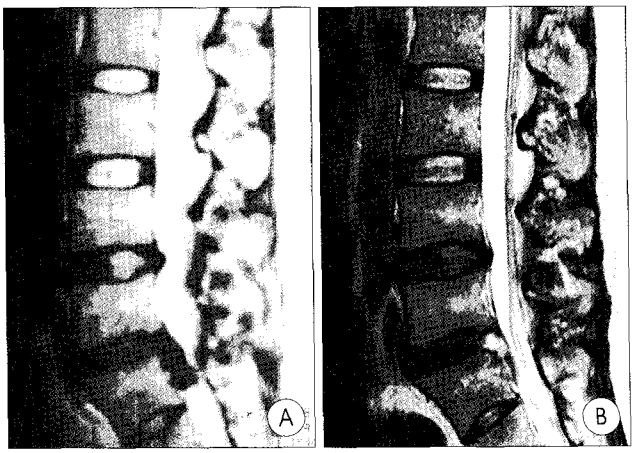

Fig. 4. Clinical example. The preoperative magnetic resonance image (MRI) (A) shows a huge downward migrated disc at L5-S1. It was totally removed using this approach, as is shown on the postoperative MRI (B).

trument Corp., Vernon Hills, IL, USA) was then inserted through the working sheath. Continuous irrigation with an antibiotic-saline solution was performed during surgery. The working sheath acted as a nerve retractor, pushing the thecal sac medially and the S1 root laterally. The working sheath was then advanced with a twisting motion to the vertebral body, and the sequestered fragments located at the axillary portion could be seen immediately after insertion of the endoscope; they could be easily removed with the use of forceps. The visualized epidural veins were coagulated using a bipolar coagulator with a flexible tip (Ellman®; Ellman International, Hewlett, NY, USA). The working sheath was then advanced into the disc space (Fig. 3C). Any ruptured disc was removed using forceps via an opening made in the annulus or the posterior longitudinal ligament with an Ellman® bipolar tip. The remaining disc fragments and thick bulged annulus were ablated with a side-firing Ho-YAG laser (Trimedyne Inc, Irvine, CA, USA). The beveled tip working sheath was better for epidural space exploration, it allowed for better visualization and so it was used for the intradiscal work (Fig. 3D). After having confirmed that the nerve root was free and intact, the sheath and endoscope were removed. The large downwardly migrated disc fragment was totally removed using this approach (Fig. 4). To evaluate whether there had been adequate removal of disc fragments, an MRI was immediately taken after the surgery, and the patients were discharged the same day.

Results

Routine follow-up was done at 6 week, 3, 6, and 12 months after surgery. According to the modified Macnab criteria, 44 patients (43.6 %) had an excellent outcome, 49 patients (48.5 %) had a good outcome, and only 8 patients (7.8 %) had a fair or poor outcome. Four patients had their procedure converted to open surgery due to severe back pain during the surgery. Additionally, 4 patients had to have a revision microdiscectomy because the postoperative MRI revealed the incomplete removal of disc fragments, and the fragments had moved to the shoulder portion of the S1 root. Twenty-six patients complained of postoperative paresthesia, which subsided in 4 weeks. Of these 26 patients, 10 received epidural blocks and 2 had severe headaches due to dural irritation; in both these cases there was spontaneous resolution within a week. Low back pain slightly decreased from a mean Visual Analog Scale(VAS) score of 2.8 preoperatively to 2.3 at the final follow-up. Mean VAS leg pain score improved from 7.4 to 2.1 at the final follow-up ($P<0.05$) (Table 1).

Table 1. Comparison of Visual Analog Scale scores preoperatively and at the final follow-up

	Preoperative	Final follow-up	P-value
Leg pain	7.4	2.1	< 0.05
Back pain	2.8	2.3	< 0.05

Discussion

At the L5-S1 level, the anatomies of the nerve roots and disc space are different from those at other levels. The axilla of the S1 root is opposite to the inferior edge of the L5-S1 disc space, while the L5 root axilla is located below the L5 pedicle (Fig. 1A)[2]. It is important to note that the S1 root runs more vertically, which can result in it being displaced subarticularly in the case of an axillary herniation (Fig. 1B).

The L5-S1 interlaminar space is the largest space in the lumbosacral region. The size of this space is influenced by age, the degree of the disc degeneration and facet joint hypertrophy. Boon et al have studied the size and shape of the interlaminar space[1]. According to their study, the horizontal measurements of L5-S1 varied from 25.75mm to 31.89mm, and from 9.95 mm to 13.24mm for the vertical paramedian measurements at L5-S1. Moreover, this space is covered only by the ligamentum flavum.

Using the Rapidia® 3-D reconstruction program enabled us to accurately assess the dimensions of the interlaminar space, the root anatomy and the endoscope trajectories. The software used CT cuts (3mm slices), to recreate a 3-D model, which significantly helped us for the preoperative planning. One third of the patients in our cases with an L5-S1 disc herniation had sufficient room for endoscopic entry. The outer diameter of working sheath was 7mm. The mean interlaminar space dimensions of this study were 8.4mm vertically and 8.7mm horizontally. Some patients had the minimum necessary interlaminar space (7.5~8mm), which made manipulation of the working sheath rather painful. The unique anatomies of the L5-S1 interspace with wide interlaminar dimensions and highly located S1 and S2 axilla, enable L5-S1 disc access via the axilla[2]. As the anatomical features allow freer access to the L5-S1 disc via the axillary space, we have devised a new percutaneous approach for the L5-S1 disc herniation.

For the treatment of radicular pain due to herniated discs, microdiscectomy has been universally accepted as gold standard[8,14]. Spengler introduced the limited disc excision technique in 1982, and he advocated the advantages as being the diminished perineural fibrosis and a lower risk or damage to vessels and/or viscera[13]. Some authors have introduced the translaminar approach[11]. In 1996, Kambin et al have introduced percutaneous transforaminal endoscopic discectomy[7]. This approach has achieved less muscle injury and the preservation of the posterior column elements. However it has some limitations at the L5-S1 level due to anatomical obstruction from a high iliac crest that can make the removal of downwardly migrated fragments extremely difficult[9,16]. Moreover, some authors have suggested the use of a transiliac crest approach[10]. In 2001, Garg and Kumar described an interlaminar technique for L5-S1 disc herniation without performing a laminotomy[4]. The results were comparable to the conventional surgical approach, with 94 % of L5-S1 herniations being treatable. Therefore, the space has sufficient size and the appropriate anatomical structure for endoscopic discectomy. However, they did not use a muscle splitting technique. In 1997, the MED using muscle splitting technique was introduced[3]. Although this technique is less traumatic than the traditional approach, it still involved a partial laminectomy and facet joint violation, which can lead to postoperative instability at the same levels[5].

In this study, we used a small diameter (7mm) sheath with muscle-splitting technique to remove L5-S1 disc fragments through the interlaminar space. The new technique in our study allows preservation of the normal spinal structure. The advantages of interlaminar approach include less postoperative pain and no spinal instability. However, there were four cases required conversion to open microdiscectomy as a consequence of the pain, and one case of severe radicular pain during insertion of the sheath due to a narrow low-lying axilla. This was usually associated with sacralization of the lumbar vertebral, and so this should be a contraindication for using this procedure.

In the initial operations, there were some disc fragments that were missed. This was probably due to the use of a round tip sheath that limited the operation's field of view. In subsequent cases, we used a beveled tip sheath, allowing for a wider view and better exploration of the epidural space, even under the S1 root, there was no more missing of disc fragments. There were no recurrent disc herniations in our cases during this follow-up period. One of the reasons for this finding could be that as we accessed the disc space through the axillary position of S1 nerve root, it was easy to remove axillary migrated disc fragments as well as intradiscal fragments by slight superior shifting of the working cannula. In previous studies the recurrence rate of fragmentectomy was comparable to that in conventional discectomy. If the fragment is connected to the disc space, intradiscal decompression may solve the problem of recurrence. All the operations were performed under direct visualization and there were no neural injuries. The operating field was continuously irrigated with antibiotics-saline solution to provide a clear surgical field and infection prophylaxis. However, 2 patients complained of severe postoperative headache along with neck stiffness, and this was most likely due to dural irritation caused by excessive irrigation force.

Interlaminar space at L5-S1 level is covered only by the ligamentum flavum. This operation spares the ligamentum flavum, as this structure is just split and not removed. The ligamentum flavum covers the epidural space, and as noted by Song and Park, saving it will minimize postoperative perineural adhesions[12]. The endoscope was too long to handle. Therefore, the instrument was actually designed for the posterolateral approach, and so a shorter endoscope is currently being designed for the interlaminar approach.

Conclusion

Axillary approach of percutaneous interlaminar endoscopic discectomy is less invasive procedure than MED,

while avoiding any bone dissection. Our preliminary result shows that it is effective for the treatment of L5-S1 disc herniation in properly selected patients.

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Commentary

The authors have described a less invasive surgical technique for L5-S1 disc herniation and their early clinical outcome is quite comparable with the conventional, "gold standard", open microscopic discectomy and similar to the endoscopic interlaminar discectomy series reported by Choi et al[1]. It is certain less invasive surgical procedures are trend in contemporary spinal surgery and have definite merits in points of operation time, blood loss, hospital stay, more cosmetic wound, and return to occupation or ordinary activity. However, their limitations for clinical application are the competence in achieving the goal of surgery and the ability to manage inevitable complications of the procedures. Such limitations may be resulted from a smaller skin incision and inherited narrower surgical field as well as surgical skill. As the authors described, there were considerable numbers of failure or complication : four patients of inadequate decompression required secondary open discectomies, another 4 cases of conversion to open surgery because of severe back pain during procedures, 26 patients of transient postoperative paresthesia, and even 2 cases of severe postoperative headache. Most of them might be avoided by open microscopic discectomy. How beneficial the merits of a less invasive surgical technique, its value must be assessed in aspect of accomplishing the goal of surgery. This new endoscopic approach for L5-S1 disc herniation, however, is valuable in selected cases and has encouraging surgical outcome. Some shortcomings of the procedure will be expected to be overcome in the near future through further surgical experiences and refined instruments.

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