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Video Article

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O-Arm Navigation-Guided Unilateral Biportal Endoscopic Decompression of Far-Out Syndrome

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The main aim of this video article is to demonstrate the combined use of O-arm navigation and unilateral biportal endoscopy (UBE) to manage far-out syndrome (FOS). In FOS there is entrapment and compression of the fifth lumbar nerve beyond the foramen and between L5 transverse process and the sacral ala at the lumbosacral junction. Conventional microscopic decompression using a paraspinal approach had been the gold standard for its management. However, the surgery is technically challenging due to the deep location of the pathology and intricate anatomy of extraforaminal space. There have been some published reports of unsatisfactory outcomes with microscopic decompression for FOS. We decided to integrate navigation with UBE to increase precision for the management of FOS. A 70-year-old female presented to us with chief complaint of left lower limb radiculopathy since 1 year. She also complained of numbness and paresthesias in her left leg and foot. She was unable to walk for more than 10 minutes due to pain. Her magnetic resonance imaging scan revealed compression of left L5 nerve root in the extraforaminal region. UBE decompression via paraspinal approach was performed for her under O-arm navigation. She experienced immediate relief of her symptoms in the postoperative period. O-arm-navigation-guided UBE is an effective and safer alternative to microsurgical decompression for the management of FOS. This video demonstrates the step-by-step implementation of O-arm navigation with endoscopy and its precise execution.

Keywords: Far-out syndrome, Unilateral biportal endoscopy, O-arm navigation, Bertolotti syndrome, Extraforaminal stenosis, Paraspinal approach

CASE REPORT

1. Patient History and Examination

The patient described in this video article is a 70-year-old female with a body mass index of 28.09 kg/m^2 and no other medical comorbidities. Her chief complaint was left lower limb radiculopathy since one year (visual analogue scale [VAS], 8/10). She also complained of numbness and paraesthesias in her left leg and dorsal aspect of foot. She was unable to walk for more than 5 minutes due to pain. On physical examination, she had 3/5 weakness in left extensor hallucis longus.

2. Imaging and Diagnosis

The x-rays showed the presence of a lumbosacral transitional vertebra (LSTV). Her magnetic resonance imaging scan revealed compression of the left L5 nerve root in the extraforaminal region. The computed tomography (CT) scan confirmed the presence of a Castellvi type 2b LSTV. The pain did not improve with conservative management and physiotherapy. She underwent selective nerve root block for left L5 nerve root. She had short term relief with 2 nerve root blocks. This also confirmed left L5 nerve root is the pain generator. Given her activities of daily living being affected our team decided to go for surgical management. We opted for UBE paraspinal approach under O-arm navigation to decompress her left L5 nerve root at the extraforaminal zone.

3. Surgical Approach and Procedure

1) Patient positioning

The surgery was performed under general anesthesia. The patient was positioned prone on a radiolucent operating table with spine, knees and hips flexed to reduce the lumbar lordosis and all the bony prominences were adequately padded with gel rolls. The main surgeon stood on the ipsilateral side of pathology, which was the patient's left side. Sterile painting and draping were performed. Afterward, the dynamic reference array frame was attached to the patient's right posterior superior iliac spine. Following this, intraoperative CT scan were obtained using the O-arm navigation system.

2) Skin marking

For ease of understanding, we draw the midline, medial and lateral pedicle line with the help of a skin marker. The chief surgeon in this case was right-handed so the cranial incision was planned as an endoscopic portal and the caudal incision as a working portal. Both the incisions usually lie in the region 1 cm lateral to lateral pedicle line. The navigated probe was placed on the skin and reformatted images on the workstation give an idea about its inclination and projected trajectory. With the help of navigation, one can accurately point towards the extraforaminal region while avoiding the iliac crest. The marking of the working portal is very crucial as the instruments for decompression should reach the target without any bony hindrance. Following this, the endoscopic portal was marked 2–3 cm cranial to working portal incision.

3) Incision

We made 2 horizontal small skin incisions over the planned sites just enough to pass the endoscope and instruments. The same incisions were used to penetrate the fascia to maintain continuous outflow of the irrigation saline during the surgery. Following this, the serial dilators were introduced from both incisions to reach the target point in a triangular fashion.

4) Triangulation

The tip of the dilator is used for the tactile confirmation of bony landmarks such as the transverse process (TP), superior articular process (SAP) or superior sacral notch (SSN). Both the dilators were docked at the TP-SAP junction. Triangulation aims to touch the tip of the dilators over a bony landmark.

5) Insertion of the endoscope and navigated probe

The 0° endoscope was introduced through viewing portal and navigated probe through the working portal. The navigated probe was placed directly on the bony landmarks to identify the TP, SAP, and SSN.

6) Making working space

The radiofrequency probe via the working channel was used to clear soft tissues and delineate the bony surface of sacral ala, SAP lateral aspect of sacral 1 vertebra and lower border of the TP of lumbar 5 vertebra. The surgeon should keep on checking for the continuous inflow and outflow of irrigation saline.

Due to complex anatomy of this region the navigation probe is used to reconfirm the anatomy periodically.

7) Bone removal and decompression

The inferior aspect of the TP of the lumbar 5 vertebra, the superomedial part of the sacral ala and the lateral aspect of the SAP of S1 are removed with the help of high-speed drill and Kerrison rongeur. The curette is used to detach the foraminal ligament from the bony edges. The diamond burr is much safer and also helps to reduce the bleeding coming from cancellous bone. The periodic checking of anatomy with a navigation probe helps to avoid getting lost in magnified endoscopic vision. The perineural network of blood vessels and perineural fat helps to identify the exiting L5 nerve root.

8) Suggestions

A tight, thickened ligament with cranial and caudal attachments is identified between the TP and the sacral wing. This ligament is referred to as the lumbosacral ligament (LSL). To ensure proper decompression, the LSL must be removed along with a deeper, more distal ligament in the extraforaminal space called the far-out band. Both the LSL and far-out band often compress the exiting L5 nerve root, so removing them is necessary to achieve full extraforaminal decompression of the L5 nerve root. Once decompression is complete, the surgeon must ensure adequate hemostasis using plasma radiofrequency. Floseal is injected to prevent hematoma formation and prevent secondary neurological symptoms. Bone or soft tissue remnants may cause perineural hematoma, which can lead to radiculitis. Hence,

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a drain is usually inserted to evacuate any residual fluid collection and prevent nerve root inflammation.

Written informed consent was obtained from the patient.

DISCUSSION

The primary goal of this video article is to showcase the combined use of O-arm navigation and unilateral biportal endoscopy (UBE) in the management of far-out syndrome (FOS). This innovative approach integrates advanced imaging technology with minimally invasive surgical techniques to enhance precision and outcomes in treating FOS, a condition characterized by nerve compression in the far lateral zone. Through this demonstration, the article aims to highlight the benefits of combining these 2 technologies, offering improved visualization, real-time guidance, enhanced precision, and a safer, more effective intervention for patients with FOS.

Extraforaminal stenosis at L5–S1, also known as FOS, was first described by Wiltse et al.[1] in 1984. They demonstrated that the L5 nerve could be compressed beyond the foramen between the L5 TP and the sacral ala, at the lumbosacral junction. In degenerative conditions like scoliosis or asymmetric disc degeneration at L5–S1 there is tilting of TP towards the sacral ala leading to entrapment syndrome. In addition, an extraforaminal disc herniation or even a disc bulge at L5–S1, combined with TP hypertrophy, a prominent accessory process, TP degeneration with osteophytes, or LSTV anomalies, can cause the L5 exiting nerve root to shift posteriorly. This displacement forces the nerve to follow a more lateral path outside the foramen, passing through the narrowed space between the TP and the sacral ala, which can lead to entrapment and compression of the fifth lumbar nerve. Low back pain in the setting of LSTV was coined "Bertolotti syndrome" by Bertolotti in 1917.[2] The patient presented in the video had symptomatic LSTV on the left side.

Traditional microscopic foraminotomy has been the gold standard for surgical treatment of FOS.[3,4] Surgical access to the L5–S1 extraforaminal region is challenging because of its intricate anatomy and deeper location.[5-7] Moreover, in patients with high pelvic incidence, the TP moves anteriorly, making the approach further difficult.

A prominent iliac crest also hinders the surgical pathway when using the paraspinal Wiltse approach. Some of the evidence published in the literature has reported poor outcomes after microscopic foraminotomy for extraforaminal stenosis at L5–S1.[8,9] With endoscopic approach, we can reach the deeper site of pathology quickly and cause less damage to the soft tissues.[10] Moreover, the well-illuminated surgical field, with proper magnification and high-quality images, enables the surgeon to meticulously identify key landmarks.[11,12] Use of 3-dimensional (3D) navigation optimises the workflow of spine endoscopic surgery by improving the precision of pathology localization and minimizing radiation exposure to the surgical team through fewer C-arm shoots. Navigation technology enhances the precision and safety of endoscopic spine procedures by providing real-time 3D visualization of spinal anatomy, allowing surgeons to plan and execute the surgical approach more accurately.[13] It also helps surgeons avoid getting lost in complex anatomy, especially when visibility is limited by the magnified view of the endoscope.

UBE offers a distinct advantage over uniportal endoscopic surgery, as its separate working channels provide greater flexibility and make it easier for instruments to reach the targeted pathology, thereby reducing the learning curve. The familiar anatomy provided by the 0° endoscope, combined with the ability to use open surgery instruments in UBE, has contributed to its growing popularity and widespread adoption worldwide. In 2019, Heo et al.[14] were the first to describe the technique and report the successful application of UBE for treating FOS in 14 cases, showing positive clinical outcomes such as reduced operation time, less blood loss, and minimal damage to musculo-ligamentous structures. In their 2021 study, Park et al.[15] demonstrated favourable clinical outcomes in 35 patients by using UBE for decompression of extraforaminal stenosis at the lumbosacral junction. They identified 3 key factors contributing to nerve compression in extraforaminal stenosis at L5–S1: (1) pseudoarthrosis between the L5 TP and the sacral ala, (2) osteophytes and disc bulging, and (3) thickened lumbosacral and extraforaminal ligaments. In the same study, they observed that in 19 patients (15.4%), nerve root compression was linked to the LSL and other tight, thickened ligaments. Many patients of FOS have concomitant foraminal stenosis. UBE surgery offers a distinct advantage in such cases compared to the microscopic approach, as it is more facet-preserving, thereby reducing the risk of iatrogenic instability.

The retroperitoneal fluid collection is one of the fatal complications following UBE paraspinal approach.[14] This can happen when the thickened lumbosacral and extraforaminal ligaments are removed which acts as a wall between the extraforaminal and retroperitoneal area. This can be avoided by preventing unnecessary lateral decompression. Other significant risks involved with this approach are dural injury, root injury, postoperative dysesthesia, postoperative hematoma, infection, and insufficient decompression. One should be wary of the tips of instruments all the time to prevent injury to the common iliac vessels which are close to extraforaminal region.

The patient showed in the operative video had immediate relief of her symptoms with VAS score for left leg pain dropping to 1/10. Her power in L5 myotome increased to grade 4/5. She had no intraoperative adverse events. She was mobilized on the next day and the drain was also removed. On discharge, she complained of some residual numbness in the foot. On subsequent follow-up, her power further improved and numbness disappeared. The postoperative CT scan shows well decompressed extra-foraminal region with the removal of the pseudoarthrosis lesion. Also, the facet joints were not resected.

In conclusion, combining O-arm navigation with UBE for the management of FOS makes this decompression surgery highly precise and meticulous. This helps to avoid the complications associated with the paraspinal UBE approach and also reduces the learning curve of UBE.

NOTES

Video File: The video file for this article is available at https://doi.org/10.14245/ns.2449140.570.

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