Full-Endoscopic Trans-Kambin Triangle Lumbar Interbody Fusion: Surgical Technique and Nomenclature

Yoshihiro Ishihama[1] Masatoshi Morimoto[2] Fumitake Tezuka[2] Kazuta Yamashita[2] Hiroaki Manabe[2] Kosuke Sugiura[3] Makoto Takeuchi[2] Yoichiro Takata[1] Toshinori Sakai[2] Toru Maeda[3] Akihiro Nagamachi[1] Koichi Sairyo[2]

[1] Department of Orthopedics, Tokushima University Hospital, Tokushima, Japan
[2] Department of Orthopedics, Tokushima University Graduate School, Tokushima, Japan
[3] Department of Orthopedics, University of Tokushima Graduate School of Biomedical Sciences, Tokushima, Japan

Address for correspondence Masatoshi Morimoto, MD, PhD, Department of Orthopedics, Tokushima University Graduate School, 3-18-15 Tokushima 7708503, Japan (e-mail: masa_m_089034@yahoo.co.jp).

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Abstract

Background Full-endoscopic lumbar surgery is used for decompression of lumbar spinal canal stenosis. Now, a cage can be inserted through Kambin's triangle for lumbar interbody fusion (LIF). We have been performing full-endoscopic trans-Kambin triangle LIF (KLIF) at our institution since 2018. In this article, we describe this technique and present our results.

Methods We performed full-endoscopic one-level KLIF in 10 patients. The procedure is as follows. First, percutaneous pedicle screws are inserted. Listhesis is reduced if necessary. The endoscope is inserted in Kambin's triangle. Next, the superior articular process is partially removed, enlarging Kambin's triangle to allow safe insertion of the cage. A cannula is inserted into the disk to avoid damaging the exiting nerve. The disk material is shaved and curetted. Finally, the harvested bone is packed in a cage and inserted into the disk space. We analyze the complications, visual analog scores (VAS), and MacNab's criteria.

Results One patient had an irritation in the exiting nerve at L4–L5. The VAS for back pain and leg pain decreased from 69 to 9 and from 60 to 9, respectively. The clinical outcome was considered excellent in eight and good in two patients.

Conclusions Kambin's triangle lies immediately behind the psoas major. Therefore, we consider KLIF as a lateral LIF procedure comparable with oblique or extreme LIF. However, unlike oblique or extreme LIF, there are no major vessels and organs in the surgical field; therefore, KLIF is the safest type of lateral LIF. Furthermore, using the endoscope, we can perform decompression directly using the facetectomy technique.

Keywords
- full endoscopy
- lumbar intervertebral fusion
- kambin's triangle
- KLIF

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Introduction

Lumbar interbody fusion (LIF)[1,2] can be performed as anterior LIF (ALIF) or posterior LIF (PLIF) approach.[1,2] A transforaminal LIF (TLIF) has also been introduced. More recently, three types of lateral LIF (LLIF) have been established: oblique LIF (OLIF), extreme lateral LIF (XLIF), and direct lateral LIF.

Full-endoscopic surgery (FES) has been developed over the past two decades and is now established as minimally invasive spine surgery.[3–7] It was initially used for diskectomy in patients with herniated nucleus pulposus[3,4] and its indications have since been extended to include bony decompression for spinal canal stenosis. Moreover, using a transforaminal approach, foraminal and lateral recess stenosis can now be decompressed using FES.[5–7]

The next step for FES would be application in spinal arthrodesis, such as LIF. There are several reports on LIF using a full endoscope and although the basic concept underlying the techniques used is similar, there is still no consistent nomenclature, such that many terms, including percutaneous endoscopic LIF,[8] percutaneous endoscopic transforaminal LIF (PETLIF),[9] full-endoscopic LIF,[10] and full-endoscopic TLIF,[11] have been used to describe the same method. Very recently, Lewandrowski et al proposed lordotic endoscopic wedge lumbar interbody fusion (LEW-LIF) as the name for a similar technique.[12] Despite the variable nomenclature for full-endoscope–guided LIF, the basic concept is insertion of a cage through Kambin's triangle[13,14] under the guidance of the full endoscope. Therefore, we have named this surgery full-endoscopic trans-Kambin LIF (KLIF).

About 2 years ago, we started performing full-endoscopic KLIF using the PETLIF method developed by Nagahama et al.[9] In this article, we review the clinical and radiologic results for our first 10 cases and discuss the nomenclature of the technique.

Methods

This research has been approved by the Institutional Review Board of the authors' affiliated institutions.

Surgical Indication

The best candidates for full-endoscopic KLIF at present are patients with a single-level disorder. Although it seems technically possible to treat patients with a multilevel disorder using this method, we refrained from multilevel surgery during our learning curve. We considered full-endoscopic KLIF for single level spondylolisthesis, scoliosis, discogenic pain, and Modic change.

Surgical Technique

The entire surgical procedure is performed with electrophysiologic monitoring. The first step is insertion of percutaneous pedicle screws under C-arm fluoroscopic guidance. Listhesis can be reduced if necessary. The cannula of the full endoscope (Karl-Storz, Tuttlingen, Germany) is then placed in Kambin's triangle safety zone (►**Fig. 1**). ►**Fig. 2** shows a radiograph of the surgical field obtained intraoperatively. Four percutaneous pedicle screws are installed, and the cannula is docked on the bony structure of the superior articular process (SAP). The SAP is usually covered by a soft tissue–like capsule. ►**Fig. 3** demonstrates the SAP and disk surface. Two milliliters of indigo carmine is injected into the disk space at the start of surgery so that the disk surface can be identified by the color blue. The red circle in the left panel of the figure indicates the endoscopic view shown in the right panel.

The SAP is partially removed using a surgical drill until the triangle is large enough for safe insertion of the cage. ►**Fig. 3** shows the cage insertion area of the disk. The blue dye stains the surface of the disk. After foraminoplasty, the distance is enlarged. The distance between the bone of the facet joint and the exiting nerve should be at least 12 mm for safe insertion of the cage. The diameter of the diamond burr is 3 mm; thus, four diamond burrs can achieve a distance of 12 mm, as shown in ►**Fig. 4a**. An 8 mm × 12 mm oval-shaped cannula (the PETLIF system devised by Nagahama et al[9]) is advanced carefully in the disk taking care not to damage the exiting nerve. The disk materials are then shaved and curetted via the oval-shaped

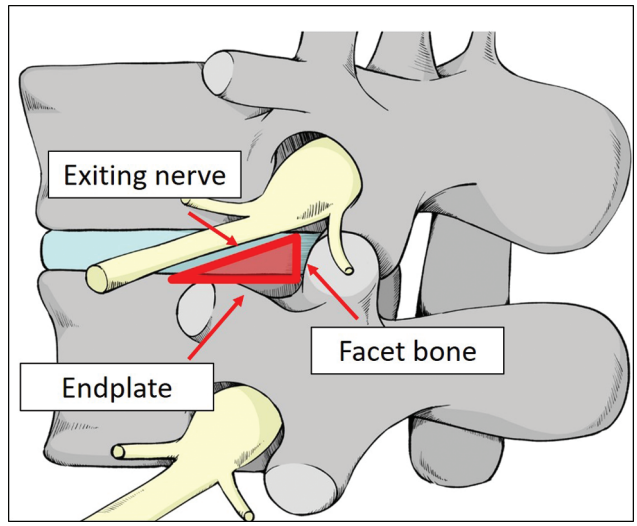

Fig. 1 Kambin's triangle.

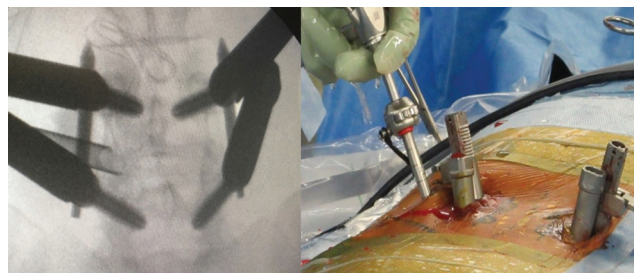

Fig. 2 Intraoperative radiograph showing the surgical field. Four percutaneous pedicle screws are inserted, and the cannula is docked on the bony structure of the superior articular process.

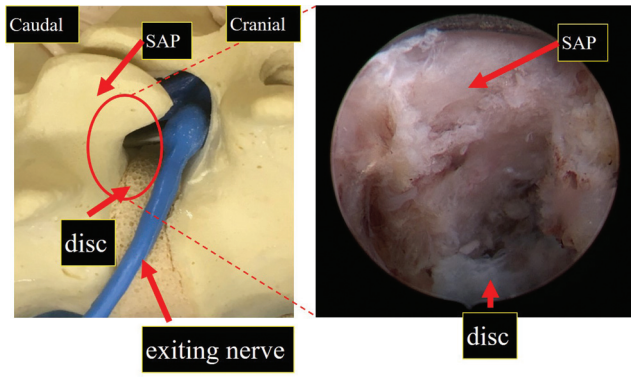

Fig. 3 Intraoperative photograph showing the superior articular process (SAP) and disk surface before foraminoplasty. The red circle in the left panel indicates the endoscopic view area shown in the right panel.

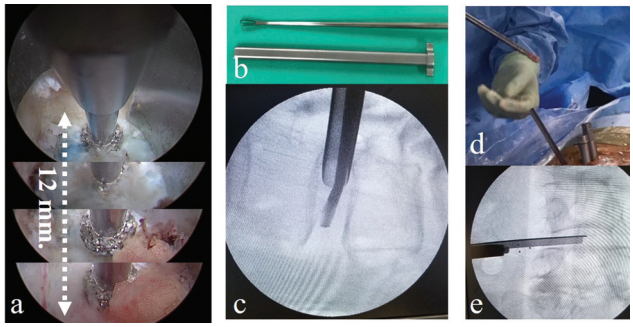

Fig. 4 (**a**) Intraoperative photograph showing the area of the disk (*blue dye stain*) after foraminoplasty. To insert the cage safely, the distance between the facet bone and the exiting nerve should be widened by more than 12 mm. (**b,c**) Intraoperative photograph showing curettage of the end plate surface. The disk material can be shaved and curetted via the oval-shaped cannula. (**d,e**) Intraoperative photograph showing insertion of the cage using a specially designed **L**-shaped slider (from the PETLIF system by Nagahama et al[9]).

cannula. A standard curette can be used to scrape the surface of the end plate (►**Fig. 4b, c**). After packing the disk with harvested bone, a cage is inserted using a specially made **L**-shaped slider from the PETLIF system; ►**Fig. 4d, e**). Neuromonitoring is continued throughout the surgery to avoid damage to the exiting nerve root. Full-endoscopic ventral facetectomy is performed for unilateral decompression and an additional mini-open laminectomy for bilateral decompression.

Clinical Evaluation

Operating time and estimated blood loss were recorded. Surgery-related complications, including exiting nerve root injury, hematoma, and infection, were also reviewed. Clinical outcomes were evaluated using the visual analog scale (VAS) scores for low back pain and leg pain recorded at the final follow-up visit, which was at least 6 months later.

Results

The patients comprised three men and seven women of mean age 62.6 (range: 34–83) years (►**Table 1**). All surgeries were performed successfully without the need for conversion to an open procedure. The mean operating time was 170.6 (range: 145–193) minutes and the intraoperative blood loss was 50.0 (range: 10–150) mL. There were no major complications, such as nerve root or major vessel injury, dural tear, hematoma, or infection. Our first patient complained of exiting nerve root irritation that improved within 2 weeks of surgery. In all cases, neurologic improvement was evident after surgery and remained stable during 6 months of follow-up. The mean VAS scores for back pain and leg pain decreased from 69 ± 18 to 9 ± 10 and from 60 ± 33 to 9 ± 10, respectively, and the median VAS scores of back pain and leg pain also decreased from 62.5 to 10 and 62.5 to 7.5, respectively. According to the modified MacNab criteria, the results were rated as excellent in eight cases and good in two.

Two representative cases are described here in more detail. The first case was a 61-year-old woman with low back and left leg pain due to lateral recess stenosis with instability at L4–L5 who underwent full-endoscopic KLIF for L4 degenerative spondylolisthesis. The patient had a history of partial laminectomy for lumbar spinal canal stenosis at the same segment. Meyerding grade II olisthesis was reduced after surgery (►**Fig. 5a**). The patient's symptoms significantly improved postoperatively. According to the modified MacNab criteria, this patient had an excellent clinical outcome. The second case was an 83-year-old woman with low back and right leg pain who underwent full-endoscopic KLIF for L4 degenerative spondylolisthesis. Meyerding grade II olistesis was reduced after surgery (►**Fig. 5b**). Full-endoscopic ventral facetectomy was performed for radiculopathy. The patient's symptoms significantly improved postoperatively. According to the modified MacNab criteria, the clinical outcome was excellent.

Discussion

Anatomical Nomenclature

In this article, we have described the surgical technique used to perform full-endoscopic KLIF. As mentioned earlier, many names have been used to describe various types of LIF surgery performed via Kambin's triangle under full-endoscopic guidance. These surgical procedures, including our full-endoscopic KLIF method, have many similarities. All the techniques use a full endoscope to create the route via which the cage is inserted, and in full-endoscopic KLIF, the cage is inserted through Kambin's triangle (►**Fig. 1**). Hence, on anatomical reasons, we propose that this technique be named trans-Kambin triangle LIF (KLIF). Furthermore, as shown in ►**Fig. 1**, the trans-Kambin triangle route is different from the transforaminal route. If we want to spare the facet joint, it is difficult to insert a cage via the transforaminal route, and the maneuver could damage the exiting nerve root.

Table 1 Patients' information

No.	Sex	Age (yrs)	Diagnosis	Fusion level	Preoperative symptom
1	Man	34	Spondylolytic spondylolisthesis	L2/L3	Buttock and leg pain
2	Man	49	Degenerative spondylolisthesis	L4/L5	Low back pain
3	Man	82	Degenerative spondylolisthesis	L4/L5	Low back pain, leg numbness, intermittent claudication
4	Woman	48	Degenerative spondylolisthesis	L4/L5	Buttock and leg pain
5	Woman	61	Degenerative spondylolisthesis	L4/L5	Low back pain
6	Woman	62	Degenerative spondylolisthesis	L4/L5	Low back and leg pain, leg numbness
7	Woman	68	Degenerative spondylolisthesis	L4/L5	Low back and leg pain, leg numbness
8	Woman	69	Degenerative spondylolisthesis	L4/L5	Low back pain, intermittent claudication
9	Woman	70	Degenerative spondylolisthesis	L4/L5	Leg pain, intermittent claudication
10	Woman	83	Degenerative spondylolisthesis	L4/L5	Low back and leg pain

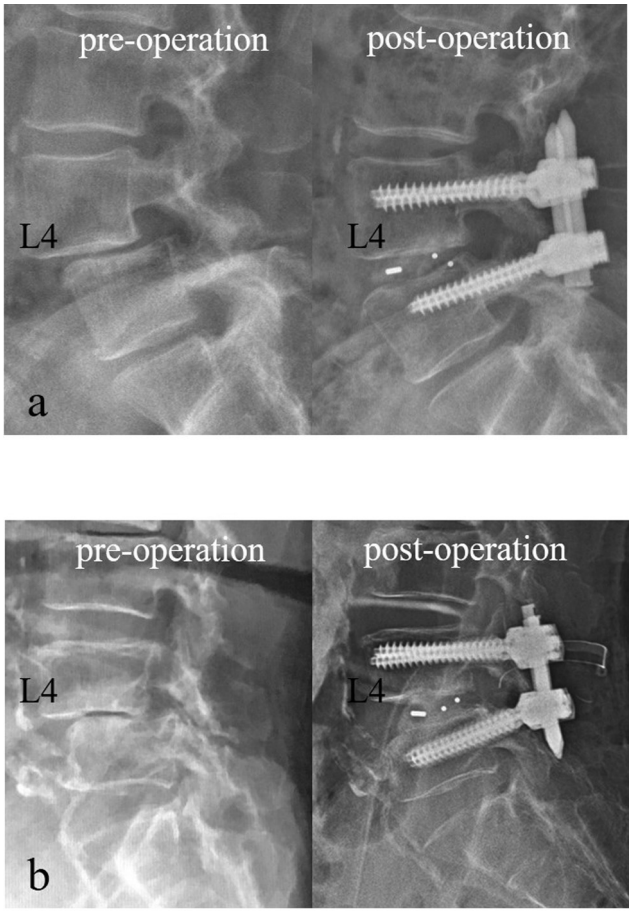

Fig. 5 (**a**) Lateral radiographs before and after the surgery in case 1. Representative case of a 61-year-old woman who underwent full-endoscopic trans-Kambin triangle lumbar interbody fusion (full-endoscopic KLIF) for L4 degenerative spondylolisthesis. The Meyerding grade II olisthesis is reduced after surgery. (**b**) Lateral radiographs before and after the surgery in case 2. Representative case of an 83-year-old woman who underwent full-endoscopicKLIF for L4 degenerative spondylolisthesis. The Meyerding grade II olisthesis is reduced after surgery.

KLIF as a Lateral Access Lumbar Interbody Fusion

Kambin's triangle is located just behind the psoas major muscle (►**Fig. 1**). The technique used to insert the cage just anterior to the psoas muscle is known as OLIF and that used for transpsoas insertion of the cage is called XLIF.[1,2] Therefore, we propose that KLIF is a type of lateral access LIF (LLIF) like OLIF and XLIF. However, unlike OLIF and XLIF, there is no major vessel, ureter, or colon in the surgical field. Therefore, KLIF is likely to be the safest type of LLIF. There have been reports of major complications with OLIF and XLIF. In a nationwide survey of 2,998 cases (1,995 XLIF and 1,003 OLIF), Fujibayashi et al[15] found a total of 540 complications, including major vascular injury, bowel injury, and surgical site infection rates of 0.03, 0.03, and 0.7%, respectively. In contrast, there have been no major complications with full-endoscopic KLIF so far. Nakamura and Mizuno[8] considered that percutaneous endoscopic LIF would be safest, given that they had not encountered complications. Nagahama et al[9] reported two complications (i.e., temporary muscle weakness, $n = 1$; and cage subsidence, $n = 1$) in 25 patients who underwent PETLIF. Similarly, we found only one minor complication in our first case and none of the major complications found with XLIF and OLIF. Therefore, we believe that full-endoscopic KLIF is the safest LLIF technique.

Prevention of Exiting Nerve Injury

The most severe potential surgery-related complication is exiting nerve root injury. The highest rate of exiting nerve root injury after cage insertion via Kambin's triangle (60.4%, 29/48) was reported by Lewandrowski et al,[12] although most cases healed within 6 weeks after surgery. The second highest rate of 22% was reported by Morgenstern et al.[16] The first of our 10 patients complained of exiting nerve root injury, which translates into a rate of 10%. We have since performed full-endoscopic KLIF in five more patients, none of whom have developed nerve root injury; therefore, our exiting nerve root injury rate at the time of writing has decreased

to 6.7%. Abbasi et al have devised a technique called oblique lateral LIF whereby they inserted a cannulated cage through a K-wire via Kambin's triangle under fluoroscopic guidance without full endoscopy.[17,18] Although they do not use a full endoscope, their technique for inserting the cage is very similar to our KLIF maneuver. They reported that 16 of 303 patients (5.3%) who underwent oblique lateral LIF developed exiting nerve root injury during 1 year of follow-up and stressed the importance of intraoperative electrophysiologic monitoring for prevention of this complication. We also use electrophysiologic monitoring during surgery, and our present exiting nerve root injury rate of 6.7% is similar to that reported by Abbasi et al.[18]

Difference between KLIF and TLIF

Tumialán et al considered the trans-Kambin triangle and transforaminal approaches to be fundamentally different[19] despite their apparent similarities. TLIF was first introduced by Harms and Jeszenszky.[20] The medial wall of their window after facetectomy is the dural sac, whereas the medial wall in Kambin's triangle is the SAP and dural sac.[19] Therefore, TLIF can be performed after facetectomy, and cage insertion without facetectomy via Kambin's triangle should be called KLIF, not TLIF. Very recently, Morgenstern et al[16] reported a method of percutaneous insertion of a cage that is similar to our KLIF technique. They did not perform facetectomy and inserted the cage through the window of Kambin's triangle. They described their technique as "full percutaneous TLIF using the facet-sparing, trans-Kambin approach." Not using the transforaminal route, the term TLIF appears not suitable. Nagahama et al called their technique PETTLIF,[9] but preserved the facet joints. Therefore, their technique is LIF through Kambin's triangle, which should be considered being KLIF and not TLIF.

Learning Curve of KLIF

KLIF is completely different from conventional surgery (such as TLIF or PLIF). Therefore, we think there is a learning curve for KLIF. First, it is necessary to learn surgical orientation by cadaver or sawbones surgical training. Next, it is necessary to learn the endoscopic procedures by performing operation of lumbar disk herniation. In the case of lumbar disk herniation at L5/S, the pelvis is obstructing the trajectory and it is difficult to insert the endoscope safely. Therefore, it is better to start with the segments L4/L5 and above. After feeling comfortable, the attempt to perform KLIF could be made.

KLIF as a Minimally Invasive Fusion Surgery

Full-endoscopic KLIF has some advantages over the more conventional posterior techniques such as PLIF and TLIF. In PLIF and TLIF, wide muscle dissection is needed for insertion of the screws and cage; however, muscle dissection is minimal using our method because the screws are inserted percutaneously, and the cage is also inserted via a small skin incision under full-endoscopic guidance. However, in this study, we did not ascertain whether our technique was less invasive for the back muscles and plan to investigate this in a future study.

Conclusion

In this article, we described our surgical technique of full-endoscopic KLIF. Using this method, the skin incision required for insertion of the cage is ~12 mm, and minimal muscle dissection is required. Our short-term clinical results are promising, and no major complications have been observed. We believe that full-endoscopic KLIF is a minimally invasive and safe surgical technique for LIF.

Conflict of Interest
None declared.

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