Percutaneous endoscopic posterior lumbar interbody fusion(PEPLIF): technical note

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Keywords: Posterior; Endoscopy; Lumbar; Interbody fusion

Posted Date: March 10th, 2020

DOI: <https://doi.org/10.21203/rs.3.rs-16241/v1>

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Abstract

Background: Endoscopic lumbar interbody fusion is based on endoscopic lumbar discectomy, a well-established and widely used clinical procedure. Endoscopic lumbar interbody fusion has several key advantages over other types of procedures, including that it is minimally invasive, more precise, safer, and provides better visualization. Most surgeons use the transforaminal approach for this surgery. Here, we report the first percutaneous endoscopic posterior lumbar interbody fusion (PEPLIF).

Methods: The authors introduce the PEPLIF technique with step by step instructions and describe key procedures in detail. Tips for controlling hemorrhages and avoiding complications during the procedure are presented. The authors also discuss the indications and advantages of applying the PEPLIF technique.

Results: PEPLIF is a repeatable lumbar fusion technique.

Conclusions: PEPLIF is a feasible and effective technique for the fusion of L4-5 and L5-S1 (especially L5-S1). All procedures are completed in full using endoscopy without replacing the cannula. The endoscopic view is similar to that of an open posterior lumbar interbody fusion, thus reducing the learning curve.

Introduction

The posterior lumbar interbody fusion (PLIF) method of spinal fusion was introduced more than a half century ago in 1952 by Cloward. Fusion is considered to be the gold standard treatment for a variety of lumbar degenerative diseases[1]. Although many patients eventually recover fully following PLIF, the psychological and physical effects and potential complications that can arise during the postoperative period can slow or diminish the extent of patient recovery. To help address this, minimally invasive procedures were gradually developed as technology and instrumentation improved. To date, there are many new types of lumbar fusion surgery, including anterior lumbar interbody fusion (ALIF), lateral lumbar interbody fusion (LLIF), oblique lateral lumbar interbody fusion (OLIF), and transforaminal lumbar interbody fusion (TLIF). Aside from TLIF, all of these methods achieve only indirect spinal decompression, so these methods are only relevant for patients in the context of specific indications. The first attempted TLIF surgery was performed by Harms and Rolinger, and Harms described this surgery in detail along with Jeszensky in 1998 [2, 3]. In 2002, Khoo and Foley first reported a minimally invasive surgery-TLIF (MIS-TLIF) [4]. The advantages of MI-TLIF included the following aspects: reduced paraspinal muscle injury, minimized perioperative blood loss, shortened recovery time, and reduced risk of infection at surgical sites [5, 6]. However, when operating using tubular retraction systems, surgeons often cannot obtain adequate visualization. Recently, percutaneous endoscopic lumbar interbody fusion (PE-LIF) was introduced as a new iteration of LIF with improved visualization, safety and less trauma than the previous LIF procedure. The transforaminal approach, which corresponds to the transforaminal percutaneous endoscopic lumbar discectomy (TF-PELD) surgery, is the most commonly used surgical approach. We performed a posterior endoscopic lumbar interbody fusion (PEPLIF), similar to the interlaminar

percutaneous endoscopic lumbar discectomy (IL-PELD) technique, to treat L4-5 and L5-S1. We described our technique in this paper.

Surgical Technique

STEP1 Position, anesthesia, and approach

The PEPLIF surgery was performed using the LUSTA endoscopic System (Spinendos, Germany). All operations were performed under general anesthesia. The patients were placed in the prone position on a radiolucent table. The operating intervertebral space was approximately perpendicular to the ground and interlaminar space was expanded by adjusting the operating table to an appropriate position. This was helpful for fluoroscopy and operation. The skin entry point was located at the intersection of the medial edge of the inferior articular and the midline of the intervertebral space (about 2 cm lateral to the midline). An 18G needle was then firmly engaged with the facet joint in the anteroposterior view under fluoroscopy through the setpoint with a 5–10° extraversion angle (Fig. 1). Then, a 0.8 mm guide wire was inserted through the cannula and the puncture needle was removed. A longitudinal incision of about 13 mm was made. After subsequent tissue dilation, a beveled working cannula (12 mm outer diameter, 11 mm inner diameter) was introduced over the obturator. After the obturator was withdrawn, an endoscope (10 mm outer diameter, 7.1 mm working channel, with a 15° view angle) was inserted.

STEP2 Endoscopic capsulectomy of the articular process

Tissue was cleared away from the surface of the medial partial articular capsule using endoscopic pituitary forceps and radiofrequency. Once the articular capsule was prepared, an endoscopic capsulectomy of the articular process was performed using basket punches. Then the cortical bone of the inferior articular process (IAP) was exposed. It is important at this step to take caution with distinguishing the boundary of the capsule in order to avoid nerve injury.

STEP3 Endoscopic partial facetectomy of the articular process (AP) and laminectomy

The IAP underwent a partial facetectomy using an endoscopic osteotome, burr, and Kerrison punch, exposing the superior articular process (SAP). The ligamentum flavum (LF) was stripped away from the medial SAP using an endoscopic probe. A partial medial facetectomy was then performed using an endoscopic osteotome, burr, and Kerrison punch (Fig. 2). These instruments had similar size when compared to an open operation (Fig. 3), so the endoscopic facetectomy was highly efficient. The distance between the axillary of the L5 traversing nerve root and the central point of the articulating process is approximately 13 mm, and the distance between the axillary of the S1 traversing nerve root and the central point of the articulating process is approximately 20 mm. Using a 12 mm cannula, we resected about half of the medial articulating process in L4-5 and one third of the medial articulating process in

L5-S1. Hemilaminectomy in the ipsilateral superior margin of the inter-laminar space was performed to create adequate space for a cannula. The borders of the facetectomy were dependent on nerve location and channel size. The ligamentum flavum covering the dura and the nerve root was removed. At this point, the surgeon can see the disc, dura and traversing nerve root via endoscopic visualization (Fig. 4). At this step, it is critical to avoid hemorrhage or to control it quickly, as a hemorrhage at this stage could be difficult to control due to possible the presence of inflammatory vasculature related to articular joint degeneration and a limited narrow visual field. Cancellous bone hemorrhage was easier to control than other types of hemorrhage, especially when using an endoscopic piezosurgical technique. At this step, we have several notes to add: It is important to avoid vigorous blunt separation because the vascular stump will shrink and make hemostasis very difficult. When uncontrolled hemorrhage occurred, we withdrew the endoscope and working cannula and performed compression hemostasis.

STEP4 Discectomy and endplate preparation

At this step, we protected the nerve root with the bevel of cannula by rotating the cannula (Fig. 4a). Pituitary forceps and an expandable reamer were used to perform the discectomy. Expandable reamer can be inserted in an unexpanded configuration through a small-diameter cannula and expanded within the disc to an appropriate dimension, then rotated back and forth to grind the nucleus pulposus and scrape fibrocartilage off the subchondral bone. At this point in the surgery, our goal was to remove all of the disc nucleus while maintaining the integrity of the annulus and the subchondral bone which is beneficial for preventing cage subsidence.

STEP5 Bone graft, cage insertion, and percutaneous screw fixation

After preparing the fusion site, the endoscope was withdrawn. The mixture of autogenous bone from AP, allograft, and bone morphogenetic protein(BMP)-2 was placed into the anterior disc space through a funnel-shaped bone graft device. Then, we introduced the expandable spacer (REACH, Shanghai, China) through the cannula and expanded it under lateral C-arm fluoroscopy (Fig. 5). The expandable spacer has a height of 8 mm and a length of 22 mm and is made of titanium. The expandable spacer can expand from 8 mm to a height of 9–12 mm. After expansion, the spacer is shaped like a trapezoid with a 3° angle between the upper and lower edges and horizontal plane for the purpose of maintaining lumbar lordosis (Fig. 6).

After checking the position of the implant, the working tube was removed by turning it counterclockwise. Percutaneous pedicle screws were used to fix the hardware in place. After this, all instruments were removed and the skin and fascia were sutured.

Discussion

Form PLIF to MIS-TLIF and OLIF, there have been many advances in development of minimally invasive lumbar interbody fusion procedures with that are precise, provide better visualization, safer, and have

enhanced recovery after surgery (ERAS). Although these methods have had high success rates, iatrogenic complications, such as nerve injury and stripping of the paravertebral muscles resulting in long-lasting sequelae, cannot always be avoided[6, 7]. The major complications of MI-TLIF include dural tears, neurological injury, wound infection, urinary tract infection, and hardware failure[8]. Limited visualization is the main disadvantage of all tubular techniques, especially when difficult to control hemorrhages arise. Therefore, it is beneficial for surgeons to adapt the procedure to be done through a slender tube. He EX et al[9] reported 42 patients that underwent a full endoscopic minimally invasive transforaminal lumbar interbody fusion. An 8 mm wide fusion cage was easily implanted via a 22 mm working trocar, and a 25° endoscope provided clear visualization during surgery to enhance nerve protection. The fusion rate at the last follow-up visit was found to be 92.9%. This was an attempt to obtain adequate visualization in MIS-TLIF.

Selection of an appropriate approach, adequate neural decompression, sufficient endplate preparation, and fusion device improving are the four most significant challenges that have been addressed over time in the evolution of the interbody fusion procedure, resulting in the development of endoscopic procedures. Endoscopic lumbar interbody fusion based on endoscopic lumbar discectomy is an advanced technology that is now widely used in the clinical setting. This approach has a variety of advantages, including that it is minimally invasive and has improved visualization, and is safer and more precise than previous procedures. Said G[10] reported a series of 60 patients treated with endoscopic transforaminal decompression and interbody fusion in 2012. The operational approach in this study was similar to PELD. Endplate preparation was performed with an expandable reamer. A mixture of recombinant human BMP-2 and an absorbable collagen sponge was packed into the disc space for fusion because the cage could not fit through the working cannula. No facetectomy was performed. This approach resulted in solid fusion in 28 patients (59.6%) and stable fixation in 17 (36.2%). The typical starting point for a transforaminal endoscopic discectomy is 10 to 16 cm from the midline, which allows the starting needle to enter the disc space from an oblique trajectory by just sliding off the ventral portion of the superior articulating process and entering the disc space just underneath the traversing nerve root. However, with this approach the operational field is limited and a cage cannot be inserted.

The working triangle between the exiting and traversing nerves in the lumbar neural foramen is a relatively large area (the mean surface area for the working triangle was 1.83 cm², with L5–S1 having the largest area at 2.19 cm²). The minimally invasive removal of the superior articulating process to expose the traversing nerve root is necessary for providing an adequately sized safe zone. More oblique access to the disc could allow for adequate neural decompression and insertion of a cage with removal of less than 50% of the facet bone[11]. Wu J et al[12] were the first to perform a traditional PELD procedure. After primary disc removal and nerve root decompression, the working tube was withdrawn, replaced with a working tube (15 or 18 mm in diameter), and an autogenous bone graft from the superior articular process and a commercially available cancellous bone allograft was placed into the interbody space. The cage was then introduced into the intervertebral disc space. Youn MS et al[13] reported a full endoscopic lumbar interbody fusion (FELIF). They used a beveled working cannula (13.7 mm outer diameter, 10.2 mm inner diameter) and an endoscope (10 mm outer diameter, 6 mm working channel, and 15° view

angle) to carry out an endoscopic partial facetectomy of the superior articular process with sufficient decompression and proper endplate preparation. The working cannula was then replaced with a custom-made working sheath (16–20 mm outer diameter) so a cage could be implanted. Heo DH et al[14] used two channels (an endoscopic portal and a working portal) to perform an endoscopic lumbar fusion surgery. In this case, an ipsilateral facetectomy and partial hemilaminectomy were performed to create sufficient space to operate. This technique could achieve direct neural decompression similar to that of a conventional open surgery.

Here, we designed and performed a percutaneous endoscopic posterior lumbar interbody fusion (PEPLIF). PEPLIF is difficult in L1-4 due to the small interlaminar space, so this method was performed for L4-5 and L5-S1. Our procedure has three main advantages over other similar procedures. First, the operative region is far away from exiting nerves, minimizing the possibility of exiting nerve injury. Second, this approach allows for the direct decompression of traversing nerves. The operational field is quite similar to that of an open posterior lumbar interbody fusion, which permits us to perform circumferential decompression with the traversing nerves and ipsilateral dural sac. Third, the working cannula is more vertical than it is in the transforaminal approach. This is more convenient for completing the discectomy of the anterior disc and endplate preparation. We could complete decompression and fusion without replacing the cannula. With wider interlaminar space and without concerns of an ilium block, our approach requires less facetectomy and fluoroscopy than the transforaminal approach in L5-S1. Therefore, our method should be more advantages than the transforaminal approach for L5-S1.

The following types of patients can undergo PEPLIF: (1) lumbar disc herniation with segmental instability (2) lumbar spinal stenosis with segmental instability (3) Lumbar spondylolisthesis (less than Meyerding grade II). Patients with severe central canal stenosis, spondylolisthesis greater than grade III, and any disease that could adversely affect bone quality may be unable to undergo a PEPLIF surgery. Severe disc space narrowing may be contraindication for the transforaminal approach but is not necessarily for our approach. Furthermore, polar lateral disc herniation cannot be resolved using our approach.

Conclusions

Percutaneous endoscopic posterior lumbar interbody fusion (PEPLIF) is a feasible and effective method for fusion of L4-5 and L5-S1, and is more advantages compared with the transforaminal approach for L5-S1 fusion. All procedures are completed in full endoscopy without replacing the cannula, which can help simplify the procedure and save time during the operation. Our visualized facetectomy was highly efficient and safe. The endoscopic view in our approach is similar to that of an open posterior lumbar interbody fusion, reducing the learning curve for our procedure. The approach described here should be easy for a surgeon who has performed PLIF to master.

Lists Of Abbreviations

PEPLIF percutaneous endoscopic posterior lumbar interbody fusion

PLIF posterior lumbar interbody fusion

ALIF anterior lumbar interbody fusion

LLIF lateral lumbar interbody fusion,

OLIF oblique lateral lumbar interbody fusion

TLIF transforaminal lumbar interbody fusion

MIS-TLIF minimally invasive surgery-TLIF

PE-LIF percutaneous endoscopic lumbar interbody fusion

TF-PELD transforaminal percutaneous endoscopic lumbar discectomy

IL-PELD interlaminar percutaneous endoscopic lumbar discectomy

AP articular process

IAP inferior articular process

SAP superior articular process

LF ligamentum flavum

BMP-2 bone morphogenetic protein-2

ERAS enhanced recovery after surgery

FELIF full endoscopic lumbar interbody fusion

PEPLIF percutaneous endoscopic posterior lumbar interbody fusion

Declarations

Ethics approval and consent to participate: Not applicable.

Consent for publication: Not applicable.

Availability of data and materials: Not applicable.

Competing interests: The authors declare that they have no competing interests.

Funding: Fund Program for the Scientific Activities of Selected Returned Overseas Professionals in Shanxi Province.

Acknowledgements: Not applicable.

Conflicts of interest/Competing interests: The authors declare that they have no competing interests.

Availability of data and material: Yes.

Code availability: Yes.

References

1. Bagan B, Patel N, Deutsch H, Harrop J, Sharan A, Vaccaro AR, Ratliff JK (2008) Perioperative complications of minimally invasive surgery (MIS): comparison of MIS and open interbody fusion techniques. *Surg Technol Int* 17:281-286
2. Harms J, Rolinger H (1982) [A one-stager procedure in operative treatment of spondylolistheses: dorsal traction-reposition and anterior fusion (author's transl)]. *Z Orthop Ihre Grenzgeb* 120 (3):343-347. doi:10.1055/s-2008-1051624
3. Harms J, Jeszenszky D (1998) Die posteriore,lumbale,interkorporelle fusion in unilateraler transforaminaler technik. *Oper Orthop Traumatol* 10(2):90-102. doi:10.1007/s00064-006-0112-7.22
4. Foley KT, Lefkowitz MA (2002) Advances in minimally invasive spine surgery. *Clin Neurosurg* 49:499-517
5. Phan K, Rao PJ, Kam AC, Mobbs RJ (2015) Minimally invasive versus open transforaminal lumbar interbody fusion for treatment of degenerative lumbar disease: systematic review and meta-analysis. *Eur Spine J* 24 (5):1017-1030. doi:10.1007/s00586-015-3903-4
6. Schizas C, Tzinieris N, Tsiridis E, Kosmopoulos V (2009) Minimally invasive versus open transforaminal lumbar interbody fusion: evaluating initial experience. *Int Orthop* 33 (6):1683-1688. doi:10.1007/s00264-008-0687-8
7. Ohtori S, Orita S, Yamauchi K, Eguchi Y, Ochiai N, Kishida S, Kuniyoshi K, Aoki Y, Nakamura J, Ishikawa T, Miyagi M, Kamoda H, Suzuki M, Kubota G, Sakuma Y, Oikawa Y, Inage K, Sainoh T, Sato J, Fujimoto K, Shiga Y, Abe K, Toyone T, Inoue G, Takahashi K (2015) Mini-Open Anterior Retroperitoneal Lumbar Interbody Fusion: Oblique Lateral Interbody Fusion for Lumbar Spinal Degeneration Disease. *Yonsei Med J* 56 (4):1051-1059. doi:10.3349/ymj.2015.56.4.1051
8. Li HM, Zhang RJ, Shen CL (2019) Radiographic and Clinical Outcomes of Oblique Lateral Interbody Fusion Versus Minimally Invasive Transforaminal Lumbar Interbody Fusion for Degenerative Lumbar Disease. *World Neurosurg* 122:e627-e638. doi:10.1016/j.wneu.2018.10.115
9. He EX, Guo J, Ling QJ, Yin ZX, Wang Y, Li M (2017) Application of a narrow-surface cage in full endoscopic minimally invasive transforaminal lumbar interbody fusion. *Int J Surg* 42:83-89.

doi:10.1016/j.ijsu.2017.04.053

10. Osman SG (2012) Endoscopic transforaminal decompression, interbody fusion, and percutaneous pedicle screw implantation of the lumbar spine: A case series report. *Int J Spine Surg* 6:157-166.

doi:10.1016/j.ijsp.2012.04.001

11. Hardenbrook M, Lombardo S, Wilson MC, Telfeian AE (2016) The anatomic rationale for transforaminal endoscopic interbody fusion: a cadaveric analysis. *Neurosurg Focus* 40 (2):E12.

doi:10.3171/2015.10.FOCUS15389

12. Wu J, Liu H, Ao S, Zheng W, Li C, Li H, Pan Y, Zhang C, Zhou Y (2018) Percutaneous Endoscopic Lumbar Interbody Fusion: Technical Note and Preliminary Clinical Experience with 2-Year Follow-Up. *Biomed Res Int* 2018:5806037. doi:10.1155/2018/5806037

13. Youn MS, Shin JK, Goh TS, Lee JS (2018) Full endoscopic lumbar interbody fusion (FELIF): technical note. *Eur Spine J* 27 (8):1949-1955. doi:10.1007/s00586-018-5521-4

14. Heo DH, Son SK, Eum JH, Park CK (2017) Fully endoscopic lumbar interbody fusion using a percutaneous unilateral biportal endoscopic technique: technical note and preliminary clinical results. *Neurosurg Focus* 43 (2):E8. doi:10.3171/2017.5.FOCUS17146

Figures

Fig. 1. The site of punctured needle.

Figure 1

The site of punctured needle.

Fig. 2. a The borders of the facetectomy in the specimen. b The borders of the facetectomy in postoperational CT reconstruction. We could find that partial laminectomy was necessary expect facetectomy. c The nerve root is visible when SAP is resected.

Figure 2

a The borders of the facetectomy in the specimen. b The borders of the facetectomy in postoperational CT reconstruction. We could find that partial laminectomy was necessary expect facetectomy. c The nerve root is visible when SAP is resected.

Fig. 3. Endoscopic osteotome and Kerrison punch.

Figure 3

Endoscopic osteotome and Kerrison punch.

Fig. 4. a Diagram depicting the approach for the operation, specifically showing the protection of the nerve root with the bevel of the cannula by rotating the cannula. b, c The position of the cannula intraoperation. d Endoscopic visualization after a work channel is established.

Figure 4

a Diagram depicting the approach for the operation, specifically showing the protection of the nerve root with the bevel of the cannula by rotating the cannula. b, c The position of the cannula intraoperation. d Endoscopic visualization after a work channel is established.

Fig. 5. a, b The expandable spacer was expanded in the disc space. c Fusion and thorough decompression were completed.

Figure 5

a, b The expandable spacer was expanded in the disc space. c Fusion and thorough decompression were completed.

Fig. 6. The expandable spacer in initial configuration and expanded configuration.

Figure 6

The expandable spacer in initial configuration and expanded configuration.

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