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Endoscopic TLIF versus MIS TLIF in the Treatment of Degenerative Lumbar Disc Disease

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ABSTRACT
Lumbar degenerative disc disease (LDDD), an age-associated disease characterized by severe back pain and disability, is highly prevalent across the world. The pathogenesis of LDDD involves age-related or injury-induced degeneration of the intervertebral discs (IVDs). Decreased hydration, reduced proteoglycan content, loss of disc height, annular fissuring, and ingrowth of nerve and blood vessels are observed in degenerating discs. These changes can lead to structural breakdown, biomechanical dysfunction, instability, herniation, and nerve compression.Spinal fusion surgery is a recognized treatment option of LBP but its efficacy and success remain controversial. Minimally invasive surgery transforaminal lumbar interbody fusion (MIS-TLIF). Compared to conventional TLIF, MIS-TLIF protects paraspinal structures, resulting in less trauma, bleeding, and quicker recovery
This review article aims to compare the results of treatment of degenerative lumbar disc disease with endoscopic TLIF versus MIS TLIF in the treatment of Degenerative Lumbar Disc Disease.

Keywords: TLIF , LDDD , fissuring, ingrowth , hydration

INTRODUCTION

Lumbar disc degeneration disease (LDDD) is defined as the wear and tear of lumbar intervertebral disc, and it is mainly occurring at L3-L4 and L4-S1 vertebrae. LDDD may lead to disc bulging, osteophytes, loss of disc space, and compression and irritation of the adjacent nerve root. Clinical presentations associated with LDDDand lumbosacral nerve lesion are discogenic pain, radical pain, muscular weakness, and cutaneous. Discogenic pain is usually felt in the lumbar region, or sometimes, it may feel in the buttocks, down to the upper thighs, and it is typically presented with sudden forced flexion and/or rotational moment. Radical pain, muscular weakness, and sensory defects associated with lumbosacral nerve lesions are distributed on lower extremities, the buttock, lower abdomen, and groin region[1].

Surgical interventions for lumbar degenerative diseases with lower limb and low back pain (LBP) yield better results than conservative treatments, benefiting both physical and mental health. Since Boucherintroduced the pedicle screw technique in 1959, transforaminal lumbar interbody fusion (TLIF) has become the standardfor spinal fractures, lumbar degenerative disease, infections, and deformities. Traditional TLIF surgery faces issues common to open surgery, such as large incisions and soft tissue trauma, which can cause liquefaction necrosis and postoperative LBP [2].

With advancements in surgical techniques and minimally invasive concepts, Foley proposed minimally invasive surgery transforaminal lumbar interbody fusion (MIS-TLIF). Compared to conventional TLIF, MIS-TLIF protects paraspinal structures, resulting in less trauma, bleeding, and quicker recovery[3]. However, MIS-TLIF has a limited workspace and field of view, and the dilatation cannula can cause tissue damage from muscle compression. Recently, with advances in spinal endoscopy, percutaneous endoscopic-assisted transforaminal lumbar interbody fusion (Endo-LIF) has emerged. Besides its minimally invasive nature, Endo-LIF offers a clearer intraoperative view, avoiding vascular damage and facilitating safe decompression of the dural sac and nerve roots[4].

This review article aims to compare the results of treatment of degenerative lumbar disc disease with endoscopic TLIF versus MIS TLIF in the treatment of Degenerative Lumbar Disc Disease.

Degenerative lumbardisc disease

Low back pain (LBP) is the most frequent chronic pain condition, leading to disability, increased risk of falling, and depression, as well as substantial societal costs, impairment, and health consequences. Disc desiccation [low signal intensity on T2-weighted magnetic resonance imaging (MRI)], which is a common finding in adults irrespective of symptoms, to particular symptomatic disorders, like disc herniation with concordant radiculopathy. The degenerative disease of the intervertebral disc and back pain are chronic conditions that are caused by several factors and represent an important cause of morbidity and mortality in everyday clinical practice [4].

It is a common condition characterized by the breakdown (degeneration) of one or more of the discs that separate the bones of the vertebrae, causing pain in the back or neck as a consequence of the cell-mediated response to multifactorial contributions, such as genetics, micro/macro trauma, accelerated age-related changes, inflammation, local nutritional deficiency, and vascular factors, leading to excess catabolic over anabolic responses[5].

The intervertebral discs (IVD), provide cushioning between vertebrae and absorb pressure put on the spine. IVD disorders can affect both the young and old population. Treatment strategies need to consider age of presentation, comorbidities, severity of IVD, neural elements compression and stability of the spinal column, many of the restorative and reconstructive management strategies are still at the early stages of laboratory experimental and animal trials, with clinical efficacy yet to be proven. Degenerative disc disease (DDD) and prolapsed intervertebral disc (PID) are the two commonest forms of IVD diseases[5].

They have a close cause and effect relationship as a prolapsed intervertebral disc is a risk factor of degenerative disc disease while advanced degenerative disc often presents with disc prolapse with annular fissure due to degeneration leading to a fragmented disc being prolapsed into the spinal canal. Physical exercise is clinically recommended in several guidelines to help in alleviating pain. Physical exercise helps in IVD cell proliferation in animal model studies, particularly in moderate to high volume low repetition and frequency exercises. It has an effect on paraspinal muscle strength and aids in reducing pain and disability. Up to 80% of patients with a prolapsed intervertebral disc respond to conservative therapy in an average of 4 to 6 weeks [6].

Epidemiology

Lumbar back pain affects 70–85% of people at a certain point in their lives. Back pain is more common as people age, and up to 85% of people will have it again in their lives. In people between the ages of 45 and 65, chronic LBP remains the main reason of debility. A prospective study using MRI on 67 asymptomatic individuals ranging in age from 20 to 80 years old (average 42 years old) found a significant abnormality in 28% of the participants, with 24% having herniated nucleus polposus and 4% having spinal canal stenosis. Around 34% of the younger age group and all but one of the older age groups had at least one degenerated disc. Nearly half of all degenerative discs have bulged irrespective of age. The prevalence of these abnormalities was the same in both genders; however, it varies across the age group. Despite all aberrant lumbar disc findings on MRI, it is most dependable on symptomatic patients under the age of sixty [7].

Pathophysiology of DDD

DDD is caused by a complex combination of structural, genetic, environmental, trauma, and age factors. These changes cause a decrease in pH and oxygen concentration. Calcification of endplates evolved as a result of these alterations, which led to a reduction in nutrient flow and blood supply, resulting in additional disc dysfunction in response to microtrauma. Pathological pain-triggering pathways generated by stimulation of inflammatory pathways with its secreted cytokines lead to an inflammatory response that leads to neuropathy of the diseased IVD tissues frequently results in a cascade of catabolic processes in the disc, which is related to the onset of DDD [8].

- **Mechanical load**

Long-term and excessive exposure to high mechanical loads have been shown to have detrimental effects on in vitro diagnostics, Low rate of loading, on the other hand, is critical for forced convection, which aids in the distribution of nutrients to both normal and degenerative discs [8].

- **Genetics and degenerated disc**

DDD is considered to be linked to genes that influence IVD structure, catabolic cytokines polymorphisms, and inflammatory cascade cytokine polymorphisms. Variations in the genes producing Type II collagen, a key component of the NP and inner AF extracellular matrix (ECM) [9].

- **Environmental and psychosocial factors associated with DDD**

Smoking, obesity, and diabetes mellitus are all linked to DDD. Smoking has the greatest connection to DDD of the three variables, and their impact is synergistic[8].

- **Vitamin D and degenerated disc**

Polymorphisms in the growth differentiation of factor 5, vitamin D receptor, and matrix degradative protease genes, among others, have been associated with IVD. however, the amount of each genes effect on the illness remains unclear [10].

- **Aging and degenerated disc**

In the early stages of DDD, enhanced Type II collagen formation is found in the NP, potentially as a self-repair mechanism; however, as the illness progresses, production of Type I collagen increases dramatically while Type II collagen synthesis diminishes. This change in collagen types in the NP and inner AF is followed by a reduction in aggrecan concentration, resulting in disc hydration and turgor pressure loss Excessive pressures on the weaker outer AF lamellae eventually result in the creation of cracks and fissures, which increases the possibility of NP material seeping into the outer AF. Furthermore, these defects in the degenerated discs outer AF enable neoinnervation and angiogenesis within the IVD [11].

Clinical features

There are many different and nonspecific clinical manifestations of DDD) Back pain is an essential feature in the midline and paraspinous of the lumbar region. Also, sitting intolerance is considered a major feature of DDD. Other features of pain that its usually worsened with flexion and decreased with extension. DDD can occur in absence of back pain, and 30% of asymptomatic patients had disc abnormalities in MRI were reported. Discogenic pain is mainly axial but can be somatic referred pain to the lower extremities which is common too. it appears to be ill-defined,widespread, and intolerable deep pain deep in the limb [12].

Back pain has many different red flags that should be considered such as saddle paraesthesia, sudden and unexpected bladder or bowel dysfunction/ incontinence, anal sphincter unexpected laxity, severe or progressive lower limb neurological deficit. Furthermore, sleep disturbance from night pain, history of cancer, and major trauma such as fall from height or road traffic accidents. Also, Loss of tendon reflexes, Up-going plantar reflex are considered to be red flags. Movement and position may exacerbate LBP such as flexion. In contrast, the extension will relieve it. Facet arthropathy may be indicated if the pain appeared with extension. So, it's important to exclude other etiologies when examining patients with assumed Lumber DDD. Some pathologies such as renal calculi, pancreatic disease, aortic aneurysms should be excluded. In addition, the doctor should ask about constitutional symptoms for other pathologies [13].

Diagnostic imaging

The clinical diagnostic procedure begins with a medical history and physical examination. Aiding the clinical finding, radiographic diagnostic modalities can be used to confirm degenerative disc disease, including plain roentgenogram (X-ray), computed tomography (CT) scan, MRI, and provocative discography, or rule out other diagnoses. When a patient presents with lower back pain, it is important to correlate clinical symptoms with imaging. If symptoms are not concordant with the imaging modality, interventional treatment may not yield the benefits desired. Two planes, upright lumbar X-ray are the first-choice imaging study. It is used to exclude other diagnoses more than diagnose DDD directly[14].

The findings of the lumbar disc disease radiograph include a variety of indicators that can be utilized to determine DDD, especially in symptomatic patients, although further studies are indicated. Within the early stages, due to the difficulty of x-rays to view the discs and soft tissues directly, annular tears and painful discs may be identified, but there is no major evidence of Disc damage. In later stages, there are indications of a disc narrowing, combined with the development of osteophyte in the adjacent vertebral body, facet hypertrophy, and vacuum phenomenon within the disc that help the diagnosis of DDD [15].

The standard imaging technique for identifying IVD diseases, MRI, is more sensitive in evaluating DDD. MRI scan findings include T2 signal loss within the NP, disc space narrowing, endplate changes, and internal disc tear or derangement signs. Two useful classifications commonly used to interpret the severity of DDD and associated problems, Pfirrmann classification for disc morphology, demonstrates the degeneration progression of the disc, while Modic classification for adjacent vertebral body alterations shows active inflammation and hematopoietic marrow fibrovascular replacement [8].

Diffusion-weighted imaging (DWI) can give important information on the microstructure of tissues by providing motion probing gradient (MPG) in some directions to track the random movement of water molecules that are normally limited in tissues. Recently had been focused on echoplanar diffusion tensor imaging for MR tractography had enhanced image and tract fiber quality on both qualitative and quantitative metrics. These methods can be used to examine the neural adhesions and the connection between nerve fibers and DDD, especially in advanced stages of the disease [16].

In general, a CT scan is of little use in determining the proper DDD diagnosis. However, with a long term of intervertebral disc (IVD) degeneration that can lead to tissue damage, in the future, a multi-detector CT scan might be a useful assessment tool, especially for people who are unable to obtain an MRI scan for DDD evaluation. More research and categorization on multi-detector computed tomography scan assessment of DDD

will be required. When imaging studies such as MRI and plain radiography fails to demonstrate the pathologies necessary for a proper diagnosis in a symptomatic patient, provocative lumbar discography is a technique that can be used to elicit and recreate a patient's pain. It's helpful to find DDD levels that replicate the patient's pain. Identifying adjacent levels that do not reproduce their pain is extremely beneficial [17].

Treatment of degenerative lumbar disc disease

- **Endoscopic transforaminal lumbar interbody fusion**

There are three types for endoscopic spinal fusion:

- Percutaneous endoscopic (or full-endoscopic) TLIF
- Second Percutaneous biportal endoscopic (or full-endoscopic) TLIF
- Third microendoscopic LIF[4].

- **Percutaneous endoscopic TLIF**

The primary three steps of the procedures are as follows: (i) the traditional transkambins percutaneous approach; (ii) full-endoscopic uniportal decompression using endoscopic burrs and instruments; and (iii) the insertion of an interbody fusion cage with or without percutaneous instrumentation. While specifics of the surgical technique vary among reports.Anesthesia might be applied locally, epidurally, or throughout the procedure. The entry site is identified at the lateral edge of the paravertebral muscle, which is normally 8–13 cm laterally from the midline, depending on the patient's mass index, with the patient in the prone position on a radiolucent table. The facet joint and paravertebral muscle are injected with local anesthetics. The surface of the superior articular process (SAP) or facet joint is the approach needle's target point, as has been verified[18].

A guidewire replaces the needle as it securely engages the facet joint, and a tapered obturator is then advanced to the with caution to avoid damaging the exiting nerve root, the tapered obturator is advanced to the SAP surface or intervertebral foramen while the needle securely engages the facet joint and is replaced by a guidewire. Next, a working cannula with a bevel on it is inserted over the obturator and securely positioned onto the facet joint or intervertebral foramen. Now that the guidewire and obturator have been removed, the foraminal structures are reached using a working-channel endoscope. The SAP's surface and foraminal features can be seen well enough in the first endoscopic field[19].

Following a secure engagement of the needle in the facet joint, a guidewire replaces the needle, and a tapered obturator is carefully advanced to the SAP surface or intervertebral foramen, taking care not to damage the exiting nerve root. After that, the obturator is covered by a functional cannula that has a bevel on it, which is then firmly placed into the facet joint or intervertebral foramen. Using a working-channel endoscope, the foraminal structures are now accessible after the guidewire and obturator have been removed. In the first endoscopic field, the surface and foraminal characteristics of the SAP are sufficiently visible[20].

Discectomy and endplate preparation for interbody fusion are performed after adequate transforaminal decompression. Initial discectomy can be performed using endoscopic forceps, and a specially designed endoscopic reamer is inserted into the disc space under fluoroscopic and endoscopic control. The reamer is expanded within the disc space and rotated back and forth in the plane of the disc space, to excise the fibrocartilage. Adequate endplate preparation can be ensured under image control[21]

After fusion site preparation, the anterior disc space is filled with allograft bone chips. The working cannula is then replaced with a larger working cannula that facilitates delivery and placement of the interbody fusion cage under fluoroscopic and full-endoscopic guidance.Additional percutaneous pedicle screws or facet screws are then inserted. Upon completing the instrumentation procedures,direct closure of the skin incision is performed, and the patient is monitored for complications**(Figure 1)**[4].

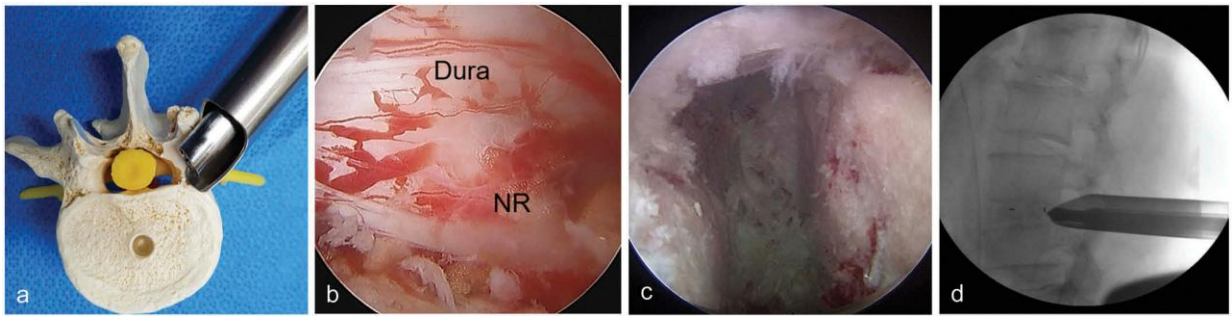


Figure 1: Showing Percutaneous endoscopic TLIF Percutaneous endoscopic (full-endoscopic) transforaminal lumbar interbody fusion. (a). Full-endoscopic decompression with a working-channel endoscope.After removal of superior articular process, the dural sac and nerve roots are decompressed. (b) exposeddural sac and ipsilateral nerve root (NR). (c) discectomy and endplate preparation are performed under endoscopic visualization. (d). Interbody fusion with bone graft and an interbody fusion cage is then performed under

fluoroscopic and endoscopic guidance. additional percutaneous pedicle screw fixation can be conducted under fluoroscopic control[4]

- **Biportal endoscopic TLIF**

These operations are performed under general or epidural anesthesia. All decompression and interbody fusion procedures are performed with a biportal endoscopic system **(Figure 2)**. With the patient placed in prone position on a radiolucent operating table, waterproof drapes are installed and the portal sites are established under image control.Two ipsilateral skin incisions are made in the paramedian region, at 1 cm above and 1 cm below the midpoint of the disc space in the lateral fluoroscopic view, and on the ipsilateral medial border of the pedicle in the anteroposterior view. In the left-sided approach, the upper hole acts as the endoscopic portal, and the lower hole is used as the working portal. After making two small incisions in the skin and fascia, serial dilators are inserted to create adequate portals. The lamina is then dissected using a specialized lamina dissector inserted through the working portal[22].

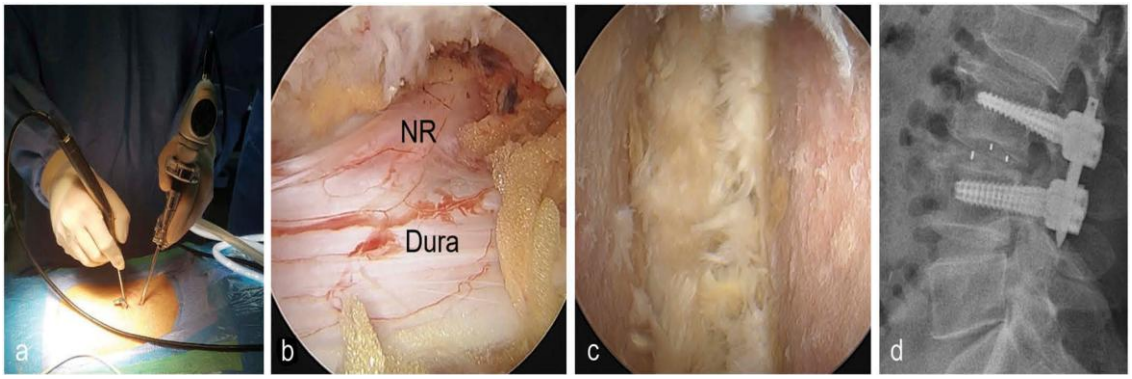


Figure 2: Biportal endoscopic transforaminal lumbar interbody fusion. (a). Overview of the Biportal endoscopic surgery. (b). Ipsilateralfacetectomy and bilateral hemilaminectomy can be performed under the biportal endoscope. Note the decompressed dural sac and nerve root (NR). (c). Complete discectomy and endplate preparation are performed under fluoroscopic and endoscopic visualization. (d). Interbody fusion with bone chips and an interbody fusion cage is then performed under fluoroscopic and endoscopic visualization. Supplementary percutaneous pedicle screw fixation can be conducted under fluoroscopic control[4]

An endoscopic irrigation system is used during the procedure, and the irrigation fluid is drained from the endoscopic portal to the working portal. The irrigation fluid can be drained naturally, without the aid of a retractor or tube. If the irrigation flow is poor, a small endoscopic retractor can be used to improve the flow and ensure adequate visibility, as well as to reduce the swelling of soft tissues. Additional bony dissection using burr and control bleeding by a radiofrequency coagulator[23].

The surgical technique of biportal endoscopic TLIF is similar to that of MIS-TLIF using a tubular retractor and a microscope. Ipsilateralhemilaminectomy is performed using endoscopic burrs and Kerrison punches. After adequate ipsilateral decompression, the contralateral sublaminar portion is decompressed by sublaminar drilling to remove the ligamentumflavum. Unilateral facetectomy is then performed using endoscopic burrs and osteotomes to harvest autograft bone. Complete exposure of the ipsilateral and contralateral nerve roots is confirmed. After complete dorsal decompression, the disc is radically removed using pituitary forceps and reamers.The cartilaginous endplate is completely removed using curettes under endoscopic visualization. Autologous bone chips from thelamina and facet are impacted into the disc space, and an interbody fusion cage packed with bone chips and fusion material is inserted under fluoroscopic guidance. Finally, additional percutaneous pedicle screws are inserted and a drain catheter is placed to prevent epidural hematoma[24].

- **Microendoscopic TLIF**

Microendoscopic TLIF done under general anesthesia.A rigid endoscope placed on the tubular retractor is mainly use for the decompression and interbody fusion procedures **(Figure 3)**. Lateral and anteroposterior view image are obtained with the patient placed in prone position on operating table. The location of the skin incision is established between the centers of the upper and lower pedicles, along the lateral pedicular lines. Therefore, the skin incision is 3.2–3.5 cm long and lies 3.5–4.5 cm laterally to the midline, typically on the side with worse symptoms. To identify the bony anatomy, a spinal needle is inserted laterally to the midline at an angle of 10°–15°. To expose the lateral lamina and lateral facet, a periosteum detacher is inserted along the needle[25].

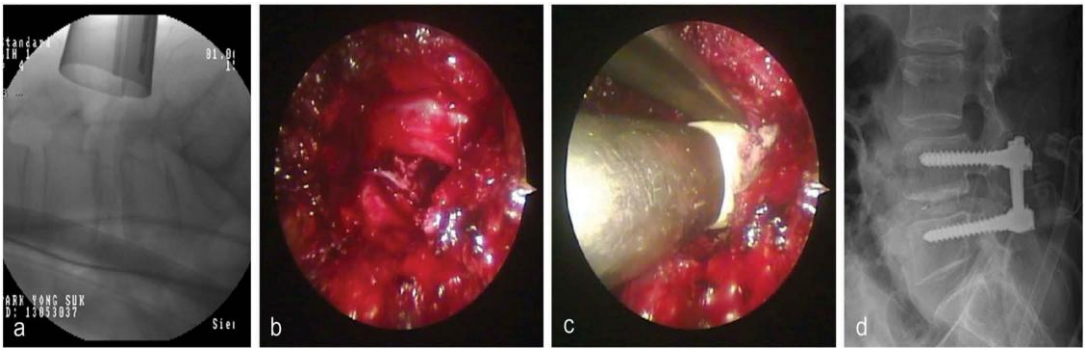


Figure 3: Microendoscopic transforaminal lumbar interbody fusion. (a). Endoscopic decompression can be performed with a 25-degree rigid endoscope attached to the tubular retractor. (b). Hemilaminectomy and facetectomy can be performed using standard surgical instruments, under endoscopic visualization. Radical discectomy and endplate preparation are performed. (c). Interbody fusion with bone chips and an interbody fusion cage is then conducted under fluoroscopic and endoscopic visualization. (d). Supplementary percutaneous pedicle screw fixation can be conducted under fluoroscopic control [4]

Serial dilator inserted through the paraspinal muscle to enlarge the surgical field. lastly, a suitable tubular retractor or X-tube endoscopic retractor is placed over the final dilator. The adequate position of the retractor can be achieved under fluoroscopic control. Aflexible arm is then attached to the retractor to hold it firmly in place. After removing the soft tissues on the bone surface using electrical cautery, a 25-degree rigid endoscope is placed using the locking arm on the ring attachment. The position of the endoscope is adjusted to identify the anatomical structures under appropriate visualization. Resection of the facet joint, together with laminectomy and removal of the ligamentumflavum are performed to achieve canal and foraminal decompression. contralateral decompression can be done by tilting the tubular retractor to the medial side, and further removal of ligamentumflavum and the inner layer of the lamina and is done to widen the canal and the foramen[26].
After adequate discectomy and preparation of endplates, the previously resected autologous bone chips are mixed with allograft bone chips and then packed into the disc space via a specialized cannula. Finally, an interbody fusion cage packed with bone chips is inserted into the disc space under endoscopic monitoring, with care not to injure the nerves. Supplementary percutaneous pedicle screws are then inserted under fluoroscopic guidance. After completing the instrumentation procedures, direct closure of the skin is performed and the patient is monitored for complications[27].

- **Advantages of endoscopic TLIF**

1) Minimal invasive approach

Offer minimal muscle splitting with little bone resection.so, the primary benefit of endoscopic TLIF is reduction in blood loss, very low risk of thromboembolism, early recovery, and lower risk of postoperative fibrotic tissue formation. The main advantage of the transforaminal approach with full-endoscopic visualization is that it eases direct safe decompression around neural tissue[28].

2) Regional and local anesthesia

Endoscopic TLIF can be done without the need of general anesthesia. especially, percutaneous endoscopic TLIF is usually operated under local anesthesia. Use of conscious sedation minimize the risks associated with general anesthesia and facilitates real-time neurological outcome from the patient. so, percutaneous endoscopic TLIF is particularly useful in medically compromised and elderly patients[29].

3) Endplate preparation

Endoscopic TLIF provide direct visualization of endplate than for open TLIF furthermore, endplate preparation accessible in open TLIF may be insufficient to facilitate fusion in some patients. End plate injury or incomplete endplate preparation may cause cage subsidence or failure of fusion following open TLIF. More than that the use of endoscopic visualization during endplate preparation assist visual confirmation of the adequacy of endplate preparation and extensive range of endplate preparation. lastly, endoscopic visualization helps minimize the risk of injury to major vessels, which sometimes occurs during unseen endplate preparation procedures[30].

- **Disadvantages of endoscopic TLIF**

1) Limited indications

Endoscopic TLIF remains technically a challenging and complex procedure with limited indications and unique complications associated with the transforaminal endoscopic approach. In patients with loss of disc space height and very narrow Kambin's triangle, it may be difficult to achieve sufficient disc preparation for safe cage insertion, resulting in some complication such as non-union, delayed cage subsidence, or migration and exiting

nerve root injury t. despite severe central stenosis is common in clinical practice, patients with this condition may be not indicated for endoscopic TLIF due to considerable risk of incomplete decompression[3].

2) Long learning curve

Other limiting factor of endoscopic TLIF is in the long curve required to learn and ensure that each step of the procedure is safe and effective: safe transforaminal approach, adequate endoscopic decompression, and proper interbody fusion under the endoscopic visualization[31].

3) Limited interbody fusion

Limited amount of autograft is available or if a fusion cage of adequate size cannot be installed or positioned properly due to small working space[32].

- **Radiation exposure**

Mostly image exposure is needed in each step of endoscopicmore radiation exposure may increase the risk of health problems for the patients and the medical staff[33].

- **Technical considerations TLIF**

Some features are common across the three reported techniques. First, all strategies generally involve a posterolateral transforaminal approach with either total or partial facetectomy. Second, visualization is obtained through an endoscopic system rather than through an operating microscope. Third, the decompression procedure is similar to that used in MIS-TLIF, regardless of the type of endoscope used[34].

However,endoscopic TLIF and MIS-TLIF differ in terms of some key features.First, endoscopic TLIF requires a smaller skin incision with less muscle dilation, though there is no evidence that this actually results in less pronounced muscle trauma. Second, endoscopicTLIF allows more flexibility in terms of the method of anaesthesia. Unlike MIS-TLIF, endoscopic TLIF can be performed under local anaesthesia or conscious sedation, which is a unique benefit of endoscopic TLIF. Third, despite these advantages, the indication of endoscopic TLIF may be limited to degenerative stenosis with low-grade spondylolisthesis, whereas MIS-TLIF is more appropriate for deformity correction or reduction of vertebralslippage in high-grade spondylolisthesis[35]. Finally, the optimal instrumentation technique to accomplish solid fusion or stabilization of the vertebral segment in endoscopic TLIF has yet to be established. Several categories of endoscopic TLIF can be distinguished based on the type of endoscope used: percutaneous endoscopic TLIF, biportal endoscopic TLIF, and micro endoscopic TLIF. Unfortunately, a direct comparison among these categories cannot be conducted based on the evidence available to date. Moreover, the choice of endoscopic system is not standardized yet, and is generally left to the surgeon's discretion. Well-designed studies with long-term follow-up and large sample size are required to compare the clinical characteristics among the surgery types[4].

Minimally invasive spine surgery

Lumbar spine fusion procedures have come a long way since the first description of the same by Albee and Hibbs in independent reports in 1911. The evolution of these spinal fusion procedures has seen some remarkable developments in the last century which include: description of ALIF (Anterior Lumbar Inter-body Fusion) by Burns (1933), PLIF (Posterior Lumbar Inter-Body Fusion) by Cloward (1943), pedicle screws by Roy-Camille (1970) and TLIF (Trans-foraminal Lumbar Inter-body Fusion) by Harms and Rolinger (1982). Along with development of carbon fibre cages and orthobiologics in the 1990s, each of these developments has contributed in achieving better fusion rates and clinical outcomes for lumbar spine fusion procedures. The more lateral exposure to the interspace in TLIF as compared to PLIF gives it three distinct advantages over the latter[36]:

a) Minimal neural retraction.
b) Thorough interspace preparation through a unilateral approach owing toits lateral-to-medial trajectory.
c) Avoidance of midline scars in revision cases (like recurrent disc herniations).

The evolution of MAST (Minimal Access Spine Technique) in the last two decades has been nothing less than spectacular. Taking cue from the dramatic success of laparoscopic and endoscopic techniques in other surgical disciplines, spine surgeons have also focused on minimal invasive techniques. While excellent results were obtained with open TLIF, there was significant morbidity seen due to iatrogenic soft tissue and muscle injury that occurs with subperiostealparaspinal muscle stripping and prolonged retractor application. Therefore, a fusion can be achieved without permanent structural damage to the bone or the multifidus muscle, which is vital to spinal stability and functional recovery[37].

Access to lumbar interbody fusion

Lumbar Interbody Fusion (LIF) involves placement of an implant (cage, or structural graft) inside the disc space after discectomy and endplate preparation.LIF can be performed using 5 main approaches **(Figure 4)[38]:**

1. Posterior lumbar interbody fusion (PLIF).
2. Transforaminal lumbar interbody fusion (TLIF or MI-TLIF).
3. Oblique lumbar interbody fusion/anterior to psoas (OLIF/ATP).
4. Anterior lumbar interbody fusion (ALIF).

5. Lateral lumbar interbody fusion (LLIF)

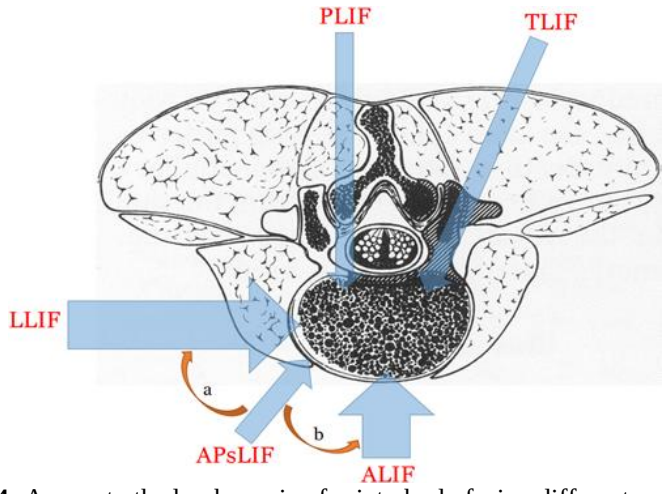


Figure 4: Access to the lumbar spine for interbody fusion different methods[39]

Anterior options are any approach that is anterior to the Transverse Process that includes a retroperitoneal corridor to the lumbar spine (ALIF/OLIF/LLIF), and posterior options posterior to the Transverse Process, involving traversing the spinal canal or foramen for access to the disc and interbody space (PLIF/TLIF/MI-TLIF).The conventional TLIF approach is a posterior surgical approach that was reported by Harms and Rolinger in 1982 for fusion to avoid complication of PLIF (neural retraction, with particular concerns surrounding possibility of nerve root injury, dural tears and epidural fibrosis) [39].
Like other fusion procedures, TLIF can be performed via an open procedure or MIS "mini-open" technique with smaller incision sizes and use of microscopy.The TLIF approach involves positioning the patient prone after the patient is put under general anesthesia. In O-TLIF, a midline incision is used, while in MIS-TLIF a unilateral paramedian (Wiltse) mini-open incision is used, allowing access to the disc space suitable for levels L1-S1 with percutaneous fixation of the contralateral side.The spinal canal is entered via a unilateral laminectomy and inferior facetectomy, which facilitates bone graft placement[40].

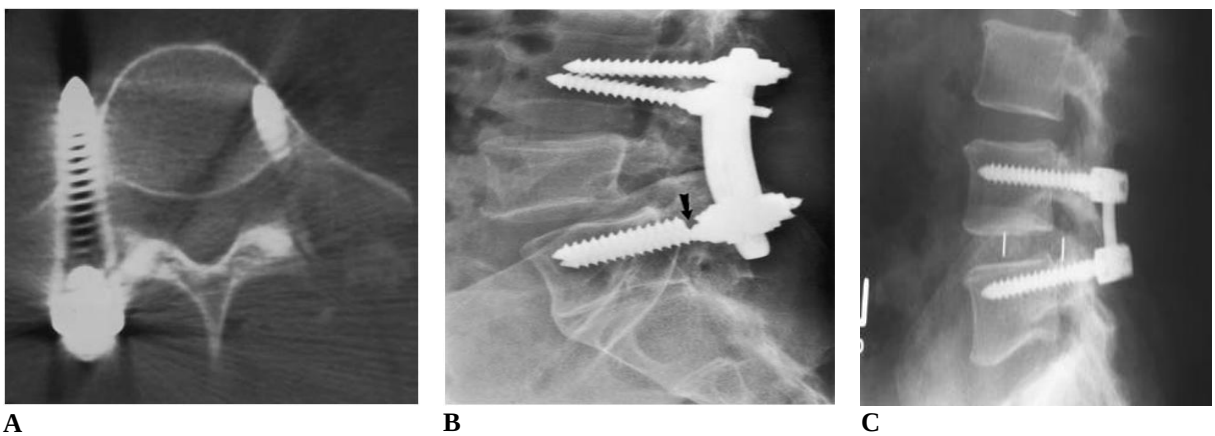
Complications

- **Complications of posterior instrumentation**

➢ Mal positioned screw
➢ Neural injury: due to stretch on the nerves or screw misplacement.
➢ Coupling failure: caused by inadequate tightening of the rods.
➢ failure of implant: screw bending or screw breakage can occur
➢ Cage dislodgement: affected by:

a) Size (more with small cages than with large ones).
b) Shape (more with rectangular cages than with kidney shaped cages).
c) Shape of endplates (more with linear than with concave endplates).

➢ Pedicle fracture.
➢ Prominent instrumentation and skin breakdown**(Figure 5)**[41].



A **B** **C**

Figure 5: A: screw malposition, B: broken lower pedicle screws, C: cage posterior migration

Endoscopic TLIF versus MIS TLIF in the treatment of degenerative lumbardisc disease

Lumbar degenerative disease, common among the elderly, is the leading cause of LBP. LBPis the most frequent pain and disability complaint among patients aged 65 years and older, and it is also highly prevalent in the second most common age group for LBP[42]. Lumbar fusion is an excellent solution for severe lumbar degenerative disease and is widely recognized by spine surgeons. Wong et al. [43]prospectively studied 198 patients and found a significantly lower complication rate with MIS-TLIF. It is attributed to less tissue trauma, lower blood loss, less drainage, and a smaller potential dead space.

He et al. [44]concluded that the Endo-LIF technique has the following advantages over the TLIF technique:

a) Endoscopic removal of the hyperplastic ligamentumflavum allows for more thorough decompression of the lateral recess and central areas.
b) Most spine surgeons are familiar with posterior lumbar surgery and can more easily overcome the learning curve of endoscopic techniques.
c) A shorter working channel makes it easier to control instruments, improving decompression efficiency and reducing operative time.
d) Endoscopic osteotomy is safer.
e) A nucleus pulposus that prolapses upward or downward can be removed by expanding the working area accordingly.

Although postoperative follow-up data show that the Endo-LIF technique is as effective as the TLIF technique, Endo-LIF offers faster postoperative recovery, minimizes damage to the paraspinal muscles, and results in less intraoperative blood loss and shorter hospital stays compared to TLIF[45].

Therefore, the authors concluded that Endo-LIF may be a reliable alternative to minimally invasive lumbar fusion. Endo-LIF significantly reduces blood loss and hospitalization time. It offers the advantages of less surgical injury, less blood loss, faster recovery, and early relief of postoperative back pain[21]. One article pointed out that there is no significant difference in the short-term clinical efficacy and safety between Endo-LIF and MIS-TLIF for the treatment of single-segment degenerative lumbar spine disease, but no report has been seen about Endo-LIF and MIS-TLIF for the treatment of two-segment lumbar degenerative disease[46].

Ito et al. [47]concluded that intervertebral fusion typically occurs 2 years after surgery, with significant intervertebral bone growth occurring 3 to 5 years post-surgery. Due to regional and economic constraints, surgical patients in this study could not receive long-term follow-up beyond the final assessment. Therefore, the long-term fusion efficacy of the two techniques could not be further investigated, which is a limitation of the study. However, 1 day after surgery, the VAS (back) score in the Endo-LIF group was (4.07 ± 1.09) lower than that in the MIS-TLIF group (5.40 ± 1.60), with a statistically significant difference ($P = 0.02$).

Song et al. [46]suggested that the lack of difference may be due to the identical screw placement in both surgeries, resulting in similar trauma from the screw insertion. Other studies have noted that gender differences in pain persist before and after surgical interventions for lumbar degenerative pathologies. The authors suggest that physiological, environmental, and economic factors may contribute to these differences, with females potentially being more sensitive to pain[48].

Due to limitations in surgical conditions, intraoperative hemorrhage during Endo-LIF is aspirated along with the flushing saline, making it difficult to accurately measure the exact amount of blood loss. Therefore, used the difference between preoperative and postoperative Hb levels to estimate blood loss. This method may introduce some errors in accurately measuring blood loss, which is an area for improvement. Compared to MIS-TLIF, Endo-LIF minimizes excessive handling of tissue during the procedure and is performed under constant water pressure, which helps compress surrounding tissues and blood vessels to reduce bleeding. Additionally, endoscopic observation of tiny blood vessels allows for the use of a radiofrequency knife to pre-emptively stop bleeding, further reducing blood loss[45].

The patient, a 45-year-old with normal preoperative coagulation, likely developed the postoperative epidural hematoma due to the multi-segmental surgery. The extensive duration and scope of the surgery may have caused significant damage to the venous plexus, leading to increased bleeding. Intraoperative water pressure aids in hemostasis, but its withdrawal post-surgery can cause some venous plexuses to reopen and bleed, increasing the incidence of postoperative epidural hematoma. Longer surgery duration, more surgical segments, and greater blood loss are also key factors in postoperative infections [49].

Endo-LIF requires continuous saline irrigation, which lowers body temperature and may increase the likelihood of postoperative wound infections. Therefore, in future Endo-LIF operations, used thermostatic saline as the flushing fluid. Recent studies show that interleukin 6 is very useful for early diagnosis of postoperative wound infections, with levels of 26.0 pg/mL or higher indicating a surgical incision infection [50].

Endplate extrusion and collapse observed during URP may result from compression injury during the initial placement of the cage. Damage to the posterior edge of the endplate increases the height behind the fusion device, making retropulsion more likely. In lumbar fusion surgery, endplate injury ≥ 5 mm is a risk factor for cage retropulsion. Lumbar fusion takes about 3 months. Early removal of lumbar support and premature activity can affect lumbar stability and increase the risk of cage retropulsion. Peter et al. [51]found that the complication

rate for single-segment and two-segment lumbar fusion surgery is relatively low. However, for three-segment fusion, the rate is comparable to open surgery. This study, limited by clinical data, does not discuss three-segment fusion outcomes. To obtain more accurate results for multi-segment fusion, further case collection is needed.

Endo-LIF procedure offers several advantages over MIS-TLIF for treating two-segment lumbar degenerative disease: it theoretically causes less damage to muscles and soft tissues, results in reduced intraoperative bleeding, and reduces early postoperative pain. These factors facilitate earlier postoperative rehabilitation exercises for patients and align more closely with the ERAS concept. However, the learning curve for Endo-LIF is steep, requiring a significant number of surgeries to achieve proficiency. Additionally, compared to MIS-TLIF, Endo-LIF has a relatively longer operation time and higher surgical costs[45].

CONCLUSION

Degenerative lumbar disc disease and resulting LBPimpart a large socioeconomic impact on the health care system. Degenerative disease of the intervertebral disc is, in fact, still a common and remarkable health problem in the aged population, not completely understood, and it contributes significantly to the years of life disability. Both MIS-TLIF and Endo-LIF are promising treatments for two-segment lumbar degenerative disease. The choice of a surgical procedure depends on the patient's financial situation, their ability to tolerate surgery, and the surgeon's expertise.

REFERENCES

1. Liyew WA. Clinical Presentations of Lumbar Disc Degeneration and Lumbosacral Nerve Lesions. Int J Rheumatol. 2020;2020:29-35.
2. Zhai WJ, Wang ZK, Liu HL, Qin SL, Han PF, Xu YF. Comparison between minimally invasive and open transforaminal lumbar interbody fusion for the treatment of multi-segmental lumbar degenerative disease: A systematic evaluation and meta-analysis. Exp Ther Med. 2024;27:16-22.
3. Chen H, Zheng G, Bian Z, Hou C, Li M, Zhang Z, et al. Comparison of minimally invasive transforaminal lumbar interbody fusion and endoscopic lumbar interbody fusion for lumbar degenerative diseases: a retrospective observational study. J Orthop Surg Res. 2023;18:38-49.
4. Ahn Y, Youn MS, Heo DH. Endoscopic transforaminal lumbar interbody fusion: a comprehensive review. Expert Rev Med Devices. 2019;16:373-80.
5. Battié MC, Joshi AB, Gibbons LE. Degenerative Disc Disease: What is in a Name? Spine (Phila Pa 1976). 2019;44:1523-9.
6. Sollmann N, Fields AJ, O'Neill C, Nardo L, Majumdar S, Chin CT, et al. Magnetic Resonance Imaging of the Lumbar Spine: Recommendations for Acquisition and Image Evaluation from the BACPAC Spine Imaging Working Group. Pain Med. 2023;24:81-94.
7. Wan ZY, Zhang J, Shan H, Liu TF, Song F, Samartzis D, et al. Epidemiology of Lumbar Degenerative Phenotypes of Children and Adolescents: A Large-Scale Imaging Study. Global Spine J. 2023;13:599-608.
8. Kim HS, Wu PH, Jang IT. Lumbar Degenerative Disease Part 1: Anatomy and Pathophysiology of Intervertebral Discogenic Pain and Radiofrequency Ablation of Basivertebral and Sinuvertebral Nerve Treatment for Chronic Discogenic Back Pain: A Prospective Case Series and Review of Literature. Int J Mol Sci. 2020;21:20-39.
9. Kirnaz S, Capadona C, Lintz M, Kim B, Yerden R, Goldberg JL, et al. Pathomechanism and Biomechanics of Degenerative Disc Disease: Features of Healthy and Degenerated Discs. Int J Spine Surg. 2021;15:10-25.
10. Zolfaghari F, Faridmoayer A, Soleymani B, Taji M, Mahabadi M. A Survey of Vitamin D Status in Patients with Degenerative Diseases of the Spine. Asian Spine J. 2016;10:834-42.
11. Silwal P, Nguyen-Thai AM, Mohammad HA, Wang Y, Robbins PD, Lee JY, et al. Cellular Senescence in Intervertebral Disc Aging and Degeneration: Molecular Mechanisms and Potential Therapeutic Opportunities. Biomolecules. 2023;13:50-60.
12. Beatty S. We Need to Talk about Lumbar Total Disc Replacement. Int J Spine Surg. 2018;12:201-40.
13. Litak J, Szymoniuk M, Czyżewski W, Hoffman Z, Litak J, Sakwa L, et al. Metallic Implants Used in Lumbar Interbody Fusion. Materials (Basel). 2022;15:50-60.
14. Wu PH, Kim HS, Jang IT. Intervertebral Disc Diseases PART 2: A Review of the Current Diagnostic and Treatment Strategies for Intervertebral Disc Disease. Int J Mol Sci. 2020;21:20-40.
15. Mallio CA, Vadalà G, Russo F, Bernetti C, Ambrosio L, Zobel BB, et al. Novel Magnetic Resonance Imaging Tools for the Diagnosis of Degenerative Disc Disease: A Narrative Review. Diagnostics (Basel). 2022;12:30-40.
16. Norimoto M, Eguchi Y, Kanamoto H, Oikawa Y, Matsumoto K, Masuda Y, et al. Diffusion Tensor Imaging of the Spinal Canal in Quantitative Assessment of Patients with Lumbar Spinal Canal Stenosis. Asian Spine J. 2021;15:207-15.

17. Murata K, Akeda K, Takegami N, Cheng K, Masuda K, Sudo A. Morphology of intervertebral disc ruptures evaluated by vacuum phenomenon using multi-detector computed tomography: association with lumbar disc degeneration and canal stenosis. BMC Musculoskelet Disord. 2018;19:16-24.
18. Ao S, Zheng W, Wu J, Tang Y, Zhang C, Zhou Y, et al. Comparison of Preliminary clinical outcomes between percutaneous endoscopic and minimally invasive transforaminal lumbar interbody fusion for lumbar degenerative diseases in a tertiary hospital: Is percutaneous endoscopic procedure superior to MIS-TLIF? A prospective cohort study. Int J Surg. 2020;76:136-43.
19. Ono K, Fukuhara D, Nagahama K, Abe Y, Takahashi K, Majima T. Percutaneous Endoscopic Transforaminal Lumbar Interbody Fusion (PETLIF): Current Techniques, Clinical Outcomes, and Narrative Review. J Clin Med. 2023;12:20-40.
20. Song YF, Wang H, Zhang JW, Li YM, Xue YD, Fu YF, et al. Percutaneous endoscopic versus minimally invasive transforaminal lumbar interbody fusion for lumbar degenerative diseases: a meta-analysis. Wideochir Inne Tech Maloinwazyjne. 2022;17:591-600.
21. Zhu L, Cai T, Shan Y, Zhang W, Zhang L, Feng X. Comparison of Clinical Outcomes and Complications Between Percutaneous Endoscopic and Minimally Invasive Transforaminal Lumbar Interbody Fusion for Degenerative Lumbar Disease: A Systematic Review and Meta-Analysis. Pain Physician. 2021;24:441-52.
22. Heo DH. Biportal endoscopic transforaminal lumbar interbody fusion using a large cage for degenerative spondylolisthesis with stenosis. Neurosurg Focus Video. 2024;10:15-25.
23. Kim JE, Choi DJ. Biportal Endoscopic Transforaminal Lumbar Interbody Fusion with Arthroscopy. Clin Orthop Surg. 2018;10:248-52.
24. Yu Q, Lu HG, Pan XK, Shen ZH, Ren P, Hu XQ. Unilateral biportal endoscopic transforaminal lumbar interbody fusion versus conventional interbody fusion for the treatment of degenerative lumbar spine disease: a systematic review and meta-analysis. BMC Musculoskelet Disord. 2023;24:83-98.
25. Xiao S, Zhou S, Pan S, Ning J, Gan X, Guan Y. Comparison of Endoscopic and Minimally Invasive Transforaminal Lumbar Interbody Fusion for Lumbar Degenerative Diseases: A Meta-analysis. Clin Spine Surg. 2024;37:56-66.
26. Chen G, Li LB, Shangguan Z, Wang Z, Liu W, Li J. Clinical Effect of Minimally Invasive Microendoscopic-Assisted Transforaminal Lumbar Interbody Fusion for Single-Level Lumbar Disc Herniation. Orthop Surg. 2022;14:3300-12.
27. Wang W, Wang Z, Hong Z, Chen H. Minimally invasive transforaminal lumbar interbody fusion for dual-segment lower lumbar degenerative disease. Wideochir Inne Tech Maloinwazyjne. 2018;13:525-32.
28. Kou Y, Chang J, Guan X, Chang Q, Feng H. Endoscopic Lumbar Interbody Fusion and Minimally Invasive Transforaminal Lumbar Interbody Fusion for the Treatment of Lumbar Degenerative Diseases: A Systematic Review and Meta-Analysis. World Neurosurg. 2021;152:352-68.
29. Butler AJ, Alam M, Wiley K, Ghasem A, Rush Iii AJ, Wang JC. Endoscopic Lumbar Surgery: The State of the Art in 2019. Neurospine. 2019;16:15-23.
30. Parisien A, Wai EK, ElSayed MSA, Frei H. Subsidence of Spinal Fusion Cages: A Systematic Review. Int J Spine Surg. 2022;16:1103-18.
31. Zhao T, Dai Z, Zhang J, Huang Y, Shao H. Determining the learning curve for percutaneous endoscopic lumbar interbody fusion for lumbar degenerative diseases. J Orthop Surg Res. 2023;18:19-33.
32. Pholprajug P, Kotheeranurak V, Liu Y, Kim JS. The Endoscopic Lumbar Interbody Fusion: A Narrative Review, and Future Perspective. Neurospine. 2023;20:1224-45.
33. Iprenburg M, Wagner R, Godschalx A, Telfeian AE. Patient radiation exposure during transforaminal lumbar endoscopic spine surgery: a prospective study. Neurosurg Focus. 2016;40:17-25.
34. Kim YH, Ha KY, Rhyu KW, Park HY, Cho CH, Kim HC, et al. Lumbar Interbody Fusion: Techniques, Pearls and Pitfalls. Asian Spine J. 2020;14:730-41.
35. Wasinpongwanich K, Nopsopon T, Pongpirul K. Surgical Treatments for Lumbar Spine Diseases (TLIF vs. Other Surgical Techniques): A Systematic Review and Meta-Analysis. Front Surg. 2022;9:82-94.
36. Nguyen KML, Nguyen DTD. Minimally Invasive Treatment for Degenerative Lumbar Spine. Tech Vasc Interv Radiol. 2020;23:10-20.
37. Lykissas MG, Giannoulis D. Minimally invasive spine surgery for degenerative spine disease and deformity correction: a literature review. Ann Transl Med. 2018;6:99-105.
38. Phan K, Xu J, Scherman DB, Rao PJ, Mobbs RJ. Anterior Lumbar Interbody Fusion With and Without an "Access Surgeon": A Systematic Review and Meta-analysis. Spine (Phila Pa 1976). 2017;42:92-100.
39. Reid PC, Morr S, Kaiser MG. State of the union: a review of lumbar fusion indications and techniques for degenerative spine disease: JNSPG 75th Anniversary Invited Review Article. J Neurosurg Spine. 2019;31:1-14.
40. Singh K, Cha EDK, Lynch CP, Nolte MT, Parrish JM, Jenkins NW, et al. Risk Assessment of Anterior Lumbar Interbody Fusion Access in Degenerative Spinal Conditions. Clin Spine Surg. 2022;35:61-9.

41. Bagheri SR, Alimohammadi E, Zamani Froushani A, Abdi A. Adjacent segment disease after posterior lumbar instrumentation surgery for degenerative disease: incidence and risk factors. J Orthop Surg 2019;27:23-30.
42. Bydon M, Alvi MA, Goyal A. Degenerative Lumbar Spondylolisthesis: Definition, Natural History, Conservative Management, and Surgical Treatment. Neurosurg Clin N Am. 2019;30:299-304.
43. Wong AP, Smith ZA, Stadler JA, 3rd, Hu XY, Yan JZ, Li XF, et al. Minimally invasive transforaminal lumbar interbody fusion (MI-TLIF): surgical technique, long-term 4-year prospective outcomes, and complications compared with an open TLIF cohort. Neurosurg Clin N Am. 2014;25:279-304.
44. He LM, Chen KT, Chen CM, Chang Q, Sun L, Zhang YN, et al. Comparison of percutaneous endoscopic and open posterior lumbar interbody fusion for the treatment of single-segmental lumbar degenerative diseases. BMC Musculoskelet Disord. 2022;23:32-49.
45. Zhuo C, Liu Y, Zhang Y, Zhang R, Wang L, Yang D, et al. Comparison of the short-term efficacy of MIS-TLIF and Endo-LIF for the treatment of two-segment lumbar degenerative disease. BMC Musculoskeletal Disorders. 2024;25:70-8.
46. Song Z, Zhu W, Zheng J, Wu G, Li T, Huang A, et al. Comparison of short-term efficacy of MIS-TLIF and Endo-LIF in the treatment of single-segment degenerative lumbar diseases. Front Surg. 2022;9:92-100.
47. Ito Z, Imagama S, Kanemura T, Satake K, Ando K, Kobayashi K, et al. Volumetric change in interbody bone graft after posterior lumbar interbody fusion (PLIF): a prospective study. Eur Spine J. 2014;23:44-9.
48. MacLean MA, Touchette CJ, Han JH, Christie SD, Pickett GE. Gender differences in the surgical management of lumbar degenerative disease: a scoping review. J Neurosurg Spine. 2020;32:799-816.
49. Li T, Shi L, Luo Y, Chen D, Chen Y. One-Level or Multilevel Interbody Fusion for Multilevel Lumbar Degenerative Diseases: A Prospective Randomized Control Study with a 4-Year Follow-Up. World Neurosurg. 2018;110:815-22.
50. Roch PJ, Ecker C, Jäckle K, Meier M-P, Reinhold M, Klockner FS, et al. Interleukin-6 as a critical inflammatory marker for early diagnosis of surgical site infection after spine surgery. Infection. 2024:30-40.
51. Passias PG, Bortz C, Horn SR, Segreto FA, Stekas N, Ge DH, et al. Diminishing Clinical Returns of Multilevel Minimally Invasive Lumbar Interbody Fusion. Spine (Phila Pa 1976). 2019;44:181-7.