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Percutaneous Endoscopic Lumbar Discectomy (Early Experience)

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Abstract

Background: With the advent of percutaneous endoscopic lumbar discectomy (PELD), a novel posterolateral method has been developed for decompressing the lumbar disc space and removing the nucleus pulposus. In April 1987, the authors brought the method to Germany. Individuals whose lorsal longitudinal ligament is intact and who have non-equestrated lumbar disc herniation are good candidates for this procedure. Under local anesthesia, the disc's dorsal lateral border is accessed by a working cannula with an outside diameter of 5 mm. Using anulus trephines to open the disc space and a combination of flexible and stiff forceps, as well as automated shaver devices, the nucleus pulposus is removed under intermittent endoscopic control (discoscopy). Our goal in writing this review is to provide a thorough evaluation of PLED's clinical value in the treatment of lumbar disc herniation by looking at its safety, effectiveness, and results in terms of pain reduction, functional improvement, complications, and patient satisfaction. In summary: A new less invasive surgical alternative for individuals with symptomatic lumbar disc herniation is percutaneous endoscopic lumbar discectomy (PELD). When people talk about percutaneous endoscopic discectomy, they usually mean either percutaneous endoscopic transforaminal discectomy or percutaneous endoscopic interlaminar discectomy. PELD's minimal incision, speedy recovery, short hospital stay, and comparable clinical success to open surgery have made it more well-known.

Keywords: Terms such as TELD, IELD, Lumbar Disc Herniation, and Percutaneous Endoscopic Lumbar Discectomy are used.

1. Introduction

Low Back discomfort affects a large percentage of the global population, which has a major influence on people's quality of life and causes huge societal and economic consequences. Lumbar disc herniation is the leading cause of low back pain, however there are other potential reasons as well. Lumbar disc herniation occurs when the intervertebral disc's nucleus pulposus pushes through a disc herniation rupture in the annulus fibrosus. This may cause pain, numbness, and weakness in the lower limbs as it compresses nearby nerve roots [1]

Low back and sciatica pain are often caused by LDH, which is most common in people between the ages of 30 and 50. Around 1-3 percent of persons will reportedly have symptomatic LDH throughout their lifetimes. Occupational activities including heavy lifting, genetic predisposition, smoking, and obesity are risk factors for the illness, which is more frequent in men than females [2]

One aspect of aging that contributes to the pathophysiology of LDH is the intervertebral disc degeneration. The discs dehydrate, stiffen, and become more likely to rupture as time goes on. This deterioration may be hastened by mechanical stress and trauma. Radicular discomfort and inflammatory reactions might result from the nucleus pulposus penetrating the annulus fibrosus and pressing on the spinal nerves. According to Adams and Roughley (2006), the sciatic nerve distribution corresponds to the areas of the lumbar spine that are most often affected: L4–L5 and L5–S1.

Lumbar disc herniation symptoms sometimes include radiating leg discomfort (sciatica), lower back pain, sensory problems, and, in more severe instances, motor impairments. According to clinical examination and imaging investigations like MRI and CT scans play a crucial role in diagnosis by providing visual representations of the herniated disc and its effects on nearby structures. [3]

When treating lumbar disc herniation, conservative methods such as physical therapy, NSAIDs, and epidural steroid injections are often used first. Over time, many patients report symptomatic alleviation as a result of these therapies' efforts to reduce pain and enhance function. Nevertheless, surgical surgery may be contemplated in cases where conservative therapies do not provide enough relief or when neurological impairments advance [4]

Spinal cord herniation surgery alternatives include mini-open microscopic discectomy, percutaneous endoscopic lumbar discectomy (PELD), and open discectomy. The conventional method of open discectomy, which requires more muscle dissection and a wider incision, results in more postoperative discomfort and a lengthier recovery period. According tomini-open microscopic discectomy reduces the amount of muscle tissue removed and the size of the incision, which in turn shortens the recovery period and alleviates postoperative discomfort, all while preserving positive clinical results. [5]

The percutaneous endoscopic lumbar disc decompression procedure (PELD) is the cutting edge of minimally invasive surgical options for this

condition. This technique involves removing herniated disc material via a tiny incision using specialized devices and an endoscope, which minimizes harm to the surrounding tissues. According to the hazards of general anesthesia are considerably reduced when PELD is conducted under local anesthetic with sedation.[6]

There are significant benefits to using PELD instead of more conventional surgical techniques. Some of these benefits include less discomfort after surgery, less time spent in the hospital, a speedier recovery, and less chance of problems like infection and scarring. Further, PELD facilitates a more rapid recovery and return to work, which is appealing to both patients and surgeons. [7]

The purpose of this review was to investigate PLED's results, safety, and effectiveness in treating lumbar disc herniation. With the goal of conducting a thorough evaluation of this technique's therapeutic efficacy, we will measure pain alleviation, functional improvement, complications, and patient satisfaction.

2. Historical review

In For radicular discomfort, Mixter and Barr performed exploratory laminectomy in 1934. According to there were 19 surgical instances involving the prolapse of nucleus pulposus or shattered nucleus in the lumbar, thoracic, and cervical regions. These cases were associated with the causes of sciatica and radicular pain.[8]

In 1951, Hult was the first to propose the idea of nucleotomy via the anterolateral abdominal extraperitoneal method for indirect decompression of the spinal canal [9].

Lyman Smith pioneered chemoneucleolysis in 1964 by hydrolyzing the herniated nucleus pulposus in a sciatica patient using a percutaneous injection of chymopapain; this marked a genuine paradigm change in the least invasive approach to the lumbar disk. After experiencing complications like transverse myelitis, most surgeons stopped using this method [10]

It was in January 1973 that Kambin began a posterolateral extracanal nonvisualized procedure for percutaneous indirect spinal canal decompression by nucleotomy with the Craig cannula [11].

Comparable to Hijikata's approach, Kambin and Gellman documented a 72 percent success rate in 136 patients treated using a percutaneous lateral technique. found that fenestration of the outer annulus reduced intradiskal pressure, which led to this result.[12]

William Friedman increased the danger of intestinal damage with the introduction of the straight lateral technique to percutaneous nucleotomy in 1983.

Invented a 2.8 mm diameter nonvisualized motorized aspiration nucleotomy shaver and a method called automated percutaneous nucleotomy in 1985. More advanced variants of this powered razor are modern nucleotomes [13]

To color aberrant nucleus and annular fissures, used a biportal technique with a diskoscope to inject indigo carmine, a crucial dye.[14]

Mayer and Brock described an endoscopic method that focuses the vision dorsally around the annular tear in 1993. This method is comparable to Schreiber's biportal approach.

In 1996, Kambin and Zhou described a surgical endoscopic procedure for decompressing nerve roots affected by lateral recess stenosis. The technique included annulectomy and osteophytectomy, and it made use of mechanical instruments such as forceps and trephines, as well as 0- and 30-degree scopes[15].

A wide-angled endoscope with a rigid rod lens was presented by Tsou and Yeung in 1997[16].

Endoscopic foraminoplasty using a side-firing holmium: yttrium-aluminum-garnet (Ho-YAG) laser was detailed in 2001. They came to the conclusion that endoscopic laser foraminoplasty is a great way to access the foramen and extraforaminal zone, and to mobilize the neural tissue [17]

States that by 2002, individuals suffering from low back discomfort were being encouraged to undergo percutaneous thermal annuloplasty and nucleoplasty using newly developed lasers, as well as intradiskal electrothermal annuloplasty.[18]

The Yeung Endoscopic Spine System (YESS), developed by Richard Wolf Medical Instruments Corp. of Vernon Hills, Illinois, in 2003, is a standardized approach to transforaminal endoscopic surgery. Evocative diskography, endoscopic discectomy with selective guidance, thermal diskoplasty and annuloplasty, endoscopic foraminoplasty, egress through the axillary epidural space between the nerve roots that exit and traverse, and, if necessary, partial resection of the posterior annulus to reach the underside of the herniated mass are all components of the protocol [19].

In 2004, Tsou et al. detailed a procedure for chronic lumbar diskogenic pain (CLDP) that used bipolar radiofrequency thermal annuloplasty and posterolateral transforaminal selective endoscopic discectomy. This method enabled unobstructed view of the disk nucleus and annular fissures, setting it apart from previous percutaneous CLDP treatments. But there was no discernible improvement in clinical outcomes [20].

According to the typical transforaminal approach is to the side, which might be problematic when trying to reach the epidural region directly with unobstructed visibility. In cases of lumbar disk herniations, this issue hinders adequate decompression. As a solution to this technological impasse, introduced a complete endoscopic uniportal transforaminal method that allowed for extreme lateral access. [21]

Patients with high-grade migration and high-canal compromise are more likely to have a residual fragment that causes percutaneous endoscopic lumbar diskectomy to fail, according to a 2006 study by [22] Also that year, published the results of a prospective, randomized research that included 280 consecutive cases of lumbar disk herniation treated with endoscopy alone or endoscopic diskectomy with intradiskal injection of low-dose (1000-U) chymopapain. After reviewing the literature on posterior lateral endoscopic diskectomy for lumbar disk herniation, came to the conclusion that this procedure might achieve a high rate of patient satisfaction. [23]

With their innovative extraforaminal targeted fragmentectomy procedure, [24] reported a 92% success rate in treating 41 patients with soft extraforaminal disk herniations. According to[24] their method included using a steeper angle to medialize the skin entrance site.

The Human Body

The intervertebral foramen is the usual entry point for percutaneous endoscopic discectomy. Anatomical limitations, such as a high iliac crest, a wide facet joint, a broad ala, and a limited foramen, make it difficult to achieve a trajectory from the intraoperative disc fluid (IVF) to the herniation in the L5-S1 disc. When this occurs, diskectomy may be performed via interlaminar access. To successfully execute percutaneous endoscopic diskectomy, one must have a thorough understanding of the anatomy pertaining to interlaminar access and intravenous femoral fluid (IVF) [25].

Intervertebral Foramen Anatomy

The intervertebral disc and the zygapophyseal joint are two moveable joints that allow percutaneous endoscopic lumbar discectomy (PELD) to use a transforaminal approach, which begins at the intervertebral foramen (IVF) (Figure 1). With each level and with the disc's continuous degeneration, the foramen's dimensions vary dynamically.

Ligaments of the Intervertebral Foramen:

The ligaments of the intervertebral foramen were first characterized by Golub and Silverman in 1969. They said that they were a ligamentous structure that condensed from the fascia of the foramen. Although these ligaments are not always present in every foramen, they are most often seen at L1-L2 and the fifth lumbar foramen (Figure 2) [26].

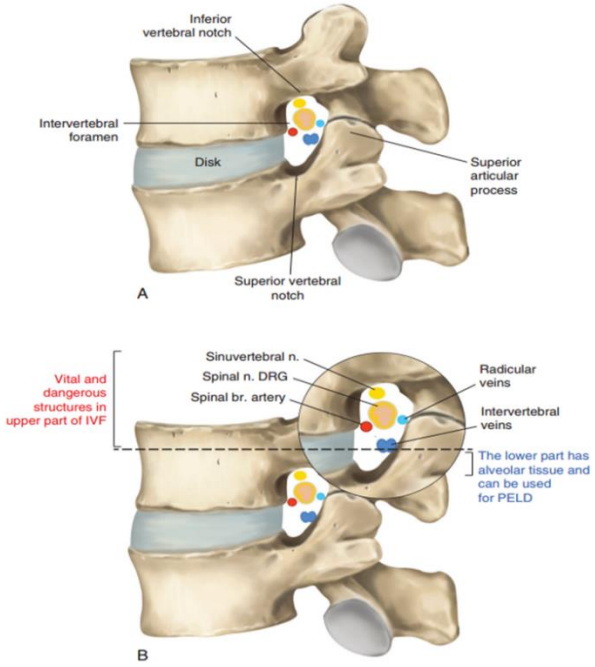

Fig. (1) Intervertebral foramen (IVF) anatomy is shown in Figure 1. A. The osseous structure of in vitro fertilization. Structures B that are undergoing in vitro fertilization. While nervous tissue takes up about a third to half of the intraventricular space (IVF), the lower half is clear of critical structures and provides a secure environment in which to insert the working channel necessary for percutaneous endoscopic lateral diskectomy (PELD). Dorsal root ganglia (DRG) 52

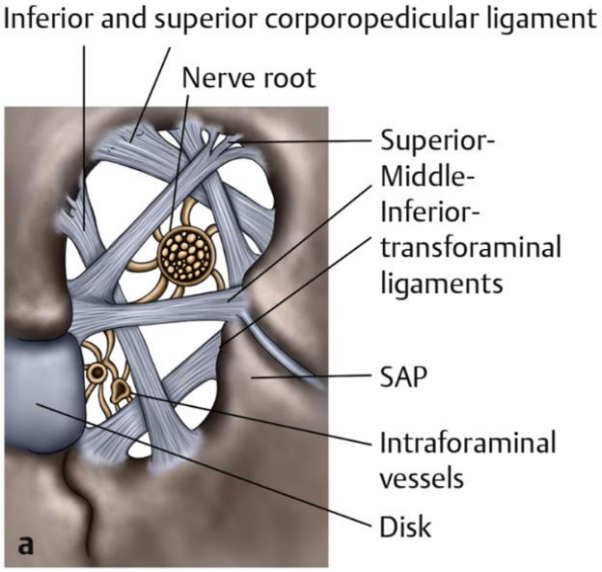

Fig. (2) According to [27], the nerve root is supported as it exits the body by intraforaminal ligaments.

Ligamentum Flavum(Yellow Ligament)[28]:
Attachments: From the dorsal surface of the lamina at the inferior level. On top of the interspace, towards the lamina's ventral side. Floats on top of the interspace between the spinal epidural spaces.
It terminates laterally, at the facet joint level.
The ligamentum flavum tends to enlarge in lumbar degenerative disorders, which may lead to spinal stenosis and other associated problems.
Helps keep the body in an upright position by preventing excessive bending over. It makes sure that the spine straightens out after bending.
The Kammin's Triangle, an Intervertebral Foramen Triangle Safe Zone
The space between the roots of the nerves that depart and those that traverse is a safe place to reach herniated discs. In 1991, Kambin outlined this triangle-shaped buffer zone.
Position and Limits [29]:
Front: Nerve root exiting
Below average: The lower lumbar segment's end plate
On the back, you'll find the superior articular process of the lower backbone.
Medial: Nerve root traversed
Located between the nerve roots that escape and those that traverse, Kambin's triangle—also called the triangular safe zone of the intervertebral foramen (IVF)—provides a safe method to reach herniated discs. The anterior aspect of this triangle is defined by the departing nerve root, the inferior aspect by the end plate of the lower lumbar segment, the posterior aspect by the superior articular process of the inferior vertebra, and the medial aspect by the traversing nerve root. This triangle was first identified by [15]. The endoscopic sleeve should be inserted at the medial end of this triangle according to [30] Radiographic markers should be used to guide the safe placement of the working cannula.
The triangular safe zone was defined by Mirkovic et al. as having dimensions of around 18.9 mm in width, 12.3 mm in height, and 23 mm in hypotenuse, based on their examination of IVF architecture from L2 to S1 vertebrae. According to[30], the optimal intradiscal access needle size is 6.3 mm when positioned centrally along the pedicle or 7.5 mm when somewhat cephalad to the midline of the disc.
Figure 3 shows that at the higher lumbar levels (L1-L2 and L2-L3), it is necessary to target the more medial and steeper discs due to the concave form of the upper lumbar discs and the closeness of the cal sac to the medial pedicular wall. Because bulging discs and hypertrophied facet joints might reduce the available space for surgery, it is essential to assess the shape of the foramen before the procedure. Continuous patient examination under local anesthetic is necessary if the surgeon is concerned about congenital root deformities, low-lying roots, or aberrant big arteries, all of which might alter the safe zone [31].

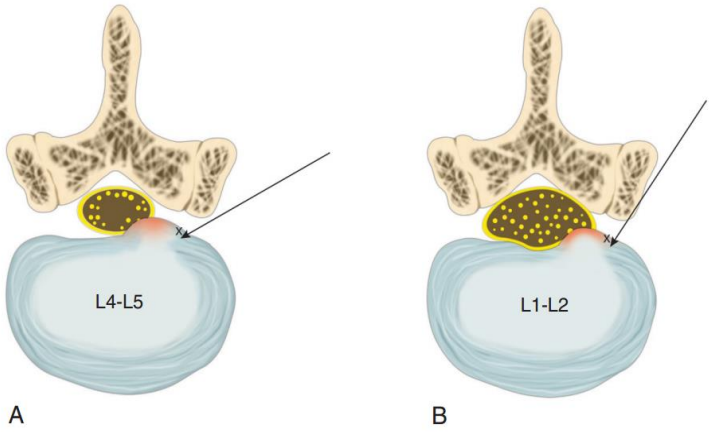

Fig. (3) we can see that the higher and lower lumbar levels have various entrance points. A, the medial pedicular line is the usual site of annular entrance when treating lower lumbar herniations, and the angle of approach is 20 to 30 degrees. [7] noted that in order to avoid dural damage, the approach angle is steeper and the annular entrance site is lateral to the mid-pedicular line at higher lumbar levels.

❖ **Endoscopic Anatomy**

Unlike spine endoscopy does not have a predetermined cavity like joint arthroscopy or other endoscopic techniques. Surgeons need to make room to potentially reach and dissect the pathology. Thorough preoperative planning is necessary to identify the target lesion and trajectory since crucial neural structures are located inside the bone window [32].

Before getting to the disk itself, a transforaminal approach will meet peri-annular tissue. There are distinguishing characteristics that allow surgeons to distinguish between peri-annular and epidural structures [33]

Elements around the annulus: Made of fibrous tissue that is loosely braided and covered with fat that is immobile.

Intraepidermal Frameworks: Shown by epidural fat that is more movable.

During dissection, surgeons use radiofrequency probes to remove fat from around the annulus, which exposes the posterior longitudinal ligament (PLL) and its superficial layer of annular fibers [28].

Procedures for Surgery: The inside-out approach is often used by surgeons, who completely penetrate the posterior disk area before making room inside. For confined herniations, this method is very helpful because it draws the material from the herniated disk into the area where the cannula can retrieve it [33]

Features of Nuclear Tissue: The endoscope shows what looks like blue fluffy cotton—dense, layered tissue—which is really the nucleus. Because it does not melt when exposed to radiofrequency radiation, it differs from annular tissue [34].

Differences and Variations in the Lumbar Nerve Root Interconnected Nerve Fibers

The most typical outlier. Posed in 14–17% of all human remains. Found in 2-5% of patients with sophisticated imaging studies (such as MRI or computed myelography). Poor results after lumbar disc surgery may be due to this clinically unrecognized and perhaps surgically injured disc. Minimally invasive procedures have a greater risk as they may not be able to see the nerves directly [35].

The Classification of Conjoined Roots [36]

Anatomically, there are many types of connected roots.

Type 1: A pair of roots emerge from the dura mater sharing a single sheath.

When a root is of type 1A, its caudal end grows below the proper pedicle and its cephalad end forms an acute angle.

Type 1B: The cephalad root emerges from the connected portion at a right angle.

Type 2: A single foramen serves as the outflow point for both roots.

When two roots occupy a single foramen but a portion of one root leaves via a different foramen, this is called type 2A.

Type 2B: A portion of a root passes out via a different foramen that is downwards from the one that the two roots are using.

Anastomosing branches join two neighboring nerve roots in Type 3.

Discectomy poses a risk of harm to this branch since it crosses into the disc space.

What are the defining features of connected roots?

Slower to spread than typical roots. Danger of inadvertent separation and harm caused by undue stress. Locations L5 and S1 are the most typical places to find it [37].

Radiological Anatomy of the Endoscope Crucial to PELD

Lower Back Pain

The ability to see the spine from all angles is crucial for endoscopic lumbar spine surgeries. The distance between the pedicles and the spinous process should be same on both sides. In the backbone's upper half, the pedicles should be in perfect alignment. When overlaid, the endplates of the vertebrae in the body should line up exactly, creating a single endplate shadow.

Also essential for treatments involving the lumbar spine is a true lateral view. Shows that the endplates are precisely aligned and that the pedicles are overlaid at the index level. It is important that the vertebral body's posterior wall remains perpendicular to the X-ray beam. [38] state that the superior articular processes (SAP) and facet joints should be easily visible.

Figure 4: Interlaminar Technique

The first stage of the interlaminar endoscopic lumbar approach is the AP endplate view. The ideal rostrocaudal approach angle may be determined using this baseline.

Adjust the distal C-arm angle in the upper lumbar region from 0 to 5 degrees. Ten to fifteen degrees in the lower back.

The aim is to center the spinous processes over the disk space projection.

Extra AP X-ray View: Important for targeting in interlaminar techniques; should show inferomedial margin of rostral index level lamina. The broad interlaminar window L5/S1 method is an exception [39]

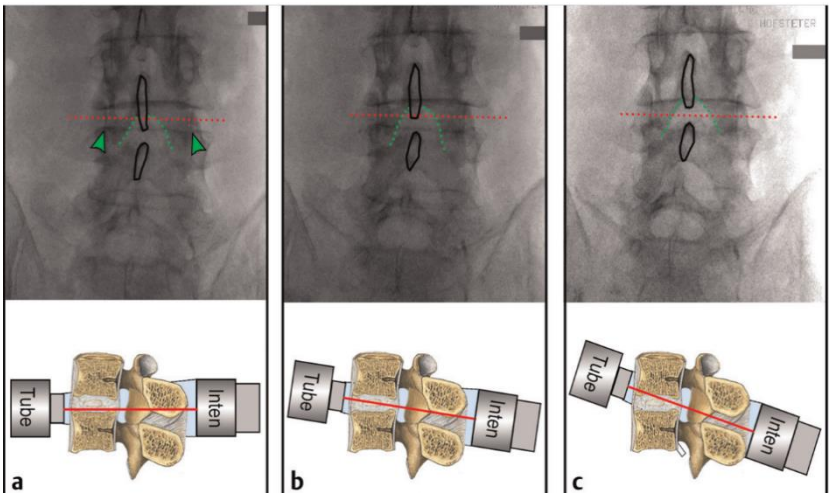

Fig. (4) shows the C-arm adjusted for the interlaminar method. (a) To begin, we acquire an anteroposterior endplate image of the caudal index level's superior endplate (L3/L4; green arrowheads). At its exact center is the index level disc, as seen by the red dotted line. (b) The projection of the superior spinous process space is moved to the right by adding a distal tilt to the rostrocaudal X-ray beam angle. (c) To find an optimum rostrocaudal trajectory, center the gap between spinous processes over the projection of the disk region. The interlaminar approach is targeted at the inferomedial margin of the rostral index lamina (green dotted line) (27).

Transforaminal Technique

Excellent Lateral and AP Views:

Targeting using lateral fluoroscopic images: posterior vertebral line and spinal artery stent (SAPS). Most transforaminal methods, including trans-SAP, aim to target SAP. The tubular retractor tip should be positioned at or beyond the posterior vertebral line, which represents the ventral boundary of the spinal canal, in order to clearly see neural components.

The medial pedicle line may stand in for the lateral edge of the thecal sac or the traversing nerve root on anterior pelvic X-rays. To prevent harm to the nervous system, place the equipment along this line. The radiographic confirmation of the caudal index-level pedicle makes it the principal anatomical marker [40]

The Anatomy and Disease of Lumbar Discs

Discs in the Back [41]:

Fibrous Annulus: Made up of proteoglycans, water, and type I collagen. Its pliability and tensile strength have made it famous. Elevated ratio of collagen to proteoglycans.

Collagen type II, water, and proteoglycans make up the nucleus pulposus. Notable for its ability to be compressed. The high water and carbohydrate content causes a low proteoglycan-to-collagen ratio. Hydrated gels resist compression due to proteoglycan interactions with water.

Shearing of the Discs:

This condition is described as the shifting of disc material (less than 25% of the disc diameter) out of the intervertebral disc space.

Herniation that is contained occurs when the outer annulus fibers and/or the posterior

longitudinal ligament envelop the displaced region [42].

Lumbar Herniated Disc Types

Lumbar disc bulge: this is not the same as a herniation. Disc protrusion that extends beyond of each vertebrae.

Protrusion Lumbar disc herniation: Outward bulging of the disc material, yet the annulus fibers on the outside remain unharmed.

The nucleus pulposus bursts through the outer annulus fibrosus in an extrusion lumbar disc, but it remains attached to the disc itself.

According to a sequestration lumbar disc occurs when the extruded disc material separates from the parent disc and is floating freely inside the spinal canal.[43]

Management

One of the most prevalent presenting complaints worldwide is lower back pain (LBP), which affects almost 80% of the population at some point in their lives. The yearly cost to the United States of this crippling and widespread disease exceeds $100 billion. There are several possible causes of low back pain, but the most prevalent ones are lumbar disc herniation (LDH) and degenerative disc disease. The regions between L4 and L5, or between L5 and S1, account for almost 95% of lumbar disc herniations [41,44].

Approximately 5 to 20 instances per 1000 individuals are reported each year for herniated discs of the back. In a 2:1 male-to-female ratio, LDH is most common between the ages of 30 and 50 .[45]

Neurological examination

If lumbar disc herniation is the cause of radiculopathy, the degree of the herniation may be determined with the use of a comprehensive neurological examination. The kind of herniation and the amount of herniation determine the radiculopathy that is linked with LDH. Paracentral or lateral herniations often impact the transversing nerve root; for example, a lateral herniation at L4-L5 would result in L5 radiculopathy. The departing nerve root is usually impacted by severe lateral (far lateral) herniations; for example, L4 radiculopathy might be caused by an extreme lateral herniation at L4-L5 [46].

The cremasteric reflex (male) is used to evaluate the L1-L2 foramina, where the L1 nerve root exits. Hip flexion weakness is uncommon due to sensory loss in the inguinal area, which is painful when a herniated disc compresses. Foramina L3-L4 and L2-L3 allow the L2 and L3 nerve roots to escape, respectively. When you sneeze, cough, or straighten your leg, your symptoms will become worse. Foramina L4–L5 is the outflow point for the fourth lumbar nerve root. L4 is evaluated by means of a patellar reflex. Compression of a herniated disc produces back discomfort that travels down the leg and into the front of the thigh. Along with this pain comes a lack of sensation in the same area, which in turn weakens the ability to bend and straighten the hips, bend and straighten the knees, and reduces the patellar reflex. One may find the L5 nerve root at the L5-S1 foramina. Pain in the back may go down the leg and into the buttocks, lateral thigh, lateral calf, the ball of the foot, and the big toe when a herniated disc presses on one of these areas. There is a lack of sensation in the web space between the second and big toes, on the bottom of the foot, and in the side of the leg. The ability to bend at the knees, dorsiflex the foot, invert the foot, and evert the big toe are all impaired. The patients' semitendinosus/semimembranosus reflex is diminished. Walking on high heels becomes difficult when the dorsiflexion strength of the foot is weak. The extensor digitorum brevis and tibialis anterior muscles at the front of the leg may atrophy if chronic L5 radiculopathy is present. The Achilles reflex is used to determine where the S1 nerve root escapes, which is at the S1-S2 foramina. When a herniated disc presses on a nerve, it may cause pain in the buttocks or sacrum that travels down the leg to the calf, plantar or lateral foot, or even the perineum. The affected foot's calf, side, or sole may be experiencing sensory loss. Plantarflexion, hip extension, and knee flexion are all areas of weakness. You can't walk on tiptoe if your foot's plantar flexion is weak. [47] noted that it may also lead to sexual dysfunction, incontinence of the urine or feces, and other similar issues.

As part of a neurological evaluation of a patient complaining of lower back discomfort, a straight leg raise test (SLR) is performed. When the radiation is directed below the knee at an angle lower than 45 degrees, reproducing the patient's discomfort and paresthesia (Lasegue's sign), the test is considered positive. Diagnosing radiculopathies of the L4, L5, and S1 levels is where it really shines. To make the test more sensitive, the examiner will raise one leg (Bragaad's sign) and ask the patient to dorsiflex their foot. Similar to the straight-leg-raise test, but performed on the limb that is not causing any symptoms, is the crossed straight-leg test. When a patient has discomfort in one leg while the other leg is asymptomatic, the crossed straight leg test is interpreted as a positive sign of a central disc herniation with significant nerve root irritation [48]

Evaluation

Within 6 to 12 weeks, the symptoms of an acute herniated disc are alleviated in 85 to 90% of people who do not undergo any therapies. Even faster results are seen in patients who do not have radiculopathy [49]

The suggestion is to refrain from ordering imaging scans during this time since disc herniation is often seen in routine neuroimaging of asymptomatic persons. The findings of these examinations will not change the care. Neurological impairment or serious underlying

disease should prompt further imaging and assessment [50].

When patients display warning signs, it is necessary to do imaging and laboratory investigations. Imaging is also advised for individuals who do not show improvement after two to three months of conservative therapy [51].

Examinations in a laboratory setting: When looking for signs of an infectious or chronic inflammatory illness, doctors may order tests like C-reactive protein and erythrocyte sedimentation rate. If you think you could have a cancer or illness, a full blood count can help rule it out [52].

Imaging studies: When a patient presents with low back pain, the first imaging study is a series of lumbar X-ray films. The three views of the spine—axial, lateral, and oblique—are used in the routine examination to check for degenerative or spondylotic changes, fractures, and general spinal alignment. If you want to check for spinal instability, lateral flexion and extension views are the way to go. Herniated lumbar discs are often indicated by radiographs showing narrowed intervertebral spaces, traction osteophytes, and compensatory scoliosis [53].

Additional imaging with a CT or MRI is necessary in the event that an acute fracture is identified [54].

The most sensitive imaging method for studying the spine's bone components is computed tomography (CT). Calcified herniated discs and other pathologies that cause bone loss or degeneration may be evaluated using CT imaging. It is not appropriate for diagnosing radiculopathy since it cannot adequately show nerve roots. When an MRI is not an option, CT myelography is the go-to imaging technique for herniated discs. However, a skilled radiologist's aid is necessary because of how intrusive it is. Potential side effects of myelography include radiation exposure, meningeal infections, and post-spinal headaches. The diagnostic quality of a multidetector CT scan is now almost identical to that of an MRI, thanks to recent advancements in the field [55].

The most reliable way to confirm a suspicion of LDH is with an MRI scan. Because of its exceptional skill in seeing soft tissues, it has the highest diagnostic accuracy (97%). This makes it the most sensitive examination for detecting herniated discs. Among imaging modalities, MRI stands out for its superior inter-observer reliability. Disc herniation is indicated by an elevated T2-weighted signal in the back 10% of the disc. Modic type 1 alterations are associated with degenerative disc disorders [56].

❖ **Treatment**

Most Most LDH symptoms go away within six to eight weeks, so it's best to take it easy at first unless there are any serious warning signs that might indicate a more serious illness, such growing neurologic deficiency or cauda equina syndrome. There has been a recent trend toward comparable medium- and long-term results from conservative and surgical treatments. Nevertheless, there are studies that suggest surgical treatment improves outcomes, leading to quicker symptom alleviation and an overall better quality of life. Despite the lack of research on a universally accepted criteria for whether surgery is necessary, there are relative indicators that individuals exhibiting warning signs should have immediate surgical intervention. The doctor-patient conversation, taking into account the assessment, the length of symptoms, and the patient's requests, determines the final choice for the kind of therapy for non-emergent LDH [57].

Interventional and medically conservative treatment options: When a patient presents with symptoms of acute lumbar disc herniation, this is the technique that is chosen for first care. In the first stages of treatment, primary care physicians may provide pain medication and physical therapy, as well as prescribe a brief period of rest if necessary, educate their patients appropriately, and suggest physical training routines. Since most people feel better after a few weeks, physical therapy isn't necessary until three weeks have passed since symptoms first appeared. Modest nonsteroidal anti-inflammatory drugs (NSAIDs) may be tried first for pain control; if these don't work, opioid analgesics may be considered. Opioids may have serious adverse effects, so it's important to talk to patients about them before prescribing them, and to keep their dosages as short as possible. For temporary pain relief (ranging from two to four weeks) in some individuals with LDH with radiculopathy, transforaminal or interlaminar epidural steroid injections may be used if symptoms continue for more than six weeks. To ensure the epidural steroid injections are administered accurately, contrast-enhanced fluoroscopy is advised. Most LDH patients whose radiculopathy does not need surgery may have better functional results after receiving medical and interventional therapy [58].

Medical Procedure: When medical and conservative treatments fail to alleviate a patient's incapacitating symptoms, surgical intervention is considered. Patients whose symptoms need surgery and whose operations are scheduled within six months to a year after diagnosis tend to recover more quickly and have better long-term results.

Both open and minimally invasive surgical techniques are available for use in interventional procedures. An open microsurgical discectomy is the method that is used in this case. Spine surgeries that use minimally invasive techniques have grown in popularity over the last 20 years. The procedure requires just tiny punctures and the insertion of a tube. Endoscopic and microsurgical procedures are the two primary subfields. The surgical team assesses the herniated disc's shape and location to

choose the best approach strategy. Minimally invasive techniques have a lower risk of complications, reoperation rates, wound infections, and shorter operating times compared to open discectomy. They also cause less blood loss. On the other hand, according to [59], minimally invasive operations and open surgeries do not vary in terms of long-term patient-centered results.

The outlook: Even faster results are seen in those who do not have radiculopathy symptoms. The phagocytosis and enzymatic resorption of the extruded particles are responsible for this enhancement. In addition, the extruded material may become hydrated or local nerve edema may reduce, leading to the alleviation of discomfort and the return of function. Surgery success is predicted by factors such as severe leg and lower back pain prior to surgery, shorter duration of symptoms, younger age, better mental health condition, and higher physical activity before surgery [60].

Methods for Percutaneous Endoscopic Lumbar Discectomy

Instruments for Endoscopy

Hand-Held Endoscope

An optical system and a conduit for lighting are enclosed inside the rigid tube of the working-channel endoscope. A rod-lens system and coherent optical fiber bundles are the two most fundamental optical systems. Because it provides better optical resolution, a rod-lens technology is used by the vast majority of spinal working-channel endoscopes.

A working channel inside the endoscope shaft enables the introduction of specialized endoscopic equipment to the operating area; this feature is specifically used in endoscopes for full-endoscopic spine surgery [61].

How the Eye Sees

The range of viewable pixels is 1.7 to 7 mm. A line perpendicular to the lens forms an angle with the endoscope's long axis, which is called the angle of inclination. For endoscopes that function via spinal canals, the viewing angle may be adjusted between zero and forty-five degrees.

In order to enter the foramen safely and see the departing and traversing nerve roots, a 25- to 30-degree angle of view is necessary for transforaminal endoscopic lumbar diskectomy.

Compared to the transforaminal method, which needs angulation of the view of 15-25 degrees, interlaminar endoscopic lumbar diskectomy provides for a straight-on view of the disease [62].

Light Source

Usually, the endoscope's light source port is located at its base. This port requires a fiberoptic connection that is compatible with the light source.

Channels for Irrigation

An endoscope's inflow and egress irrigation canals keep fluid circulating throughout the working area at all times. On most endoscopes, you can find the ports for the irrigation channels that go in and out on the side of the device. The inflow port is connected to a fluid pump by tubing, which then distributes saline irrigation. Fluid is free to flow out of the system via the egress port. It is possible to temporarily seal the exit port in the event of bleeding [63].

The Functional Path

Instruments go via a tube known as the working channel. Endoscopes come in a variety of diameters, with working-channel sizes ranging from 2.1 mm to 6.0 mm. According to Burkett and Brooks (2024), spinal endoscopes have working-channel lengths that range from 68 to 255 mm.

Tools for Surgery: Things to Help with Locating and Approaching Utilizing fluoroscopic guidance, a long spinal needle, Jamshidi needle, or trocar may dock on the approach-specific target location. The docking site is prepared using a guidewire as a place holder, and a wider working corridor is created with the application of consecutive dilators via soft-tissue planes. Bone reamers, osteotomes, or trephines may be used to remove bone along the surgical corridor during transforaminal surgeries [27]

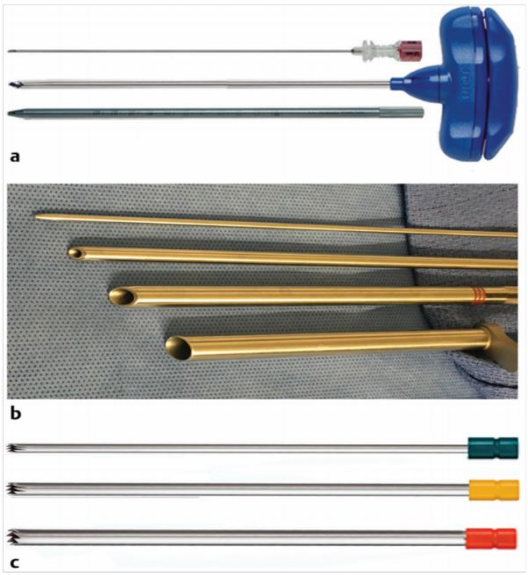

Fig. (5) Approach and targeting corridor. (a) When docking, a trocar, Jamshidi needle, or spinal needle may be used. (a) A functioning corridor is created through soft-tissue planes using serial dilators. (c) According to[27], foraminoplasty may be performed using bone reamers.

Mechanical Instruments/ Basic Surgical Instruments

Instruments needed for discectomy include articulating forceps (2.5 mm or 3.5 mm), a probe, and a dissector.

Surgical Tools for Electrosurgery

Elliquence, Oceanside, NY, offers a bipolar probe with a flexible RF trigger: Navigational cold electrocautery with little tissue toxicity. Anuloplasty, tissue dissection, and hemostasis are some of its uses.

Holmium yttrium-aluminum garnet (Ho-YAG) lasers are a kind of laser.

Features: Pulsed laser that dissipates heat little; kind that fires from the side at a 90-degree angle for pinpoint accuracy in any direction.

Surgical Procedures

We prefer to do the treatment under a combination of local anesthetic and conscious sedation to reduce the possibilities of iatrogenic nerve harm. When the patient experiences discomfort as a result of tool pressure or retraction irritating the nerves, the surgeon may use this information to make real-time adjustments to the procedure, such as avoiding the structure or repositioning it. The surgeon may confirm navigation and prevent nerve harm by having the patient wriggle their toes and feet in uncertain conditions. According to this may be helpful for older individuals who have many medical issues that make general anesthesia inappropriate. [64]

The annulus and the skin are the only major sources of discomfort throughout the surgery. A 10% lidocaine solution is used to numb the skin, the area around the needle, and the annulus. The rapid onset and selective blockage of sensory information, without affecting motor responses, make the 1% strength the preferable option. For transforaminal access, a transforaminal barrier is the way to go. For optimal drug delivery, it is standard practice to provide a caudal block before to initiating interlaminar PELD. Figure 6 [65].

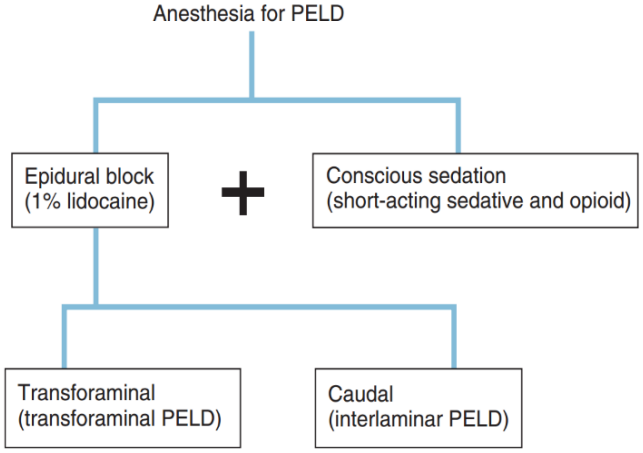

Fig. (6) Illustrates the anesthesia used during percutaneous endoscopic lateral diskectomy (PELD).[65]

3. Transforaminal Endoscopic Lumbar Discectomy:

❖ **Preoperative Planning**

The The transforaminal technique is designed to target the medial aspect of the foraminal annular window, namely Kambin's triangle, which is the specified region. Prior to surgery, axial T2-weighted MRI scans may be used to assess the skin incision's distance from the midline. Here are some rough measurements: 12 cm at L5/S1, 10 cm at L4/L5, and 8 cm at L3/L4 for the skin entrance site in relation to the midline [66].

It is possible to choose an entrance point that is further from the midline when aiming to treat pathology that is more medially positioned inside the spinal canal. On the other hand, the danger of damaging the leaving nerve root increases when the approach angle is flat. The position of the treated disease determines the rostrocaudal inclination. Connecting the rostral aspect of the superior articular process to the medial aspect of the foraminal annular window determines the inclination for subarticular disc herniations, one of the most prevalent indications. Entering the intervertebral foramen next to the pars interarticularis usually causes a 15- to 25-degree rostrocaudal tilt [67].

By using this path, one may enter the SAP via the foramen rostral and prevent the latter from lateralizing the surgical corridor. A less inclined option should be used when dealing with a disc that has migrated rostrally. The transforaminal surgical corridor may be restricted by the SAP with less inclination, and partial resection of the SAP may be required. The intended trajectory ought to permit examination of the index-level disc annulus regardless of the selected inclination. Because of how difficult the approach is at L5/S1, it is important to think about how steep the iliac crest is. It is critical to know the exact position of the departing nerve root and the extent of facet hypertrophy before doing a transforaminal approach. A trans-SAP or extraforaminal approach should be considered when inserting a trocar into a foramen that has a nerve root that is positioned within its caudal aspect because of the increased risk of impingement [68].

Arranging the Operating Room and Positioning Patients

At risk of transforaminal PELD failure. Position for interlaminar PELD: lateral decubitus (symptomatic side up). For improved scope handling and gravity-induced dura displacement, a lateral location is suggested. Foot and lower leg left uncovered for observation.

The C-arm In the field of fluoroscopy: Modified and secured to provide AP and lateral views without further movement. View from Ferguson (parallel end plates) is the preferred AP view.

The patient is prepared for surgery by having an assistant or technician draw lines on the skin to follow a predetermined trajectory.

Patient draped and equipment connected in accordance with operating room setup [69].

Both the C-arm picture and the endoscopic feed should be available to the surgeon without obstruction.

Approach

The skin is marked with vertical lines at8,10, and 12 centimeters from the midline. According to [69], the intervertebral disc may be seen on an anteroposterior (AP) fluoroscopic endplate view of the caudal index level.

Finding the angle between the rostral and medial aspects of the SAP and the foraminal annular window establishes the rostro-caudal approach trajectory, which is around 20 to 30 degrees.

As the rostrocaudal approach trajectory passes the prescribed distance from the midline, a tentative incision is noted. The incision is located with respect to the spinal column's lateral projection when lateral fluoroscopy is used. states that the incision for a conventional transforaminal access should be around a line joining the tips of the lumbar spinous processes.[70]

Following the spinous process projection-guided adjustment of the incision site along the rostrocaudal approach trajectory, a Jamshidi or 18-G needle is advanced toward the index-level foramen. It is usually passed anteromedially toward the target while angled at a 25-degree angle to the floor, also known as the coronal plane [28]

By turning the bevel, the 18-G needle may be guided to the correct spot after it has been advanced with the bevel pointing ventrally. We cautiously move the Jamshidi needle toward the target spot. It is common practice to begin with the side of the facet joint that is being examined. Next, the needle is carefully moved toward the foraminal annular window (target region) by walking it ventrally along the SAP's lateral face. The needle is advanced to a point immediately below the medial pedicle line after it has entered the foramen [71].

To confirm that the needle point stays dorsal to the posterior spinal line on lateral X-ray, a lateral X-ray is taken. It will be difficult to see what's in the lateral recess directly if the needle is in the disc at the medial pedicle line. Changing the approach trajectory or using a trans-SAP strategy are also viable options here. A No. 11 blade is used to make a stab incision. Inserting a K-wire, withdrawing the needle, and advancing a series of dilators of increasing sizes to the medial pedicle line constitute the procedure. A tubular working channel with a beveled edge is inserted into the foramen, with the

open end facing the nerve root that is departing, and then turned so that it faces the caudal pedicle. The tubular retractor is confirmed to be at or slightly posterior to the posterior spinal line using an X-ray taken before the endoscope is introduced [72].

Single Out Bony Features

After releasing the dilators, the endoscope is inserted into the tubular retractor. Grasper forceps and bipolar cautery are used to remove connective tissue from the lower foramen. Bipolar cautery and pituitary rongeur are used to expose the ventrolateral surface of the SAP and the rostral surface of the caudal pedicle. If needed, a high-speed drill or Kerrison rongeur may be used to expand the aperture into the lateral recess while respecting the ventral section of the SAP. The presence of a Kerrison rongeur on the caudal pedicle may be confirmed by radiographs and ocular examinations (Figure 7). This brings the strategy to a close [73].

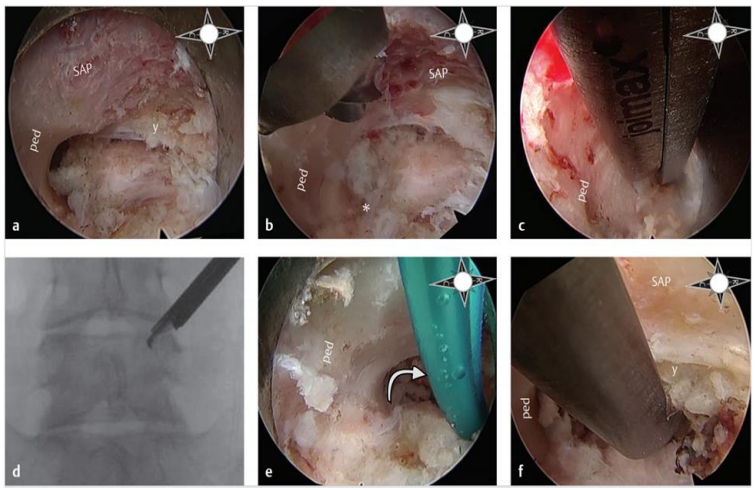

Fig. (7) The transforaminal technique is shown in Figure 7. (a) The ped and the lateral aspect of the SAP are seen in the first endoscopic image of the caudal pedicle (ped). (b) The ventral SAP is further resected with a cutting burr. The major anatomical landmark at the caudal index level may be identified without a doubt with the use of (c) a Kerrison rongeur placed over the pedicle and (d) confirmation of its correct position by AP X-ray. (f) Using a rotating maneuver (asterisk), bluntly dissect the lateral recess immediately rostral to the pedicle by inserting the bipolar cautery. (f) The Kerrison rongeur is used to resect the foraminal yellow ligament (y) [73].

❖ **Resect the Disc Fragment**

Using by use of bipolar cautery, a piece of the subarticular disc is isolated from the annulus. The posterior longitudinal ligament may also include extruded pieces. Some patients with caudally herniated disc pieces may benefit from further pedicle resection. After the disc fragment has been mobilized, it may be easily extracted using gripping forceps. Minimizing the possibility of accidental harm to brain components is achieved by an initial rotational motion. Examining the decompressed traveling nerve root is done after disc herniation excision [74].

Verify the Annular Impairment

The rostral course of the traversing nerve root is traced, and extra yellow ligament is removed if needed. To check for annular flaws, one must examine the annulus over its whole rostrocaudal length. Get all the pieces that fell to the floor. Charging the remaining disc's edge with bipolar cautery is an option.

Problems and Treatment

Up to 20% of individuals may have dysesthesia-related leg discomfort. There is a lack of clarity on the precise etiology. Possible reasons include needle, dilator, or cannula damage to the departing root or dorsal root ganglion during approach, manipulation during surgery, heat injury, development of a hematoma after surgery, and the existence of abnormal nerve fibers. Acute dysesthetic leg pain often begins 5-10 days after surgery, when the patient had initially been pain-free after the procedure. 81 Pregabalin, gabapentin, or epidural injections are among the neuropathic medicines that help alleviate the short-lived pain [75].

Care Following Surgery

You are free to move about as you want the day after your surgery. You won't need a corset. The optimal time to schedule a follow-up appointment following surgery is within a week or two in order to catch any problems early [76]

Lumbar Discectomy using Interlaminar Endoscopic Technique

Prior to Surgery, Organizing

In order to ascertain if facet resection is necessary during the approach, a standard anteroposterior radiograph should be used to evaluate the breadth of the interlaminar space.

In order to determine the best course of action during surgery, preoperative magnetic resonance imaging should evaluate the extent and placement of the disc herniation as well as its connection to the neural structures. Removing the rostral portion of the caudal lamina in order to remove the disc entirely is one possible procedure for a caudal migrating disc herniation. It may be recommended to incise the ligamentum flavum as medially as feasible to expose the axilla and remove portion of the extruded disc in the event of a significant axillary disc herniation. As a result, the danger of neurological damage is reduced and strain on the traversing root is reduced [77].

Compared to magnetic resonance imaging (MRI), computed tomography (CT) makes calcified disc herniations easier to see. When ruptured discs remain longer than six months and become attached to the neural structures around them, calcification is likely to develop. According to [78], the interlaminar technique is an effective endoscopic method for removing calcified disc herniation.

Properly Placing the Patient

The patient is positioned on a Wilson frame or Jackson table in the prone position. The interlaminar window's cranial-caudal dimension is widened by fixing the hips and knees. At the very bottom of the Jackson frame is where you'll find a tray for mayonnaise. Surgeon and intended surgical location are side by side. According to the C-arm is positioned on the opposite side of the patient.[79]

Create a Portal

An 8-10 mm skin incision is made in the midline, in the middle of the interlaminar space, under the anteroposterior fluoroscopy. The next step is to cut the fascia parallel to the wound. A dilator with a diameter of 6.9 mm is sent into the fascia and continues until it reaches the ligamentum flavum. We palpate the caudal lamina, the medial edge of the inferior articulating process, and the inferior margin of the cranial lamina with the tip of the dilator.

The ligamentum flavum, located in the middle of the interlaminar space, should be the dilator's ultimate objective. According to lateral and anteroposterior fluoroscopy are used to check the correct placement and depth of dilator insertion. [80]

The oblique aperture of an 8 mm working sleeve is positioned medially before being placed along the dilator. A 25° endoscope with a 6.9 mm diameter is inserted once the dilator is withdrawn.

Clear and Simple Brief Overview of the Method:

A pituitary rongeur is used to remove the paraspinal muscle fibers, revealing the ligamentum flavum below. To make sure the endoscope is pointing in the right direction into the disc space, a lateral fluoroscopy is performed. To further guarantee medial entrance into the epidural area, the endoscope should be tilted somewhat medially. A 3 mm punch is used to incise the ligamentum flavum layer by layer. Before making each incision, gently push down on the beveled cannula tip to stretch the ligamentum flavum. When the ligamentum flavum changes color from yellow to white with a faint blue tint, it indicates that the surgeon has reached the last layer. The next step is to puncture or bluntly probe the epidural space [81].

To prepare the deep layer of ligamentum flavum for insertion into the superior articulating process, a 3 mm punch or 3 mm Kerrison rongeur is used to expand the aperture laterally.

A 3 mm rongeur is used to remove the epidural fat that covers the neural structures, ensuring the lateral boundary of the traveling nerve root is detected. A delicate technique with an angled probe is used to dissect the epidural scars that surround the nerve root. At this point, the radiofrequency probe is often used to establish hemostasis in cases of epidural hemorrhage [82].

A probe is used to gently move the medially-positioned traveling nerve root in order to detect the underlying disc herniation. Using a pituitary rongeur, the protruded component of the disc herniation may be partly excised. Before medialization, this eases the strain on the traveling nerve root.

Underneath the root of the nerve that is being traversed is an angled probe. After that, the bevel-side-down working cannula is inserted into the spinal canal floor. The next step is to withdraw the neural structures by rotating the working cannula 180 degrees. At this point, you need to be very careful that the cannula doesn't crush the nerve root. If you feel too much pressure on the nerve root while the cannula is being rotated, you should halt the technique and return it to its original position. The release of any remaining epidural scarring is necessary. If there is any sequestration, it should be investigated in the axilla between the cauda equina and the traversing nerve root. To expand the working cannula's capacity, further excision of the medial part of the superior articulating facet may be contemplated [83].

An incision in the posterior longitudinal ligament may be made to expose the herniated disc in cases with confined herniation. A pituitary rongeur is used to remove the disc that has been extruded. It is not possible to recover a disc fragment via a functioning channel if its diameter exceeds the channel's capacity. The rongeur may be used to grip the piece. The endoscope, rongeur, and working sleeve are all removed in one piece to remove the fragment (Figure 8). The helper is subsequently held responsible for this [84].

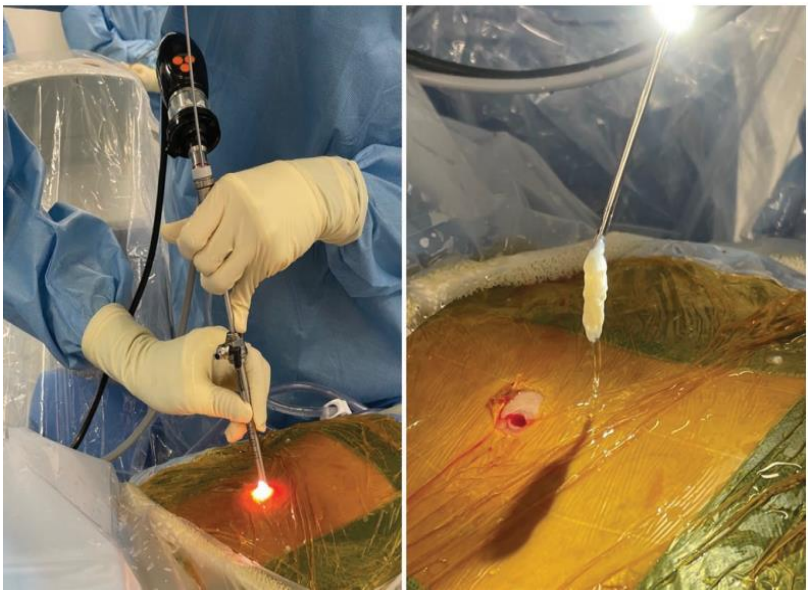

Fig. (8) The disc fragment that cannot be collected via the working channel of the endoscope is seen in Figure 8. Securing the piece requires the use of a pituitary rongeur. The endoscope and working sleeve are removed simultaneously while the assistance holds them [85].

The Afterwards, an annular tear is detected. Reducing the recurrence rate requires caution to prevent widening the annular tear. To get rid of any remaining particles within the disc, further intra-discal debridement might be done. Annuloplasty is performed by coagulating the annulus both outside and within the annular tear using a radiofrequency probe. The nerve root's mobility and the restoration of free pulsation are indicators of sufficient decompression. After that, a single skin suture is used to seal the incision [85]

Difficulties and Handling

Manipulation of neural structures, excision of ligamentum flavum and herniated disc, and access into the spinal canal all pose risks of dural sac or nerve damage. When a spinal canal narrows too much or when a disc herniation becomes chronic and calcified, adhesions may form. Endoscopically placed artificial dural replacements like Tacho-Sil or Dura-Gen may cover tiny dural tears that do not include nerve root herniation. Primary correction of nerve rootlet herniation often requires conversion to open surgery[86].

Although bleeding during interlaminar endoscopic surgery is usually modest, the surgeon must ensure rigorous hemostasis to ensure the safety of the procedure since it impacts visibility. The epidural veins, surface of the bone, and muscles are all potential sites of hemorrhage. A radiofrequency probe is sufficient for controlling the majority of bleeding. To control problematic bleeding, you may alternatively apply gel-foam or Flo-seal via the working channel. To avoid epidural hematoma development, make sure full hemostasis is accomplished before withdrawing the endoscope. [87] noted that drain is an optional component.

Care Following Surgery

Patients are encouraged to begin mobility as quickly as feasible and on the same day. While a soft lumbar corset may ease discomfort for the first four to six weeks after surgery, there is no evidence that it lowers the risk of recurrence [88].

In summary:

A new less invasive surgical alternative for individuals with symptomatic lumbar disc herniation is percutaneous endoscopic lumbar discectomy (PELD). When people talk about percutaneous endoscopic discectomy, they usually mean either percutaneous endoscopic transforaminal discectomy or percutaneous endoscopic interlaminar discectomy. PELD's minimal incision, speedy recovery, short hospital stay, and comparable clinical success to open surgery have made it more well-known.

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