3b POSTERIOR CERVICAL MICROENDOSCOPIC DISCECTOMY AND LAMINOFORAMINOTOMY

Larry T. Khoo M.D., Murat Cosar M.D. Ph.D., Adem Bozkurt Aras M.D.

1. Introduction:

Posterolateral cervical foraminotomy was commonplace for many years in the treatment of cervical disc herniations and foraminal stenosis [1,2]. However, subsequent descriptions of anterior approaches to the cervical spine [3,4] have allowed the anterior approach to gain in popularity, given that they are often felt to be safer and easier to perform. With anterior approaches, patients have had less muscle spasm and postoperative pain as compared to open posterior cervical foraminotomy. However, these anterior approach techniques carried additional disadvantages such as increased risk of injury to the trachea, esophagus, carotid artery, and recurrent laryngeal nerve [5-8]. Additionally, anterior decompression generally necessitates fusion at that level thereby resulting in an unavoidable loss of mobility and an increased risk of adjacent level degenerative changes over time [9,10].

Posterior approach via a "key hole" type osteotomy may provide better exposure for decompression of the exiting root and for removal of lateral osteophytes and discs [6,11,12]. Generally, less than 50% of the facets are removed, and of the remaining facets are enough to perserve the biomechanical strength of the cervical spine [6,13]. Previous literatures have also documented that adequate foraminal exposure can be accomplished without necessarily destroying the facet joint or causing iatrogenic instability with posterior cervical lamino- foraminotomy. Thus, the posterior approach treats the offending pathology without requiring a fusion process [6,14,15]. Additionally, the risks of injury to the anterior structures of the neck including the trachea, esophagus, thyroid, thymus, carotid arteries, jugular veins, vagus nerve, recurrent laryngeal nerve, superior laryngeal nerve, ansa cervicalis, and thoracic duct are avoided with posterior approach [6]. The limited surgical view, difficulty in resecting osteophytes, limited visualization of the distal foramen, excessive blood loss via epidural veins, increased post-operative muscle spasm, neck pain, and recovery time were the disadvantages of the posterior approaches [6,16,17].

The recent developments in surgical technologies such as atraumatic tissue dilation, endoscopic visualization, improved neuroanesthetic techniques, and improved non-invasive imaging modalities have repopularized the posterior cervical approaches again. The posterior cervical microendoscopic laminoforaminotomy (MELF) operation is the synthesis of old and new surgical techniques. MELF techniques, through a minimally invasive approach, have the potential to reduce operative blood loss and postoperative disability. This novel technique also preserves the spinal motion segment while avoiding fusion. Additionally, this MELF technique results in a shortened operation time, hospital stay and an improved post-operative recovery time as compared to open techniques [6]. In addition to the treatment of cervical stenosis, cervical lateral soft disc herniations can be comfortably be extricated with MELF (14).

We think that MELF is the modern view of the posterior procedures with a minimally invasive approach and high-magnification direct endoscopic visualization. Additionally, it is a safe, reasonable, and efficacious alternative to anterior surgical procedures for posterolateral cervical stenosis and soft lateral disc herniations. It can accomplish the direct decompression of the stenotic foramen and nerve root with a minimum risk of injury to the visceral and neurovascular structures as compared to anterior approaches [6].

2. Indications:

MELF can be used for primarily cases of posterolateral disc herniation, osteophyte compression, focal lateral thickening of the ligamentum flavum, facet thickening and arthropathy. It can be used for the cases with mild to moderate kyphosis so long as there is no evidence of instability. However, for these patients, particular caution must be taken to not resect too much of the medial facet complex during the decompression [6].

The appropriate radiographic findings (MRI, CT) in combination with a strong clinical history of radiculopathy and/or additional electrophysiological evidence of nerve compression (EMG/NCS) will aid in the appropriate selection of patient who would benefit from MELF. Careful patient selection will also help the surgeon to avoid surgical decompression for patients presenting with a clinical picture that includes other pathologies in the differential diagnosis such as spinal canal tumors, trauma, inflammatory diseases, toxic and allergic conditions, hemorrhage, congenital defects, metabolic diseases, neuropathies, thoracic outlet syndrome, rotator cuff pathology, impingement syndromes, bursitis, arthritis of the shoulder, and bicipital tendonitis [6].

Figure 1a, 1b, 1c:
The METRx endoscopic system
(Medtronic-Sofamor Danek; Memphis, TN).

3. Contraindications:

For cases of myelopathy, central or paracentral stenosis, deformity, or instability, the laminoforaminotomy technique is not the ideal procedure [6].

4. Surgical Procedures:

4.a. Surgical Equipment:

Draped C-arm fluoroscopy and monitor are essential for verifying the position and localization of the cervical level of MELF. The operating table must be suitable for the sitting position. Additionally, a high speed drill, operating microscope and the posterior cervical minimal invasive surgery instruments are essential for the MELF procedure (Figure 1a, 1b, 1c).

It is strongly advised that the surgeon request precordial Doppler monitoring and central venous pressure (CVP) catheter placement into the right atrium in anticipation of blood loss and possible venous air embolus. Additionally, intraoperative somatosensory evoked-potential monitoring of the operated dermatome and electromyographic recordings (EMGs) can also be used to assess the spinal cord and involved root integrity.

4.b. Operating Room Set-up:

The sitting position of the patient is generally preferred for MELF procedure. The C-arm and monitor is placed according to the localization of the surgeon. The surgeon generally stands directly behind the neck of the patient and a standard set up for posterior cervical surgery is used with the spine surgeon standing on the left or right side of the patient with a operation technician and a surgical assistant. It will be better if the video and C-arm monitors are placed on the opposite side of the operation area (as shown in Figure 2).

4.c. Patient Positioning:

After the patient was brought to the operation room, appropriate pre-operative evaluation was performed following the induction of general anesthesia. Then, the patient is brought to the sitting position on the operating table. The head of the patient is immobilized with Mayfield headrest without bending to right or left side in a semi-flexion position. The level of the MELF is marked and localized with the C-arm before sterile prep and drape.

The choice of the prone position with a Jackson or four-poster frame is left to the surgeon's individual preference. For the purpose of this text however, the sitting position will be assumed (Figure 2). However, it should be noted that the procedure can be carried out in the prone position with the Jackson table or other four-post frame if it is the surgeon's preference.

4.d. Surgical Technique:

After the determination of pathology level under C-arm, 0.5 cm length stab incision was made 1 cm off midline ipsilateral to the pathology. And then, a thin

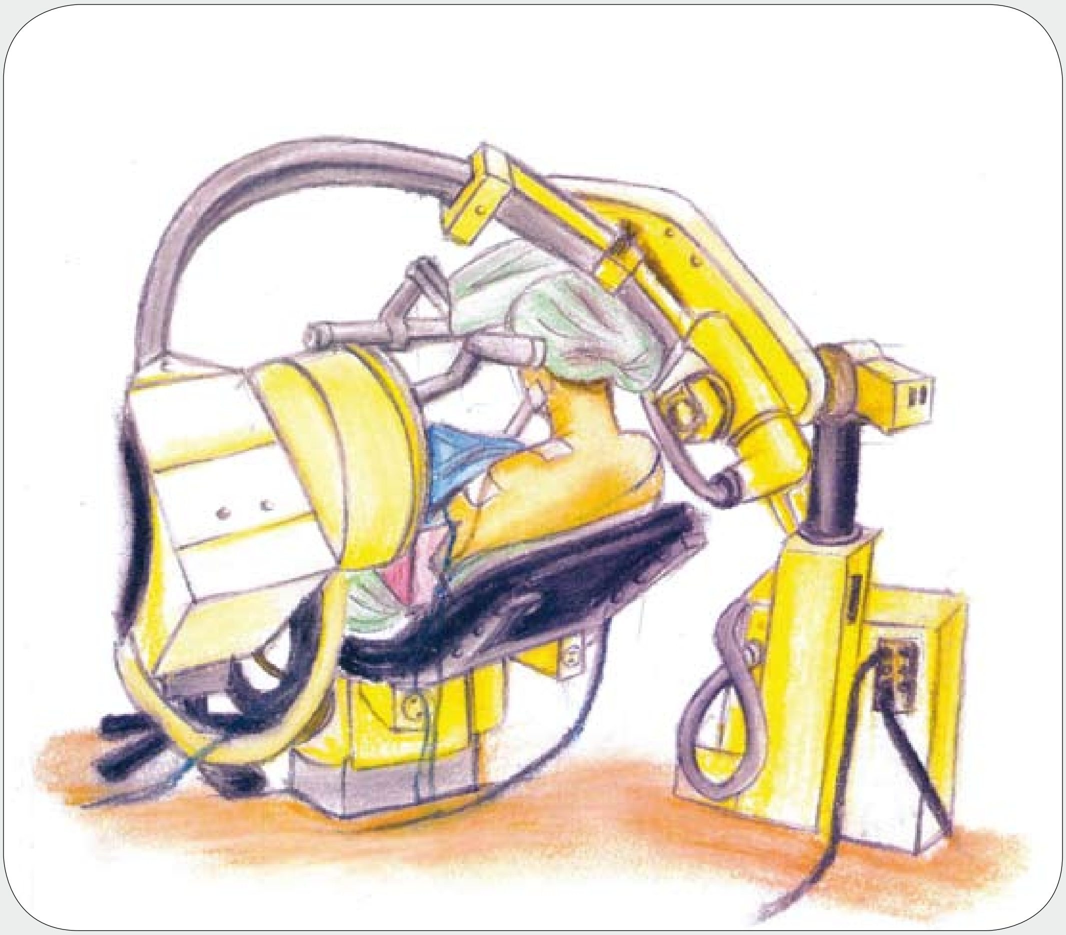

Figure 2:
The patient is positioned in the semi-sitting position with the head secured in a Mayfield headrest. The fluoroscopic C-arm is placed such that lateral images can be easily obtained throughout the procedure.

Steinman pin is inserted to the facet or lateral mass of the target level through the posterior cervical musculature and fascia. It is better to err laterally during this docking maneuver to avoid inadvertent dural penetration. At this moment, the antero-posterior radiographic images can be obtained to guarantee proper pin positioning. After the guidewire is docked on the facet, the skin incision is extended for a total length of approximately 2.0 cm. The cervical fascia is incised with maximum care to bleeding after the retraction of the skin edges. So, the cervical fascia allow to the sequential dilating cannulas with a minimum of force.

The series of dilators are then sequentially inserted over the Steinman pin until an 18mm tubular retractor is inserted (Figure 3a-d). After the insertion of final 18mm tubular retractor, the working channel (tubular retractor) is attached to a flexible retractor. This flexible retractor is affixed to the operating table side-rail and locked in position at the junction of the lamina and lateral mass. After this process, the endoscope is fixed to the tubular retractor via a circular plastic friction couple. We prefer the METRx system (Medtronic Sofamor-Danek; Memphis, TN) of endoscopic retractors, camera, and instruments for our MELF procedures. Cervical modifications of this system have been made for cervical MELF procedure after its initial designs for lumbar discectomy. The endoscopic camera with high resolutions and smaller profile dissectors and Kerrisons make this system as better selection for cervical spine.

A bovie cautery with a long tip is used to remove the remaining muscle and soft-tissue overlying the lateral mass and facet, after the tubular retractor is set in the desired position. It is best to begin this dissection laterally and continue to medially to expose the laminofacet junction with attention paid to not slip into the interlaminar space at this point.

Because of the ligamentum flavum is thin or absent at the lateral edge of the interlaminar space, there is a higher risk of injury to the dura or the cervical spinal cord. After the well visualization of the bone, the inferior edge of the superior lamina and the medial edge of the lateral mass-facet complex is scraped with a small straight endoscopic curette and extended underneath the lamina and facet with the use of a small angled endoscopic curette (Figure 4a). The angled endoscopic curette facilitates to free the soft tissue from its periosteal attachment extending under the lamina. The placement of the curettes can be confirmed with fluoroscopy (Figure 4b). The careful dissection of the soft tissues from the bone structures may prevent the incidental dural tears. Bleeding from epidural veins and from the

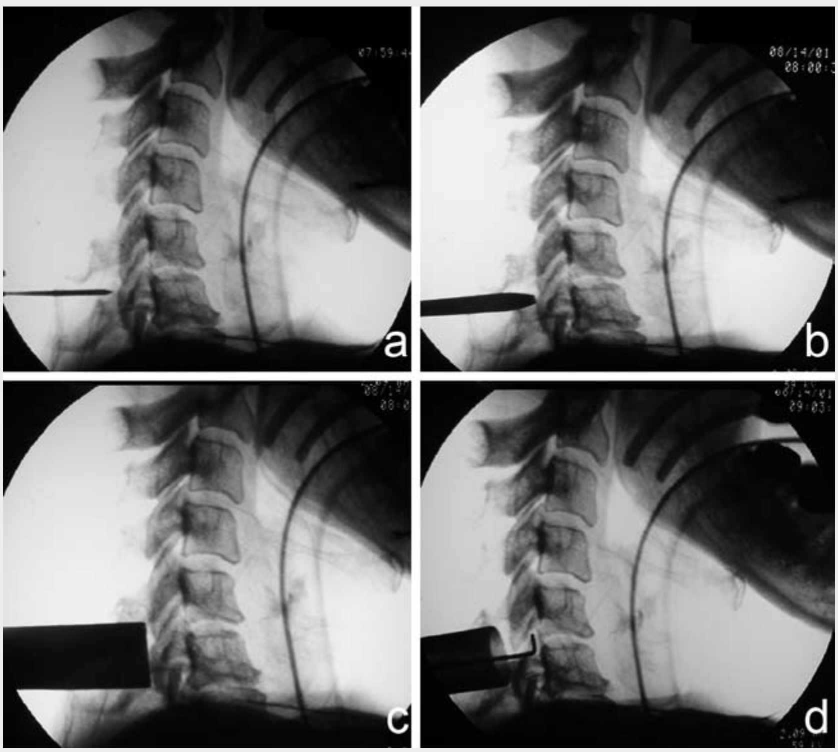

Figure 3 a-d:
A series of lateral fluoroscopic images demonstrating the: **a)** placement of the initial Steinman pin down to the operative level, **b-d)** the sequential passage of the tubular soft tissue dilators which gently spread the posterior cervical musculature.

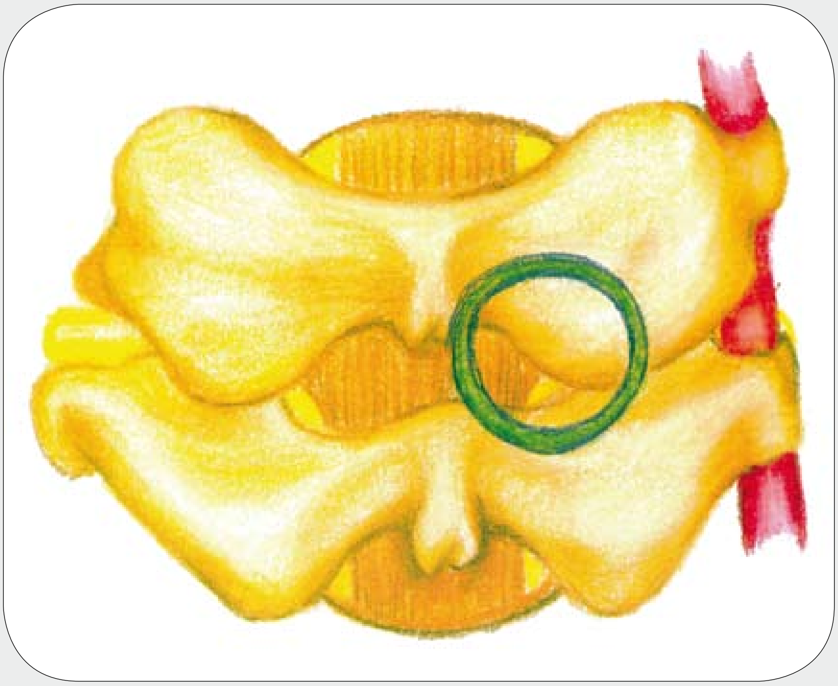

Figure 4:
This schematic set of diagrams illustrates the steps of the MEF procedure. The target laminofacet junction is highlighted on the posterior cervical spine. These diagrams are drawn from the perspective of a surgeon standing on right side of a patient in the prone position.

a) The area of the laminoforaminotomy is marked with green circle line.

edge of the flavum as it is attached to the underside of the lamina is controlled via a long tipped and/or angled endoscopic bipolar cautery. After this processes, a small angled endoscopic 1 or 2 mm Kerrison rongeur is suitable to begin the foraminotomy. Periosteal and bone bleeding can be controlled with bone wax and cautery. A drill with a long endoscopic bit (e.g. AM-8 bit with Midas Rex, or TAC bit with MEDNext drill) can be used to thin the medial facet and lateral mass for the cases with marked facet arthropathy and enlargement. The decompression is carefully continued inferiorly and laterally along the course of the neural foramen (Figure 4c).

The laminoforaminotomy is completed after the nerve root is exposed along its proximal foraminal course. The adequacy of the decompression can be checked by palpating the root along its course with a small nerve hook (Figure 4d). The nerve root is mobilized superiorly to expose the disc space and fragment with a nerve hook or small #4 Penfield for herniated disk cases. Drilling the supero-medial portion of the pedicle below the exiting nerve root can obtain additional exposure and will create space for the root to be mobilized.

The disc fragment is removed in a standard fashion with curettes and long endoscopic pituitary rongeurs underneath the retracted root. Any encountered osteophytes are drilled or curetted. It will be better to confirm the free passage along the root with a nerve hook after the completion of the discectomy and decompression under lateral fluoroscopic image (Figure 4e). Additionally, we must ensure that the anterior surface, axilla and shoulder of the nerve root are free of residual disk material. But, further caution is needed for the decompression of the paracentral disc herniations or osteophytes. Decompression of the far lateral foraminal stenosis or disc herniations can also be accomplished with MELF approach. The spine surgeons must be aware of the location of the vertebral artery during this portion of the procedure so as not to damage this vessel during decompression. Brisk dark bleeding which depends on the rich venous plexus surrounding the vertebral artery warns us against further dissection and thus helps to prevent inadvertent arterial injury. More than 50% facet removal may cause iatrogenic instability of the cervical motion segment [17,18].

The hemostasis should be obtained with a bipolar cautery and a gentle tamponade with thrombin soaked gel-foam pledgets. After the irrigation of MELF area, we may place a small piece of gel-foam soaked with

Solumedrol gently over the laminoforaminotomy defect. Use of epidural morphine paste or similar cocktails may help to reduce postoperative pain and allow for more rapid recovery and ambulation. A routine closure of the fascia and skin is performed after removing the tubular retractor and endoscope. Generally, there is no need to use a drain because of the small incision defect. The fascia is closed with reabsorbable 0-Vicryl stitches and it is continued with 4-0 Vicryl stitches for subcutaneous layer after the injection of 0.25% marcaine.

5. Postoperative Care:

The patient is returned to the upright position immediately after the operation. The patient is then taken to the post-anesthesia recovery unit after awakening from anesthesia. A muscle relaxant is given systematically. The waterproof bandage permits the patient to bath or take a shower normally. MELF procedure does not result in either instability or fusion of the operated cervical motion segment. So, soft or other comfortable semi-rigid collars can be chosen for the comfort of the patients. We commonly allow the patients to mobilize in the hours following surgery. All lines, including arterial and venous lines, as well as the foley catheter are removed. Depending on their pre-operative

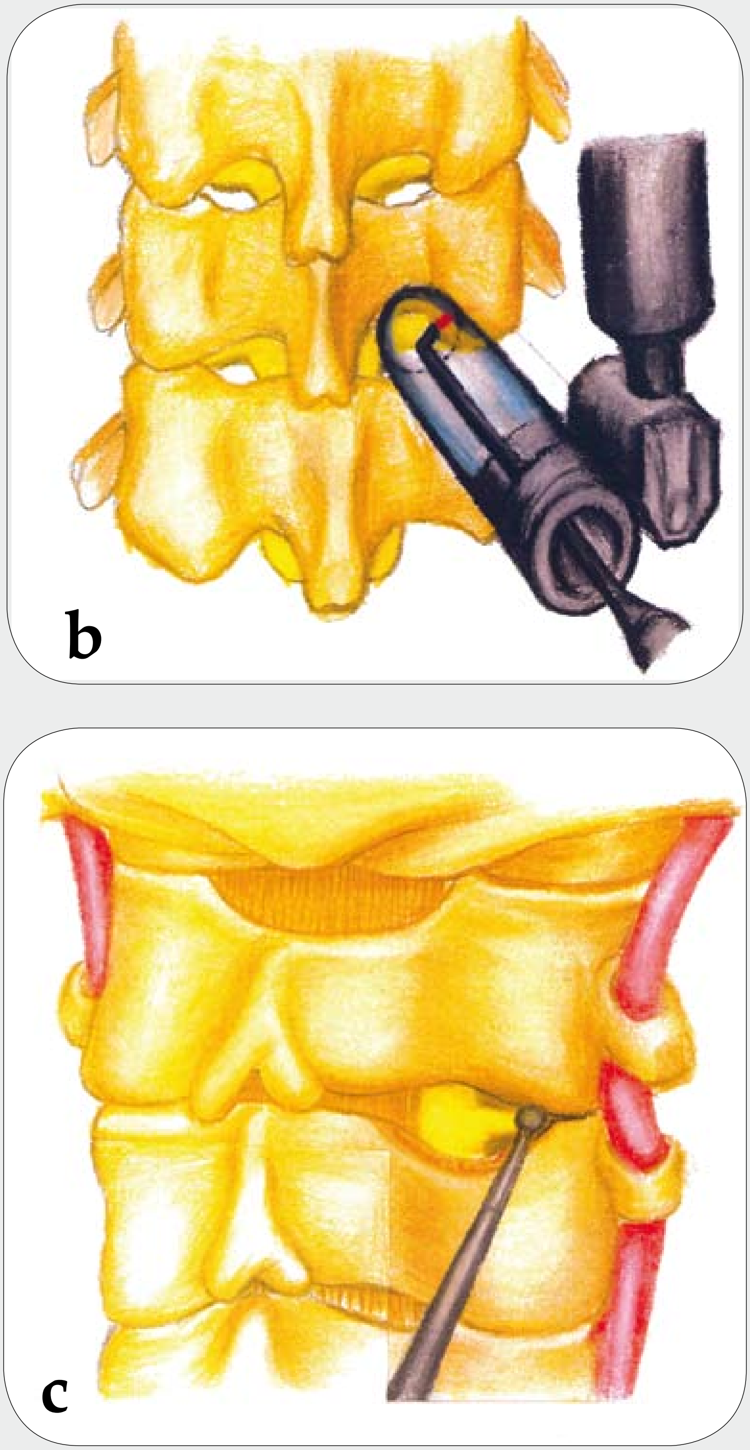

Figure 4 (b, c):
The foraminotomy is completed and the sheath is being opened with micro-scissors, high speed drills and Kerrison rongeurs.

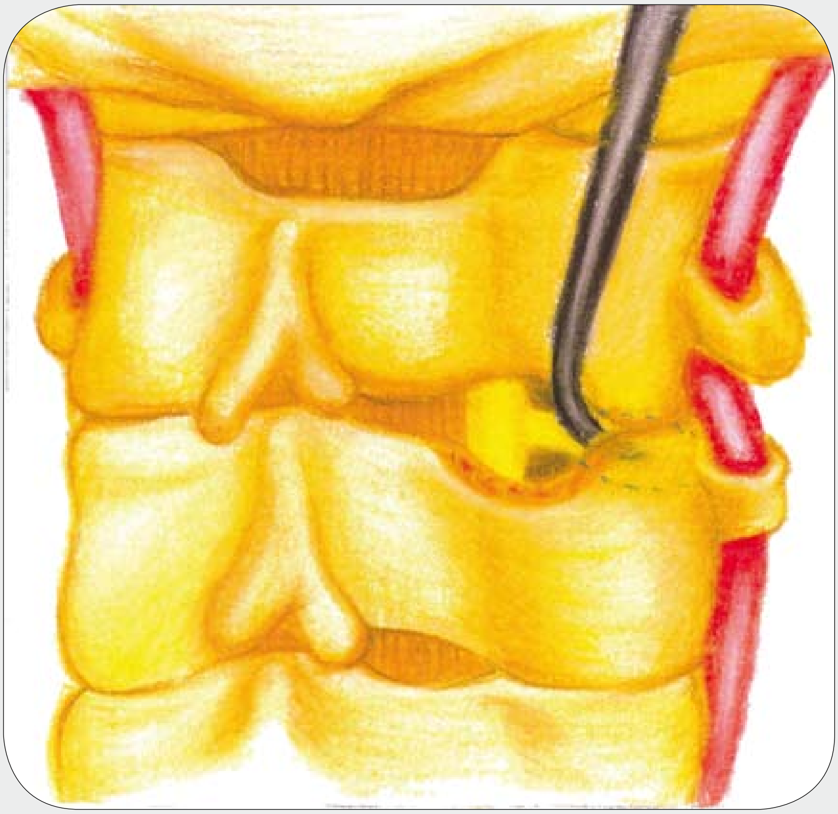

Figure 4 (d):
The root is gently elevated and the disc fragment is removed by a micro pituitary.

The sitting position during MELF has a potential to cause air embolism or cerebral ischemia. It will be better to work with experienced neuroanesthesiologist to avoid the result of this complication. Additionally, to care on the sterilisation of the operation sets and instruments may prevent the patient from deep paraspinal, epidural or superficial wound infection. Careful hemostasis before removing the endoscope tubes may prevent a postoperative compressive hematoma in the epidural space.

The occurrence of cerebrospinal fluid (CSF) leakage from a small dural tear may be treated with a lumbar drain for 2 to 3 days postoperatively without any direct repair of the dura mater. Additional adjuncts such as fibrin glue, fat or muscle grafts can also be used if we detect the CSF leakage during the operation. Direct repair can be necessary for large CSF leaks with the proper instruments through the endoscopic tube. The use of non-steroidal anti-inflammatory medications and bed rest often prevent the development of bothersome symptoms of lumbar drainage such as spinal headaches and nausea.

medications, patients undergoing MELF are typically discharged on a combination of muscle relaxant, non-steroidal anti-inflammatories, and an oral opiod for breakthrough pain. The patient may return his job in 2 weeks after surgery.

6. Complications and Avoidance:

Spinal cord injury may occur due to the removal of disc fragments, and spurs. Penetration of instruments may cause to contusion of spinal cord. These kinds of spinal cord injuries may result with quadriplegia, tetraplegia or paraplegia. Vertebral artery laceration is one of major complications during MELF. More practice with cadavers, advance anatomy education and familiar to the instruments may decrease these complications before starting the MELF.

7. References:

1. Frykholm R. Cervical nerve root compression resulting from disc degeneration and root sleeve fibrosis. Acta Chir Scand 1951; 160: 1-149.
2. Scoville WB, Whitcomb BB. Lateral rupture of cervical intervertebral discs. Postgrad Med 1966; 39: 174-180.

3. Bailey R, Badgley C. Stabilization of the cervical spine by anterior fusion. J Bone Join Surg 1960; 42A: 565-594.
4. Cloward RB. The anterior approach for removal of ruptured cervical disks. J Neurosurg 1958; 15: 602-617.
5. Cloward RB. Complications of anterior cervical disc operation and their treatment. Surgery 1971; 69: 175-182.
6. Fessler RG, Khoo LT. Minimally invasive cervical microendoscopic foraminotomy (MEF): An initial clinical experience. Neurosurgery 2002; 51(2): 37-45.
7. Henderson CM, Hennessy RG, Shuey HJ, et al. Posterior-lateral foraminotomy as an exclusive operative technique for cervical radiculopathy: A review of 846 consecutively operated cases. Neurosurgery 1983; 13: 504-521.
8. Murphey F, Simmons JCH, Brunson B. Cervical treatment of laterally ruptured cervical discs: Review of 648 cases, 1939-1972. J Neurosurg 1973; 38: 679-683.
9. Hilibrand AS, Carlson GD, Palumbo MA, Jones PK, Bohlman HH. Previous anterior cervical arthrodesis radiculopathy. J Bone Joint Surg Am 1999; 81: 519-528.
10. Hunter LY, Braunstein EM, Bailey RW. Radiographic changes following anterior cervical spine fusions. Spine 1980; 5: 399-401.
11. Raynor R. Anterior or posterior approach to the cervical spine: An anatomical and radiographic evaluation and comparison. Neurosurgery 1983; 12: 7-13.
12. Roh SW, Kim DH, Cardoso AC, and Fessler RG. Endoscopic Foraminotomy Using MED System in Cadaveric Specimens. Spine 2000; 25(2): 260-264.
13. Raynor RB, Pugh J, Shapiro I. Cervical facetectomy and the effect on spine strength. J Neurosurg 1985; 63: 278.
14. Krupp W, Schattke H, Muke R: Clinical results of the foraminotomy as described by Frykholm for the treatment of lateral cervical disc herniation. Acta Neurochi (Wien) 1990; 107: 22-29.
15. Raimondi AJ. In Pediatric Neurosurgery: Theoretical Principles, Art of Surgical Techniques. Springer, New York, 1987; pp.98-105,107-109.
16. Ebersolf MJ, Raynor RB, Bovis GK, et al. Cervical Laminotomy, Laminectomy, Laminoplasty, and Foraminotomy. In Spine Surgery: Techniques, Complication Avoidance and Management. Benzel EC (ed). Churchill Livingstone, Philadelphia. 1999; pp. 251-253.
17. Kubo Y, Waga S, Kojima T, et al. Microsurgical anatomy of the lower cervical spine and cord. Neurosurgery 1994; 34: 895-902.
18. Sandhu FA, Perez-Cruet MJ, Fessler RG. Microendoscopic cervical foraminotomy and discectomy. In An Anatomic Approach to Minimally Invasive spine Surgery. Cruet-Perez MJ (eds) Quality Medical Publishing, St. Louis, Missouri. 2006, pp. 337-349.

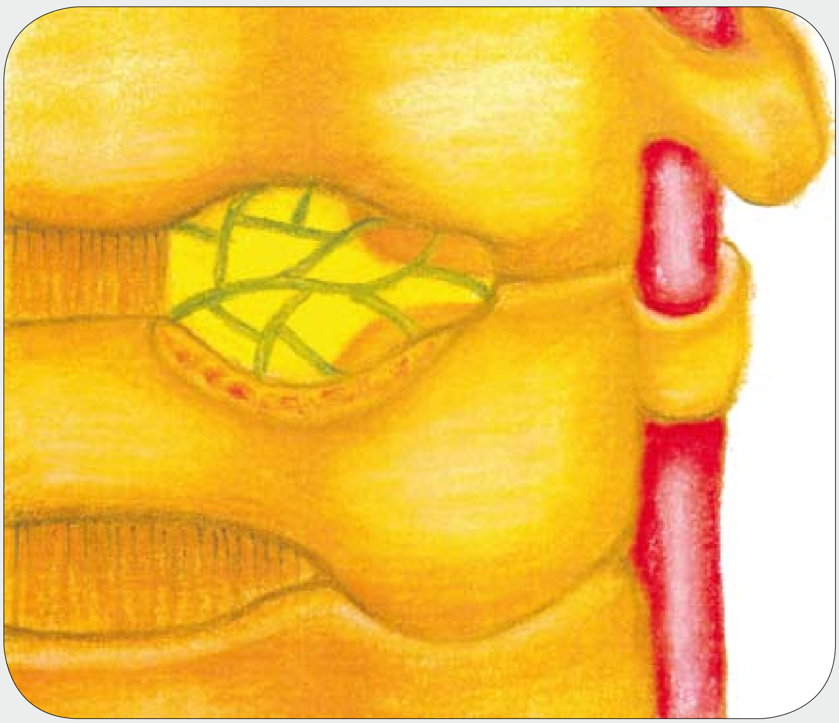

Figure 4 (e):
The nerve root is now decompressed with a full view of the foramen.