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MINIMALLY INVASIVE SPINE SURGERY (W HSU, SECTION EDITOR)

Transforaminal full-endoscopic lumbar discectomy under local anesthesia in awake and aware conditions: the inside-out and outside-in techniques

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Abstract

Purpose of the review Transforaminal full-endoscopic lumbar discectomy (TELD) under local anesthesia was first introduced in Japan in 2003. Initially referred to as percutaneous endoscopic discectomy, in 2018, a consensus was reached worldwide and the preferred term is now TELD. The procedure requires only an 8-mm skin incision and causes minimal damage to the paravertebral muscles. Thus, it is the least invasive disc surgery. In this review, we introduce two types of the TELD surgery.

Recent findings Initially, TELD was performed as the "inside-out" technique but was associated with reports of postoperative dysesthesia due to exiting nerve injury. Recently, the "outside-in" technique after foraminoplasty was proposed for safer insertion of the cannula into the disc. Foraminoplasty can widen the narrow foramen, thereby allowing the 8-mm cannula to pass through easily and safely, and thus injury to the exiting nerve root can be theoretically avoided.

Summary We described two types of the TELD in this review. Surgeons should be familiar with the inside-out and outside-in techniques for TELD; therefore, we can select appropriate technique for each case.

Keywords Transforaminal full-endoscopic lumbar discectomy · Herniated nucleus pulposus · Foraminoplasty · Inside-out · Outside-in

Introduction

The transforaminal approach to the disc space was introduced around 1970 in Japan [1]. Hijikata inserted a cannula into the disc space transforaminally under local anesthesia and successfully removed the nucleus pulposus. The surgery was referred to as percutaneous nucleotomy (PN). In the original procedure, the position of the cannula had to be confirmed

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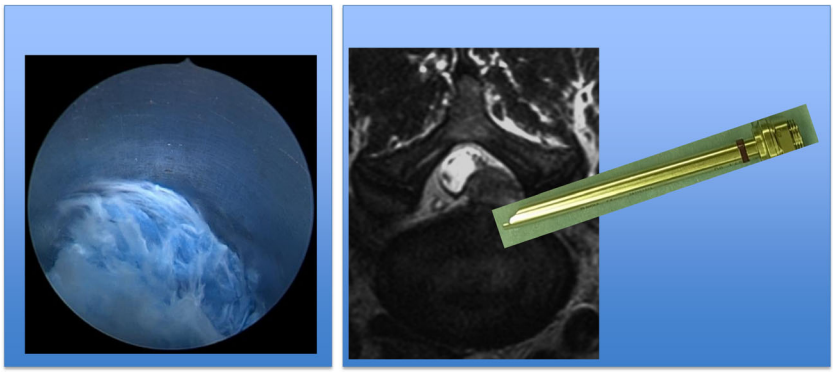

Fig. 1 Inside-out technique and endoscopic view. The cannula is first inserted into the disc just underneath the HNP. Right panel, optimal positioning of the cannula for the inside-out technique. If the cannula is inserted deep in the disc, it is then difficult to reach the HNP fragment. Left panel, the endoscopic view at the beginning of TELD. When the cannula is placed just underneath the HNP fragment, the fragment can then be pulled and taken out from inside the disc. HNP, herniated nucleus pulposus; TELD, transforaminal full-endoscopic lumbar discectomy

under C-arm fluoroscopic guidance, and thus it was difficult to insert the cannula into the neural canal. Several pioneers introduced the spinal endoscope into the PN technique [2–6]. Owing to these efforts, single-portal endoscopic discectomy was established [4–6] by Dr. Anthony Yeung. The technique was called percutaneous endoscopic discectomy (PED) by Japanese surgeons [7], because the origin of the procedure was PN. There have since been many reports on PED [4–8]. In Europe, the procedure was further developed and was called full-endoscopic discectomy (FED) [9–11]. Quite recently, a consensus was reached to call the procedure FED since the term "percutaneous" may cause confusion that the procedure is similar to the C-arm based non-endoscopic procedure. There are two established approaches into the spinal canal: transforaminal [4–8] and interlaminar [12–14].

The traditional approach in the full-endoscopic lumbar discectomy (FELD) technique would be transforaminal, now termed transforaminal endoscopic lumbar discectomy (TELD). In contrast, the interlaminar approach is called interlaminar endoscopic lumbar discectomy (IELD), and it basically requires the general anesthesia. We are preferring to perform the TELD procedure since it can be done under local anesthesia. Surgery under local anesthesia would be of benefit especially for elderly patients with poor general condition. In this review article, we introduce two kinds of TELD techniques, namely, the inside-out [4–8] and outside-in [15•,16] techniques.

Inside-out TELD

Surgical technique

In the inside-out technique, the cannula is first to inserted into the disc just underneath the herniated nucleus pulposus (HNP). Figure 1 (right panel) shows optimal positioning of the cannula of the inside-out technique. If the cannula is inserted deep in the disc, it will then be difficult to get the HNP fragment. Figure 1 (left panel) is the endoscopic view at the beginning of the TELD procedure. When the cannula is

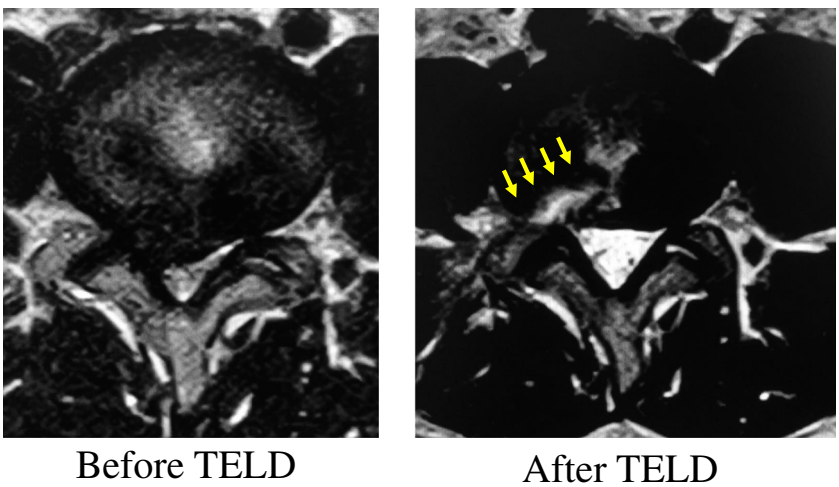

Fig. 2 MRI of L4/5 HNP case before and after TELD. The HNP fragment was completely removed without any complications; right panel, the trajectory of the cannula is clearly revealed as high signal intensity in the disc (yellow arrows). The fragment was removed from inside the disc. HNP, herniated nucleus pulposus; MRI, magnetic resonance imaging; TELD, transforaminal full-endoscopic lumbar discectomy

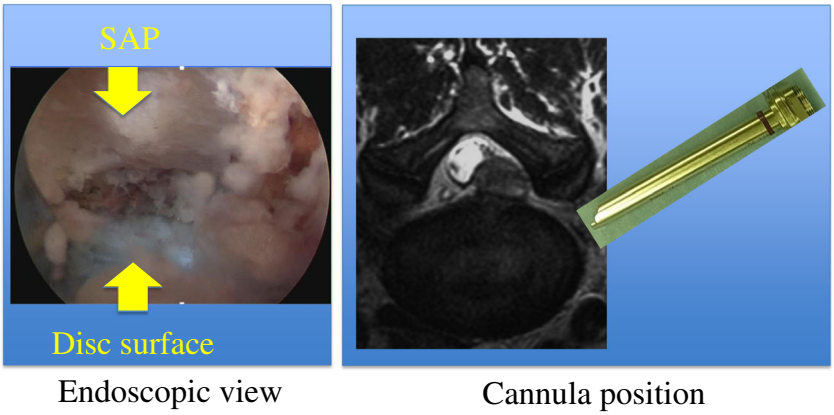

Fig. 3 Outside-in technique and endoscopic view. The cannula is placed on the disc surface and just outside of the intervertebral foramen. Right panel shows optimal positioning of the cannula for the outside-in technique. If the cannula is placed appropriately, the disc surface and SAP is seen endoscopically at 6 and 12 o′ clock (Left panel). SAP, superior articular process

placed just underneath the HNP fragment, it can then be pulled and taken out from inside the disc.

Figure 2 shows representative magnetic resonance images before and after TELD. This case is a male policeman who had severe low back and right leg pain for more than 6 months. Due to the pain, he could not drive a police car or ride a police motorbike. Conservative treatment did not effectively lessen his pain; thus, TELD was planned. The HNP fragment was completely removed surgically without any complications, and he returned to his full police duties job after the surgery. In Fig. 2 (right panel), the trajectory of the cannula is clearly revealed as high signal intensity in the disc (yellow arrows). The fragment was removed from the inside of the disc.

Clinical results

As described in the "Introduction," TELD (formerly PELD) was established early in the twenty-first century [4–6]. In Japan, it was introduced by Dezawa [7] in 2003. Most HNPs in the spinal canal are a good indication for TELD under local anesthesia, except for the intracanalicular type of HNP at L5-S with a high iliac crest. According to a review article by Gore and Yeung [17], clinical outcomes following TELD have been good, with almost 90% of patients reporting being satisfied with the results. In addition, Morgenstern et al. [18] investigated the learning curve for the procedure and found that a goal of 90% of good/excellent results for TELD could be reached after 72 cases. Birkenmaier et al. reviewed TELD in the literature [15•] and found that the clinical outcomes were similar as compared with traditional microsurgery techniques. However, they reported shorter operative times, less blood loss, less operative site pain, and faster postoperative rehabilitation/shorter hospital stay/faster return to work as benefits of FED.

Surgical complications of inside-out technique

Exiting nerve root injury (ENRI) is a specific troublesome complication of the transforaminal approach, which typically cannot occur with the interlaminar approach. In our initial 100 cases, 2% developed ENRI [19]. In cases with a narrow foramen, cannula insertion may likely cause ENRI, and the incidence ranges from 1% to 8.9% in the literature [20].

Another specific complication of FED is seizure [21], because the procedure requires a pressurized water irrigation system, which may raise the intracranial pressure. Clinical symptoms that precede the onset of seizures are neck pain and headache. We encountered two cases of neck pain during TELD among the initial 100 cases [19], and in such cases, we finalized the operation as fast as possible to prevent seizure.

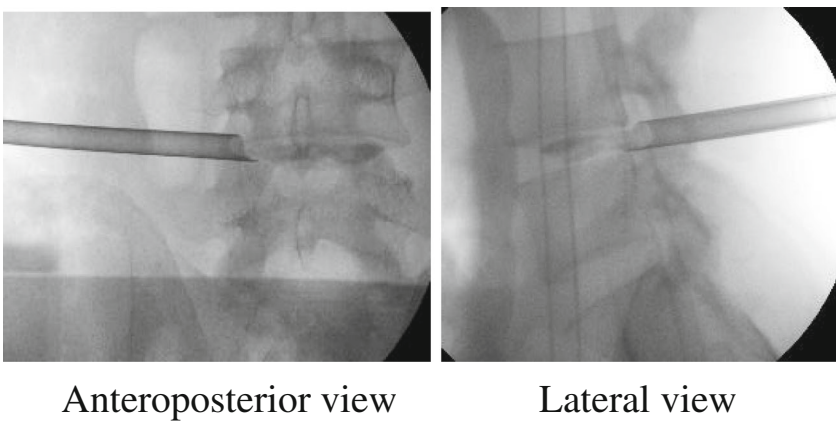

Fig. 4 Starting position of the cannula during the outside-in technique. The location of the cannula can be confirmed under the C-arm fluoroscopic guidance

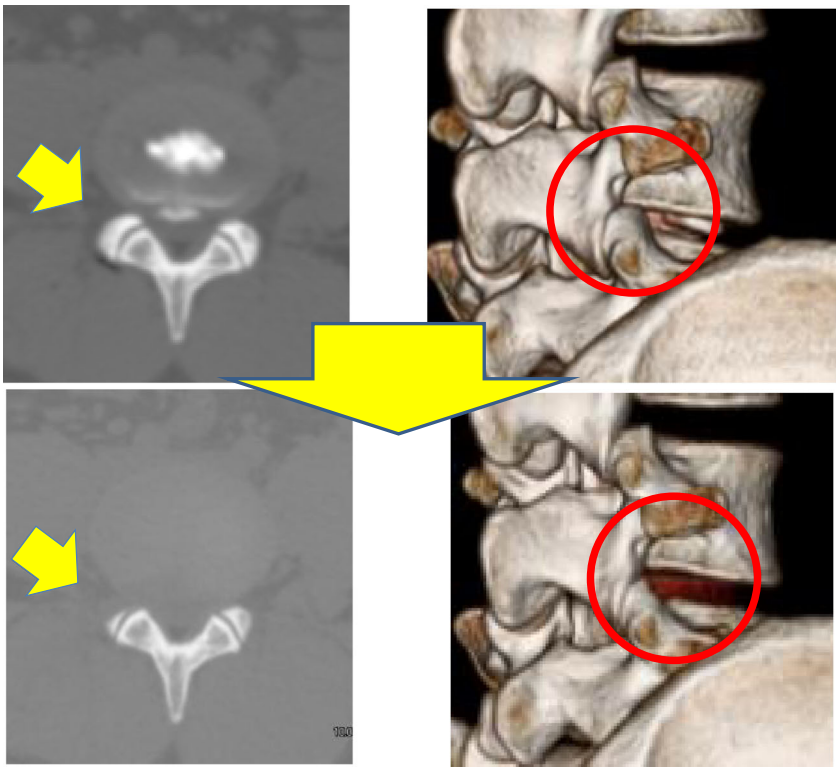

Fig. 5 Intervertebral foramen before and after foraminotomy. After shaving the tip of the SAP (yellow arrows), the narrow foramen becomes wider (red circles). Next, an 8-mm cannula can be safely inserted into the spinal canal through the widened space without pushing on the exiting nerve, preventing ENRI. ENRI, exiting nerve root injury; SAP, superior articular process

Surgeons should be aware of such symptoms and take steps to prevent major complications.

Outside-in TELD: foraminoplastic TELD

Surgical technique

In the outside-in technique, the cannula is placed on the disc surface and just outside of the intervertebral foramen. Figure 3 (right panel) shows optimal positioning of the cannula in the outside-in technique. As shown in Fig. 4, the location of the cannula can be confirmed under C-arm fluoroscopic guidance. If the cannula is placed appropriately, the disc surface and superior articular process (SAP) is endoscopically seen at 6 and 12 o′clock Fig. 3 (left panel). The first step in the outside-in technique would be enlargement of the foramen for safer insertion of the cannula into the spinal canal and foraminotomy [22] using a high-speed drill is the best technique for this purpose [23, 24].

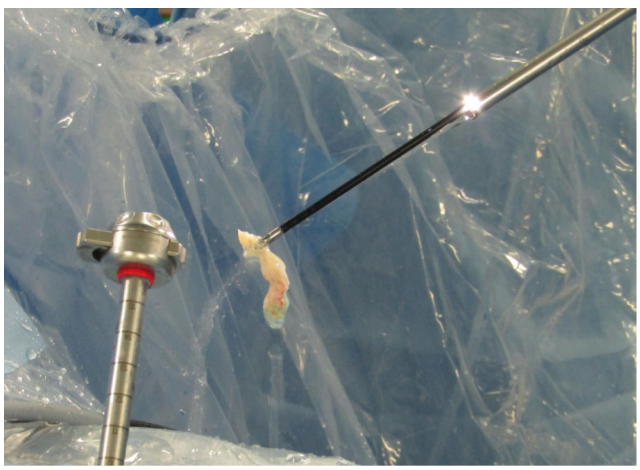

Fig. 6 Direct fragmentectomy. HNPs inside of the canal are visible and direct fragmentectomy is possible from outside of the canal sometimes after foraminoplasty

Figure 5 shows representative computed tomography (CT) scans before and after foraminotomy. One can easily understand that after shaving the tip of the SAP (yellow arrows), the hitherto narrow foramen becomes wider (red circles). Sometimes, after foraminoplasty, HNPs inside of the canal would become visible and direct fragmentectomy is then possible from the outside of the canal (Fig. 6). After this step, an 8-mm-cannula can be safely inserted into the spinal canal through the now sufficiently widened space without pushing on the exiting nerve, and so this procedure facilitates the prevention of ENRI.

Clinical results

In 2014, Lewandowski [25] reviewed 220 of his cases who had underdone the outside-in procedure. Interestingly, no surgery-related complications such as ENRI were observed. Henmi et al. [24] measured foraminal distance that is, the distance between the posterior edge of the disc and the ventral aspect of the facet joint, before and after foraminoplasty. They

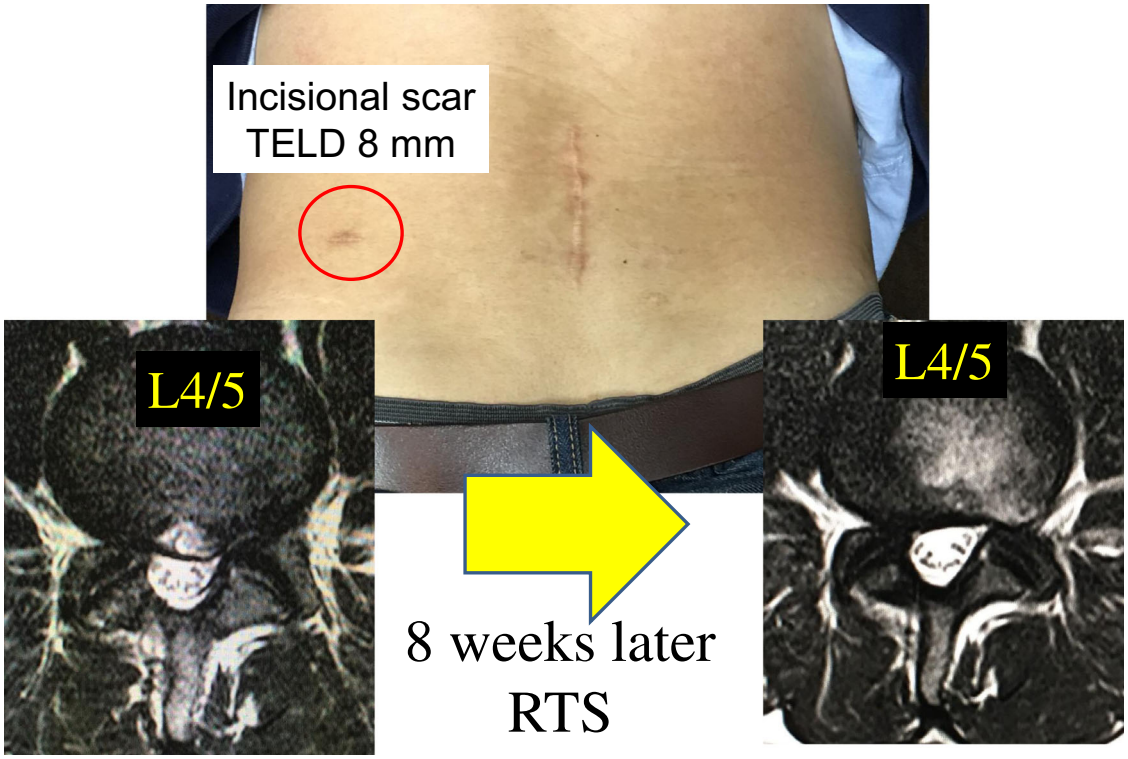

Fig. 7 Outside-in TELD in a rugby player following previous Love's surgery. Note the small skin incisional scar for TELD and the absence of HNP after the surgery on MRI. The patient could return to normal competitive sports activity following 8-week conditioning and rehabilitation. HNP, herniated nucleus pulposus; MRI, magnetic resonance imaging; TELD, transforaminal full-endoscopic lumbar discectomy

showed that the distance was less than 8 mm—the diameter of the cannula used in TELD—in most patients before the surgery. Conversely, it exceeded 8 mm after the foraminotomy, confirming that foraminoplasty can be effective in ENRI. We started performing the outside-in technique since 2017 and reviewed the initial 35 cases; no surgery-related complications including ENRI were seen [26].

Figure 7 shows representative images of a male patient with recurrence of HNP at L4/5. He had previously undergone traditional open discectomy or Love's technique. Note the small skin incisional scar for the TELD, with no HNP after the surgery as seen on MRI. With 8-week conditioning and rehabilitation, he returned to his normal level of competitive sports activity.

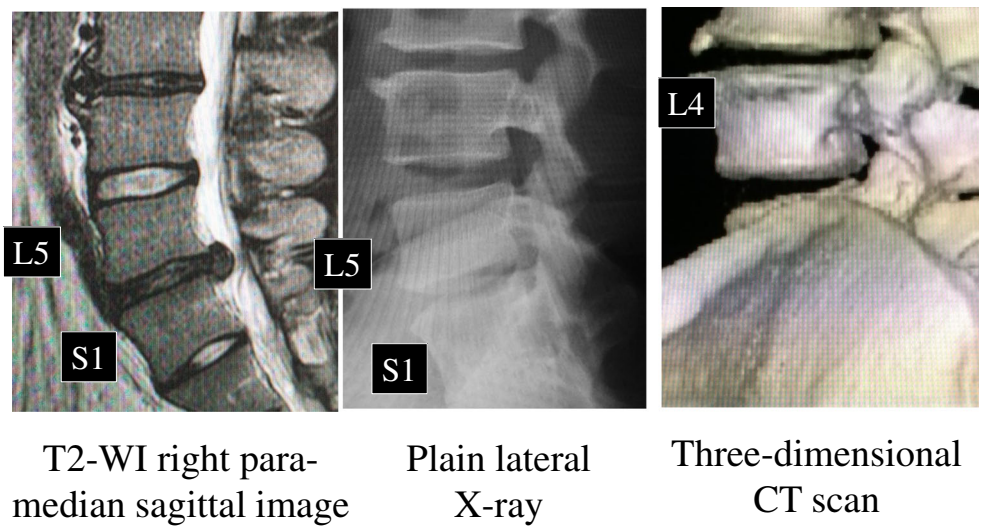

Fig. 8 Radiologic assessment in a case of L5/S HNP. MRI clearly shows HNP at L5/S. The intercristal line is seen at about the middle of the pedicle on lateral plain radiogram. 3D-CT scan shows that the disc at L5/S is completely covered by the iliac crest. 3D-CT, three-dimensional computed tomography; HNP, herniated nucleus pulposus; MRI, magnetic resonance imaging

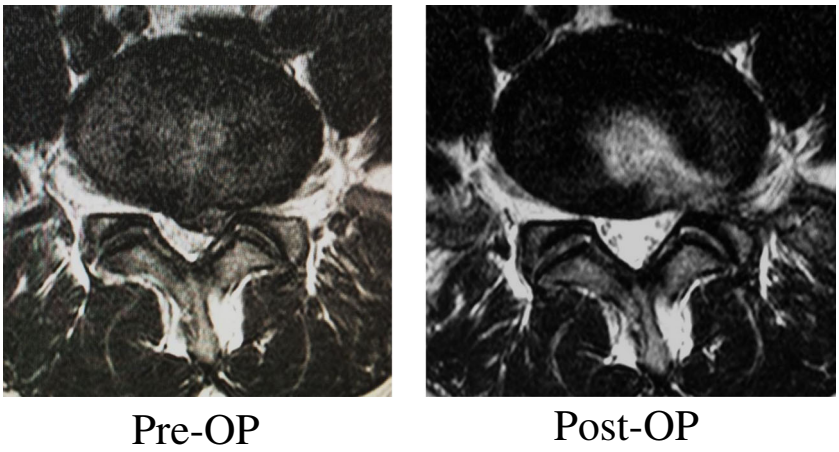

Fig. 9 MRI before and after outside-in TELD for a case of L5/S HNP. Note that the HNP is completely removed. The patient could return to competitive rugby 8 weeks after the surgery. HNP, herniated nucleus pulposus; MRI, magnetic resonance imaging; TELD, transforaminal full-endoscopic lumbar discectomy

Outside-in foraminoplastic TELD at L5-S

IELD was developed to access the spinal canal at L5/S with a high iliac crest, because the transforaminal approach was technically and anatomically difficult in such cases [12–14]. One of the great merits of TELD is what can be achieved under local anesthesia. IELD usually requires general anesthesia. Thus, even at L5/S, TELD under local anesthesia would be the best choice. As one of the pioneers of the full-endoscopic surgery, Dr. Anthony Yeung emphasized that even at L5/S with high iliac crest, the transforaminal approach can be used under local anesthesia.

Tezuka et al. reviewed 323 CT scans of the lumbo-sacral junction [27•]. They measured the trajectory angle of the TELD approach in relation to the pelvis and L5-S facet joint and found that the mean maximum angle of the trajectory was about 55 degrees in a Japanese population. It is believed that the angle should be over 65 degrees for successful TELD. The results showed that only about 10% and 30% of cases for male and female subjects, respectively, the angle was over 65 degrees. Thus, these values would indicate the operability of TELD at the L5/S level. Choi and Park [28] performed TELD in 100 cases of HNP at L5-S and foraminoplasty was required in 19 patients. Iliac crest height was significantly higher in the foraminoplasty group than in the non-foraminoplasty group, indicating that HNP at L5/S with high iliac crest may be suitable for foraminoplastic outside-in TELD.

Figure 8 shows a representative L5-S HNP case. MRI clearly shows HNP at L5/S. The intercristal line is about the middle of the pedicle on lateral plain radiogram. Three-dimensional (3D) CT scan shows the disc at L5/S completely covered by the iliac crest. However, as shown in Fig. 9, the HNP can be easily removed after foraminoplasty [29]. The patient in this case was a rugby player and he returned to his normal level of sports activity 8 weeks after the surgery.

Conclusion

In this paper, we described two types of TELD under local anesthesia, i.e., the inside-out and outside-in techniques. The procedure only requires an 8-mm skin incision and is thus the least invasive disc surgery. The TELD procedure is still being developed further, and its application is being expanded. For now, the technique has been applied for foraminal and lateral recess stenosis [30•]. Other types of minimally invasive surgery that can be performed under local anesthesia would be of benefit for elderly patients in aging communities.

Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent

This article does not contain any studies with human or animal subjects performed by any of the authors.

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