

Outside-in Technique for Transforaminal Full-Endoscopic Lumbar Discectomy Under Local Anesthesia: A Review Article

Junzo Fujitani and Koichi Sairyo*

Department of Orthopedics, Tokushima University, Tokushima, Japan

***Corresponding Author:** Koichi Sairyo, Professor and Chairman, Department of Orthopedics, Tokushima University Graduate School, Tokushima, Japan.

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Abstract

Transforaminal full-endoscopic lumbar discectomy (TF-FELD) was first introduced more than 20 years ago, followed by interlaminar full-endoscopic lumbar discectomy (IL-FELD). Both TF-FELD and IL-FELD require only an 8-mm skin incision and damage to the back muscles is minimal. Thus, these methods are the least invasive disc surgery at present. However, unlike the interlaminar method, the transforaminal method can be performed under the local anesthesia, which is its biggest advantage. Although an inside-out approach after foraminoplasty was initially recommended, an outside-in approach has recently been proposed for safety reasons. This technique is less invasive and allows an early return to the original level of activity. TF-FELD has also been used in athletes because of its minimal invasiveness. It was initially thought that the transforaminal approach would be difficult to perform at L5/S1, so the interlaminar approach was recommended. However, with the advent of foraminoplasty, TF-FELD is now possible even at L5/S1. This review article explains the TF-FELD technique in detail.

Keywords: *Transforaminal Full-Endoscopic Lumbar Discectomy; Herniated Nucleus Pulposus; Foraminoplasty; Outside-In Technique*

Introduction

More than 20 years ago, full-endoscopic disc surgery became possible as a result of the considerable efforts of pioneering spinal surgeons [1-6]. Anthony Yeung was one of the leaders in the development of this technique and demonstrated the usefulness of the transforaminal (TF) approach [4-6]. However, for anatomical reasons, discectomy via the TF approach was considered technically demanding at the L5/S1 level [7]. With the advent of the full-endoscopic system in 2006, an interlaminar (IL) approach became possible [8,9]. Spinal surgeons were already familiar with endoscopic views from traditional surgery and use of this approach enabled decompression for stenosis [10].

The main difference between the TF and IL approaches is the type of anesthesia required. TF full-endoscopic surgery can be performed under local anesthesia, which is a major advantage for patients with a poor general condition [11]. In an aging society like Japan, it would be beneficial if the indications for TF surgery could be broadened to include a greater number of spinal disorders. Nowadays, TF surgery under local anesthesia can be performed for foraminal stenosis [12], lateral recess stenosis [13], central stenosis [14], discogenic pain [15] and type 1 Modic change [16].

In this review, we explain the basic surgical technique used in the outside-in TF full-endoscopic spine surgery, taking up discectomy as an example.

Outside-in procedure

The inside-out technique was performed initially. However, there was some concern about the potential for exiting nerve root injury (ENRI) because of the need to insert a cannula into the narrow foramen when using this approach [17,18]. Therefore, an outside-in approach is recommended that allows the narrow foramen to be enlarged so that the cannula can be inserted safely.

Using the outside-in technique, the cannula is placed on the disc surface just outside the intervertebral foramen. The optimal positioning of the cannula when using the outside-in technique is shown in the right panel of figure 1, and the location of the cannula can be confirmed under C-arm fluoroscopic guidance. If the cannula is placed appropriately, the disc surface is seen endoscopically at 6 o'clock and the superior articular process at 12 o'clock (Figure 1, left panel). The first step in the outside-in technique is enlargement of the foramen for safer insertion of the cannula into the spinal canal. Henmi, *et al.* [19] measured the foraminal distance (between the posterior edge of the disc and the ventral aspect of the facet joint) before and after foraminoplasty. They demonstrated that the distance before foraminoplasty was usually less than 8 mm, which is the diameter of the cannula used in TF surgery. However, this distance was greater than 8 mm after foraminotomy, thus allowing safe insertion of the cannula without ENRI.

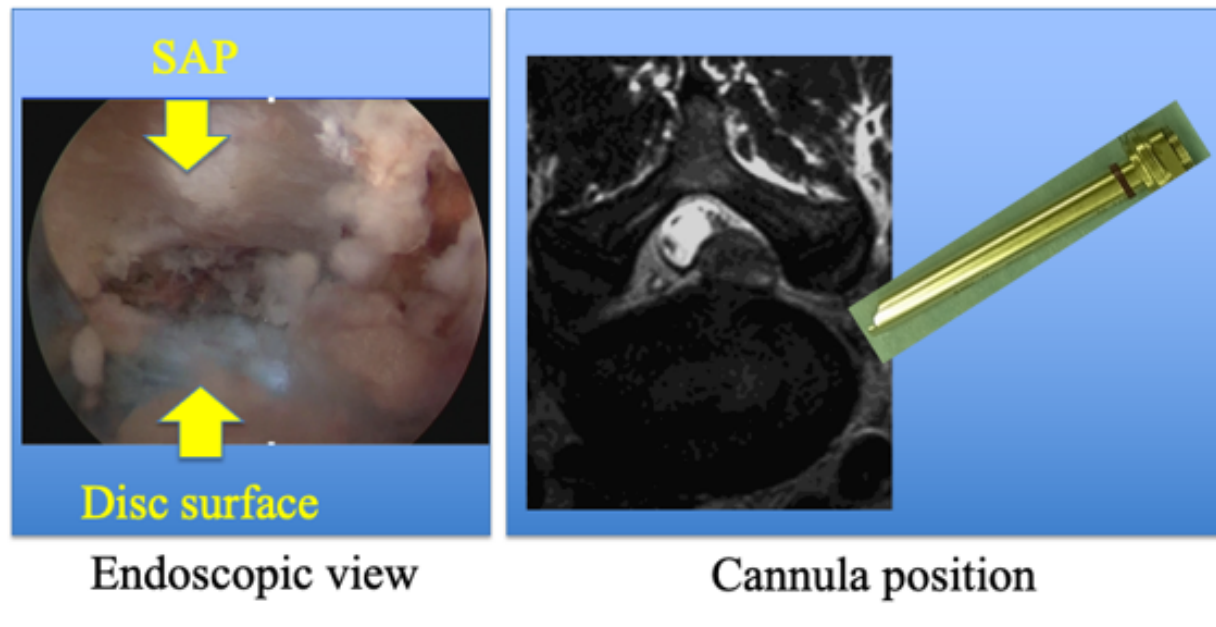


Figure 1: Outside-in technique and endoscopic view. The cannula is placed on the disc surface just outside the intervertebral foramen. The right panel shows the optimal positioning of the cannula when using the outside-in technique. If the cannula is placed appropriately, the disc surface is seen endoscopically at 6 o'clock and the superior articular process at 12 o'clock.

Figure 2 shows representative computed tomography (CT) scans obtained before and after foraminotomy. After shaving the tip of the superior articular process (yellow arrows), the narrow foramen becomes wider (red circles). After this step, an 8-mm cannula can be safely inserted into the spinal canal through the now sufficiently widened space without pressing on the exiting nerve, thereby avoiding ENRI.

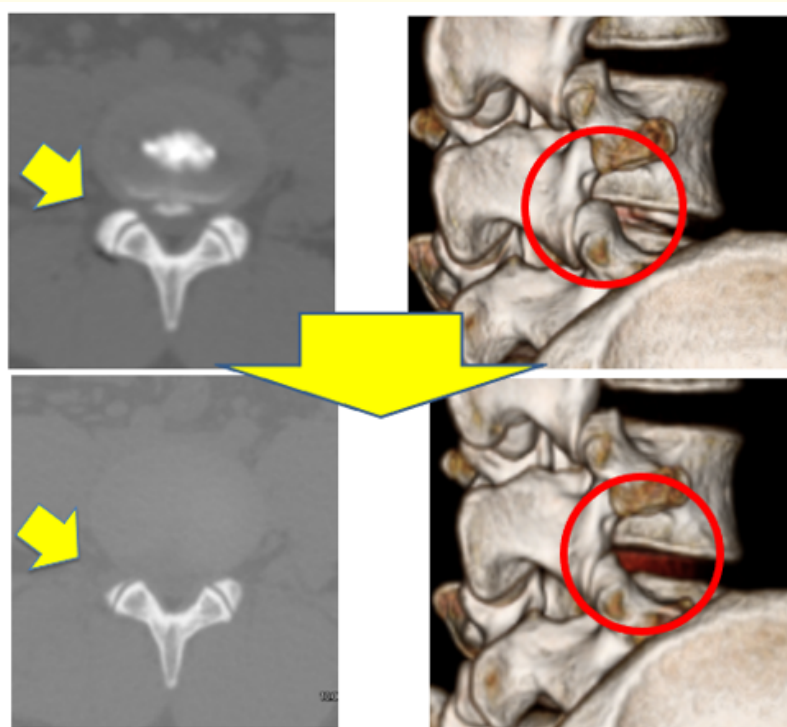


Figure 2: The intervertebral foramen before and after foraminotomy. After shaving the tip of the superior articular process (yellow arrows), the narrow foramen becomes wider (red circles).

In 2014, Lewandrowski reviewed 220 patients who had undergone the outside-in procedure and found no surgery-related complications, including ENRI [20]. We have been performing the outside-in technique since 2017 and a review of our first 35 cases similarly did not find any surgery-related complications [21].

Figure 3 shows representative images for a male professional baseball player with herniated nucleus pulposus (HNP) and a discal cyst at L4/5. Foraminoplasty was performed using the outside-in technique. The cyst was visible endoscopically. The wall of the cyst ruptured during removal of the HNP fragments.

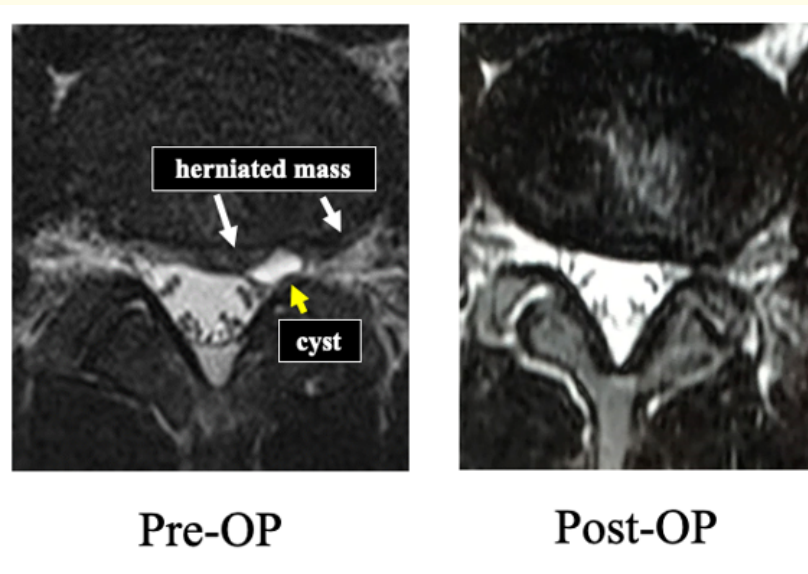


Figure 3: Application of the outside-in technique in a patient with herniated nucleus pulposus and a discal cyst. After foraminoplasty was performed, the cyst appeared in the endoscopic view. The wall of the cyst ruptured when the herniated nucleus pulposus fragments were removed.

Return to work and playing sport

Birkenmaier, *et al.* reviewed the literature [22] and reported that the clinical outcomes were similar to those of conventional microsurgical techniques. However, they also found shorter operating times, less blood loss, and less severe pain at the surgical site and identified the benefits of full-endoscopic surgery to be more rapid postoperative rehabilitation, a shorter hospital stays, and an earlier return to work. Lewandrowski, *et al.* [23] retrospectively reviewed 442 cases and also documented a comparatively rapid return to the original level of activity after TF full-endoscopic surgery. They also demonstrated that ENRI was a risk factor for delayed return to normal activity. Therefore, every effort should be made to avoid ENRI.

Sugiura, *et al.* reported the case of a male dentist who underwent full-endoscopic discectomy and lateral recess decompression (ventral facetectomy) for bilateral lateral recess stenosis due to central disc herniation. His leg pain disappeared immediately after surgery, and he was able to return to work 5 days later [24]. Fujii, *et al.* [25] reported similar outcomes in 6 physicians who underwent full-endoscopic surgery.

Takeuchi, *et al.* [26] reviewed 50 cases of TF full-endoscopic spine surgery (TF-FESS) and found that the median time to return to work was 21 days. More than half of the patients returned to work within 21 days and 12 (24%) did so within 7 days. Therefore, TF-FESS has the benefit of allowing a rapid return to work, most likely due to its minimal invasiveness.

TF-FESS involves minimal damage to the back muscles and has been used in athletes with a variety of spinal conditions [27-32]. Yamaya, *et al.* [29] performed TF-FESS in 18 high-school athletes with HNP, 94.4% of whom were able to return to their original competitive level, typically within 7 weeks after surgery. Maeda, *et al.* [31] performed TF-FESS in 5 professional baseball players. The surgery was performed in the off-season in 3 patients, all of whom returned to playing at a professional level at the start of the following season. The remaining 2 patients underwent surgery just before the start of the season and returned to playing baseball 2-3 months after surgery having lost only 1 month of competitive play. These reports indicate that TF-FESS would be of great benefit for athletes, particularly those playing at a professional level. Figure 4 shows representative images for a male professional handball player who underwent removal of HNP by TF-FESS and returned to playing at his original competitive level 2 months later.

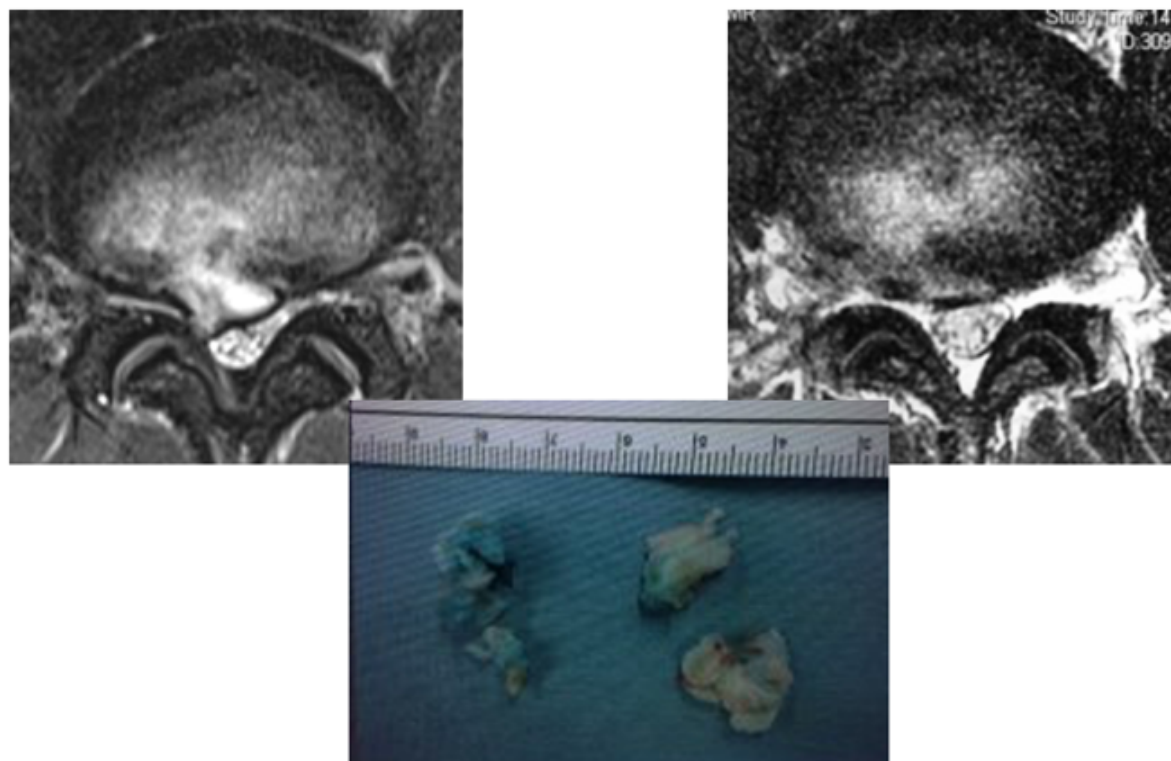


Figure 4: Transforaminal full-endoscopic discectomy was performed in a professional handball player. A herniated nucleus pulposus was removed by transforaminal full-endoscopic spine surgery. The patient returned to his original level of competitive activity 2 months after surgery.

HNP at the L5/S1 level

Figure 5 demonstrates an HNP at the L5/S1 level. A three-dimensional CT scan (Figure 5, right panel) clearly showed that the disc was completely covered with pelvic bone, which meant that TF-FESS would have been anatomically difficult. Therefore, interlaminar FESS was used to access the spinal canal at L5/S1 [8,9]. Tezuka, *et al.* measured the trajectory of the TF-FESS approach in relation to the pelvis and the facet joint at L5/S1 on 323 CT scans of the lumbosacral junction [7] in a Japanese population and found that the mean maximum angle was about 55°. It is thought that the angle should be greater than 65° for successful TF-FESS. In their series, the angle was over 65° in only about 10% of men and 30% of women. These values indicate that TF-FESS is not usually feasible at the L5/S1 level without foraminotomy (Figure 6). Gotecha, *et al.* [33] reviewed 120 patients with HNP and identified 8 cases at L5/S1 that could not be treated by TF-FESS, suggesting that HNP at L5/S1 would not be a good indication for this procedure.

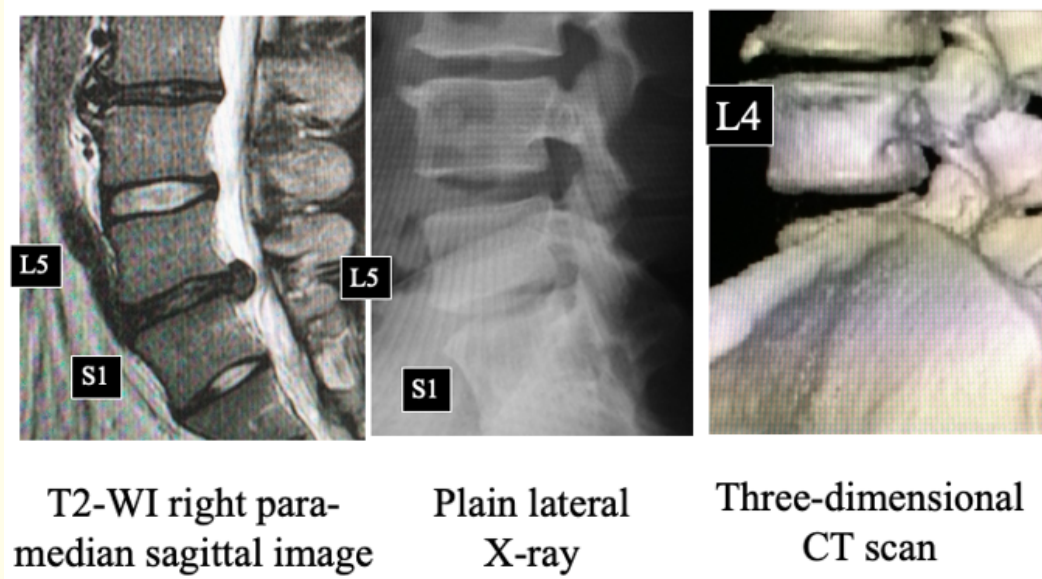
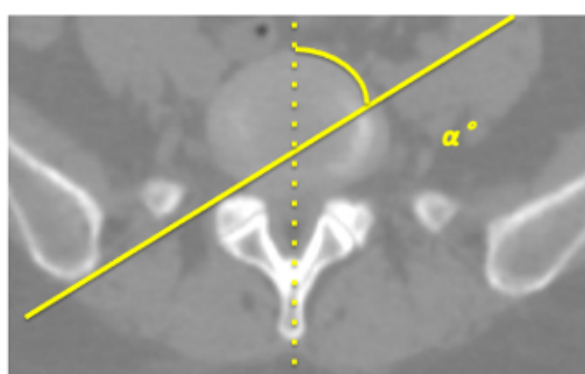


Figure 5: A three-dimensional computed tomography scan showing the relationship between the iliac crest and a herniated nucleus pulposus at L5/S1. The disc at L5/S1 is completely covered with pelvic bone, which made transforaminal full-endoscopic spine surgery anatomically difficult.



323 Japanese population
 Mean alpha angle: 55 degree

Operability
 (more than 65 degree)
 Male: 10%
 Female: 20%

Figure 6: Feasibility of transforaminal full-endoscopic discectomy at L5/S1. Analysis of 323 computed tomography scans indicated that the trajectory (alpha) angle in transforaminal full-endoscopic spine surgery is about 55° in a Japanese population. Transforaminal full-endoscopic discectomy is possible at the L5/S1 level without foraminotomy in only about 10% of men and 30% of women.

TF full-endoscopic discectomy became possible when the outside-in foraminoplasty method entered more widespread use. Lewandrowski, *et al.* [20] performed outside-in TF surgery in 220 cases, 62 of which were for HNP at L5/S1. They found that they could remove the fragment successfully with TF full-endoscopic surgery without ENRI.

Figure 7 illustrates the case of a professional female golfer with HNP at L5/S1 (the yellow dotted line in this figure indicates the trajectory of the TF-FESS approach). The HNP fragment was obscured by the iliac crest and thus was difficult to access directly. After foraminoplasty, the HNP could be removed (Figure 8) and she returned to playing golf 2 months later.

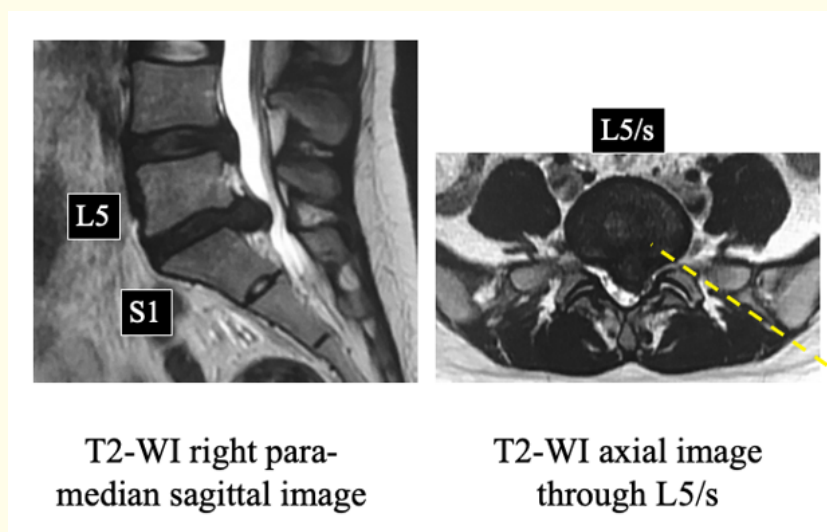


Figure 7: Images for a professional female golfer with a herniated nucleus pulposus at the L5/S1 level. The yellow dotted line indicates the trajectory of the transforaminal full-endoscopic spine surgery approach. The herniated nucleus pulposus fragment was obscured by the iliac crest and thus was difficult to access directly.

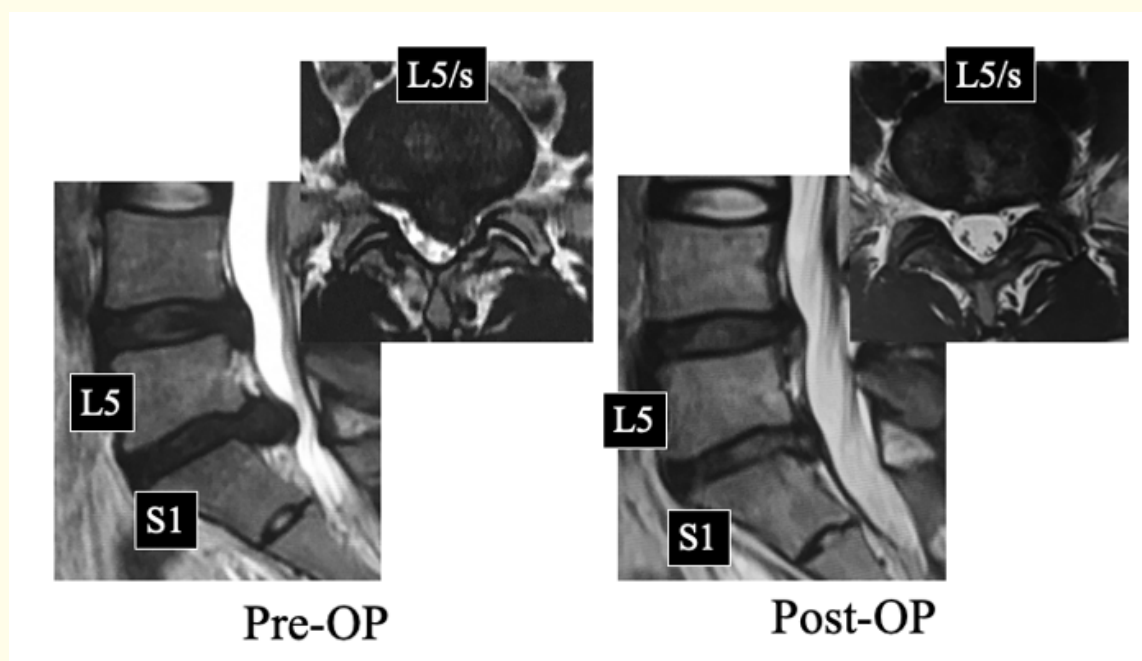


Figure 8: Magnetic resonance images obtained before and after transforaminal full-endoscopic spine surgery in a professional golfer. A herniated nucleus pulposus was able to be removed after foraminoplasty. Two months later, the patient returned to playing golf.

Conclusion

In this review, we have explained TF full-endoscopic lumbar discectomy. This technique requires only an 8-mm skin incision and involves minimal damage to the back muscles. The TF and IL methods are the least invasive approaches for disc surgery at present. Furthermore, the TF method can be performed under local anesthesia, which is very advantageous. The outside-in technique has recently been recommended given that it is minimally invasive and allows an early return to the original activity level. Nowadays, the foraminoplasty is widely performed and has enabled TF full-endoscopic lumbar discectomy even at the L5/S1 level.

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