Historical Consideration for Transforaminal Endoscopy for Lumbar Spine

Seong Kyun Jeong and Sang-Ho Lee

1 Introduction

In today's various surgical fields, endoscopic therapy plays a prominent role. Numerous surgeries performed with the naked eye in the past have achieved the same or better results using an endoscope. As in other surgical departments, spine surgery has continued to strive for the use of endoscopes for treatment. With the development of optical technology, imaging devices, and surgical instruments, and the passionate dedication of the various spine surgeons, endoscopic spine surgery (ESS) has made many advances over the past half-century. Minimizing damage to normal structures and effectively removing only lesions through spinal endoscopy helps patients recover quickly and return to daily life early while relieving patients from unnecessary worries and anxiety about the sequelae of surgery. Furthermore, it encourages patients not to hesitate to choose the appropriate surgical treatment.

The transforaminal approach is historically the most fundamental endoscopic approach among the endoscopic approaches ever been made. It is the most faithful to the minimally invasive principles and has various advantages in removing lesions. The transforaminal approach utilizes the original anatomy of the spine to its fullest extent. It allows direct access to the dorsal root ganglion, the fundamental cause of low back pain and radiating pain, by directly checking the inside of the intervertebral disc, epidural space, nerve tissue, and facet joint area.

In this chapter, we will discuss the invention of the transforaminal approach, the development of the transforaminal endoscopic spine surgery, and the spine surgeons who contributed to the ESS.

2 The Invention of the Transforaminal Approach (Before the 1990s)

Before endoscopic treatment was invented, there have been attempts to percutaneously examine spinal lesions and treat them nonsurgically using a posterolateral approach such as percutaneous biopsy, discography, and chemonucleolysis. However, after Parviz Kambin's achievements, proper percutaneous surgical treatment of intervertebral disc was possible. Confirming the concept of an accessible, reproducible, and neurologically safer corridor was a monumental event in the history of endoscopic spinal surgery (ESS).

S. K. Jeong · S.-H. Lee (✉)
Department of Neurosurgery, Chungdam Wooridul Spine Hospital, Seoul, Republic of Korea
e-mail: sh500909@wooridul.co.kr

S.-H. Lee et al. (eds.), *Transforaminal Endoscopy for Lumbar Spine*,
https://doi.org/10.1007/978-981-19-8971-1_1

Open discectomy following laminectomy was the standard treatment for disc herniation before and long after Kambin. The surgery was performed using a midline or paramedian approach. It required damage to paraspinal muscles, laminar, and facet joint structures to secure a field of view to identify and remove the herniated intervertebral discs. In addition, acceleration of disc degeneration by removing the nucleus pulposus was a common concern of spine surgeons performing open disc surgery (Fig. 1). In particular, spine surgery in historically earlier periods targeted patients with more severely degenerated diseases. In contrast, later spine surgery targeted more patients who only complained of pain and did not develop severe neurological deficits. It was essential to have an operation that caused as few sequelae as possible.

Several spine surgeons have studied alternative surgical methods that avoid the midline or paramedian approach. In 1951, Hult reported a nucleotomy using an anterolateral abdominal extraperitoneal approach [1]. In 1975, Hijikata performed nonvisualized percutaneous nucleotomy using a posterolateral approach [2].

Kambin and his colleagues have studied methods and devices to reach the posterior surface of an intervertebral disc through a posterolateral approach since the mid-1970s. He performed the first percutaneous decompression of an intervertebral disc using the Craig cannula in 1973 [3]. In 1982, he performed percutaneous posterolateral discectomy on nine patients and reported the results of suctioning fragments from the dorsal portion of the discs using high negative pressure. Kambin's research and experience of the posterolateral approach without passing through the central spinal canal led to the first description of "the triangular working zone" in 1988 [4]. It inspired many pioneering spine surgeons to develop new surgical treatments. For spine surgeons seeking new treatments, discovering a safe passage to the intervertebral disc was like Vasco da Gama's discovery of the sea route to India.

Fig. 1 Preoperative X-ray image of a patient who underwent conventional discectomy on L4–5 level (left). Two years and eight months later, the disc height was significantly decreased to cause lower back pain (right)

3 The Beginning of the Endoscopic Spine Surgery (the 1990s)

ESS began in the 1990s. After Parviz Kambin reported on a "safe triangular working zone" on the verge of the 1990s, with the addition of advances in surgical instruments and imaging devices, ESS was finally realized. Early in the history of ESS, the primary attention was focused on the intervertebral disc.

Before introducing ESS, percutaneous treatment for intervertebral discs was a blind method rather than directly viewing a fragmented disc. It was an indirect method of decompression of the center of the intervertebral disc. In 1985 Onik performed automated percutaneous nucleotomy [5]. After crushing the inside of the nucleus pulposus by a mechanical method, they were washed with saline. It was difficult to expect a high success rate due to limited indications. Still, it was an alternative treatment modality that provided a percutaneous surgical method without anaphylaxis, which was the significant side effect of chemonucleolysis.

The most significant advantage of endoscopic surgery is that lesions can be treated while closely visualizing in the surgical field. It was needed to differentiate between lesions and normal tissues to achieve the goal. As the experience of percutaneous treatment has been accumulated, several ideas have been reported that can lead to the birth of percutaneous endoscopic disc surgery around 1990. Kambin reported intraoperative discoscopic views of herniated nucleus pulposus (HNP) in 1988 [6], and Schriber in 1989 injected indigo carmine, which can stain a normal nucleus and annular fissure into an intervertebral disc [7]. In 1991 Leu and Karl Storz developed a foraminoscope. Their method, called "discoscopy," introduced an arthroscope from the contralateral side of the lesion, allowing direct visualization of intradiscal operative procedures. Leu's foraminoscope contributed to the development of early endoscopy for a long time.

Mayer and Brock first used the term "percutaneous endoscopic lumbar discectomy (PELD)" in 1993 [8]. They used a bilateral biportal approach, similar to the Leu method. They removed the intervertebral disc fragments using an automated nucleotome and rigid or flexible forceps while observing the posterior aspect of the fibrous annulus inside the intervertebral disc.

A method of treating the ipsilateral side of the lesion using an endoscope and surgical instruments like the current transforaminal ESS was reported in 1996. Mathews in 1996 and Ditsworth in 1998 performed transforaminal ESS using a working channel scope [9]. In 1996, Kambin and Zhou also reported transforaminal arthroscopic decompression of lateral recess stenosis [10]. From these, transforaminal ESS was initiated.

SH Lee, the coauthor of this chapter and the founder of Wooridul Spine Hospital (WSH), also pioneered ESS since 1991. He reported his experiences of the percutaneous endoscopic manual and laser discectomy at the 19th SICOT World Congress in 1993. He published the result in the *Orthopade*, a surgical journal in Germany, in 1996 [11]. He established the concept of "intraannular subligamentous fragmentectomy" using Ho:YAG laser. With Martin Knight and Anthony Yeung, SH Lee was invited to the American Minimally Invasive Surgery Conference in 2000 and presented his surgical method. He frequently cooperated with Kambin from the beginning and devoted his whole life to expanding ESS fundamentals worldwide (Fig. 2).

Fig. 2 Parviz Kambin and Sang Ho Lee in 1992

4 Development of Endoscopic Spine Surgery (Since 2000)

In the 2000s, two important endoscopic techniques by Anthony Yeung and Thomas Hoogland were reported (Fig. 3).

In 2002, Yeung and Tsou reported an endoscopic disc surgery using a rigid rod-lens, integrated, multichannel, and wide-angled endoscope. Anthony Yeung's surgical method was known as the "inside-out" technique due to the starting position being the inside of the discs. He developed the Yeung Endoscopic Spine System (YESS) with Wolf Company of Illinois [12].

In 2005, Schubert and Thomas Hoogland reported a surgical technique using the Thomas Hoogland Endoscopic Spine System (THESSYS). They performed foraminoplasty using a specialized reamer before removing disc particles, so their surgical method was known as the "outside-in" technique.

The two methods have become the most famous endoscopic techniques soon. Many doctors have reproduced their surgical procedures. Each method has strengths in treating prolapsed intervertebral discs through the inside of the intervertebral disc (YESS) and resolution of foraminal stenosis through foraminoplasty (THESSYS).

Spine doctors at WSH, including the author SH Lee, used the "half-and-half" technique that improved the "inside-out" technique [13]. This method was a way to see the inside of the intervertebral disc with half of the field of view and the epidural space with the other half of the field of view. As trained doctors from WSH spread nationally, this method became widely accepted, especially in Korea (Fig. 4).

Since 2000, ESS has gradually expanded the scope of decompression surgery. In 2004, Ahn et al. of the WSH group reported the usefulness of ESS for the treatment of recurrent HNP [14]. In 2008, the same group, Choi et al., reported that highly migrated intracanal disc herniations could be treated using a foraminoplastic technique using a rigid working channel endoscope [15].

In addition, transforaminal approach methods have also become more diverse. In 2005, Rutten reported a technique called full endoscopy through extreme lateral access to overcome the

Fig. 3 Martin Knight, Anthony Yeung, and Thomas Hoogland (in order from the left)

Fig. 4 The participants of the Spine Total Care Conference, 2002. Martin Knight, Sang Ho Lee, and Reuven Gepstein are sitting in the front line (in order from the left)

usual transforaminal approach, which is associated with problems in reaching the epidural space directly with unhindered vision [16].

Transforaminal ESS has been further developed. The decompression range is now available in various types of HNP, including low- and high-grade migrated HNP, huge central HNP, calcified or hard HNP, foraminal HNP, extraforaminal HNP, and recurrent HNP. It also can treat foraminal and lateral recess stenosis.

Since the mid-2010s, transforaminal endoscopic fusion surgery has also been reported [17].

In 2018, the U.S. government and academic societies approved medical insurance coverage for endoscopic disc treatment, which Kambin and Leu initiated with the International Society of Minimally Invasive Spinal Surgery (ISMISS). At the University of Miami Hospital and the training hospitals of Yale School of Medicine, endoscopic surgery was included in the regular spine doctor training program. In 2019, the North American Spine Society also had this surgery in the formal educational program.

5 Summary

Based on the advances in optical technology, imaging devices, surgical instruments, and the passionate dedication of many spine surgeons, ESS has made much progress. Only a limited portion of the prolapsed intervertebral disc inside the spinal canal could be removed in the earlier period of ESS. For the past half-century, ESS has expanded its indications to treat a broader range of diseases. The transforaminal approach is the most fundamental approach for endoscopic treatment and is most faithful to the minimally invasive principle. It is possible to solve the pain caused by compressive lesions inside and outside the intervertebral foramen. The ESS removes the cause of the disease without tissue damage, helps the patient recover quickly and return early, and encourages the patient to receive the necessary treatment in time without sequelae. It is an approved treatment recognized by the U.S. government, academic societies, and medical training institutes. Spine surgeons must acquire and further develop transforaminal ESS skills for their patients.

References

1. Hult L. Retroperitoneal disc fenestration in low-back pain and sciatica; a preliminary report. Acta Orthop Scand. 1951;20(4):342–8.
2. Hijikata S. Percutaneous nucleotomy. A new concept technique and 12 years' experience. Clin Orthop Relat Res. 1989;238:9–23.
3. Kambin P. Arthroscopic microdiscectomy. Arthroscopy. 1992;8(3):287–95.
4. Kambin P, Zhou L. History and current status of percutaneous arthroscopic disc surgery. Spine. 1996;21(24 Suppl):57s–61s.
5. Onik G, Helms CA, Ginsberg L, Hoaglund FT, Morris J. Percutaneous lumbar diskectomy using a new aspiration probe: porcine and cadaver model. Radiology. 1985;155(1):251–2.
6. Kambin P, Nixon JE, Chait A, Schaffer JL. Annular protrusion: pathophysiology and roentgenographic appearance. Spine. 1988;13(6):671–5.
7. Schreiber A, Suezawa Y, Leu H. Does percutaneous nucleotomy with discoscopy replace conventional discectomy? Eight years of experience and results in treatment of herniated lumbar disc. Clin Orthop Relat Res. 1989;238:35–42.
8. Mayer HM, Brock M. Percutaneous endoscopic lumbar discectomy (PELD). Neurosurg Rev. 1993;16(2):115–20.
9. Ditsworth DA. Endoscopic transforaminal lumbar discectomy and reconfiguration: a posterolateral approach into the spinal canal. Surg Neurol. 1998;49(6):588–97; discussion 97–8
10. Kambin P, Casey K, O'Brien E, Zhou L. Transforaminal arthroscopic decompression of lateral recess stenosis. J Neurosurg. 1996;84(3):462–7.
11. Lee SH, Lee SJ, Park KH, Lee IM, Sung KH, Kim JS, et al. Comparison of percutaneous manual and endoscopic laser diskectomy with chemonucleolysis and automated nucleotomy. Der Orthopade. 1996;25(1):49–55.
12. Yeung AT, Tsou PM. Posterolateral endoscopic excision for lumbar disc herniation: surgical technique, outcome, and complications in 307 consecutive cases. Spine. 2002;27(7):722–31.
13. Lee S, Kim SK, Lee SH, Kim WJ, Choi WC, Choi G, et al. Percutaneous endoscopic lumbar discectomy for migrated disc herniation: classification of disc migration and surgical approaches. Eur Spine J. 2007;16(3):431–7.
14. Ahn Y, Lee SH, Park WM, Lee HY, Shin SW, Kang HY. Percutaneous endoscopic lumbar discectomy for recurrent disc herniation: surgical technique, out-

come, and prognostic factors of 43 consecutive cases. Spine. 2004;29(16):E326–32.
15. Choi G, Lee SH, Lokhande P, Kong BJ, Shim CS, Jung B, et al. Percutaneous endoscopic approach for highly migrated intracanal disc herniations by foraminoplastic technique using rigid working channel endoscope. Spine. 2008;33(15):E508–15.
16. Ruetten S, Komp M, Godolias G. An extreme lateral access for the surgery of lumbar disc herniations inside the spinal canal using the full-endoscopic uniportal transforaminal approach-technique and prospective results of 463 patients. Spine. 2005;30(22):2570–8.
17. Lee SH, Erken HY, Bae J. Percutaneous transforaminal endoscopic lumbar interbody fusion: clinical and radiological results of mean 46-month follow-up. Biomed Res Int. 2017;2017:3731983.