P"osterior surgical procedures are those procedures that have been in use for a long time with established efficacy in the treatment of radiculopathy and myelopathy caused by pathologies including cervical spondylosis. However, complaints including pain and spasm is common in the postoperative period related to the widespread subperiostal dissection on the paraspinal muscles in the open posterior cervical interventions (18-60%). In addition, in case there is any preoperative lordosis loss for posterior interventions or for multiple decompressions, the risk of development of deformity in the sagittal plane will be high. Posterior stabilization techniques will eliminate this risk; however, this will increase the operation time and blood loss. Furthermore, there is the potential risk of adjacent segment degeneration development. With these reasons, laminoforaminotomy, which is among the minimal invasive spinal surgery techniques gradually developing within the recent years, is used as a minimal invasive technique. This technique is gradually gaining importance with reasons including the minimal injury caused on the normal anatomical structures during the procedure, reducing of postoperative pain and hospital stay period, and most importantly, the minimal damage on the normal structures of the anatomical support structures minimizing the structural changes including kyphosis, etc. that can develop in time.

**Advantages of Posterior Laminoforaminotomy**

Laminoforaminotomy allows the direct exposure of the nerve root and also allows better opening of the nerve root. At the same time, the nerve root can be decompressed easily without any need for fusion. Laminoforaminotomy does not impair the integrity of the intervertebral disc. There is no risk of complications including graft dislocation or pseudoarthrosis with this technique. Furthermore, patients will not need to wear collars for long periods of time in the preoperative period, and use of a soft cervical collar only for convenience for 1 to 2 weeks will suffice. The risk of tracheal or esophageal injuries that can be seen with anterior surgical techniques and the cerebrovascular complications that can develop in relation with carotid compression do not exist. Furthermore, since this is a minimal invasive intervention, the damages on the posterior muscular structures will be at a minimal level, and this will increase the comfort of the patient in the postoperative period.

**Selection of Patients**

In line with all the decisions for any surgical intervention technique, evaluating the patient in detail is very important when making the decision also for this procedure. A good physical and neurological examination is important in the first place. Patients with mono-lateral radicular symptoms are suitable candidates for laminoforaminotomy in general. For example, patients with repeating symptoms with Spurling maneuver are ideal candidates for laminoforaminotomy, because the nerve root is compressed between the uncinate process and the facet joint in these patients, and removing the dorsal portion of the neural foramen will provide good surgical result. A good radiological examination following the clinical examination is indispensable for the decision-making process for the surgery. Posterior laminoforaminotomy is the proper choice if mono-lateral soft
disc or small lateral osteophytes are present radiologically to support the clinical picture. However, if the principal complaint of the patient is axial neck pain and foraminal narrowing and spinal chord compression are present together, such patients are not suitable for laminoforaminotomy. Moreover, if the hypermobility consistent with instability is present in the dynamic x-rays, posterior laminoforaminotomy will be contra-indicated in this patient group. Therefore, dynamic and static x-rays together with magnetic resonance (MR) images must be taken as a minimum before making the decision for the surgical intervention method, and in cases where MR does not suffice the computerized tomography (CT) images must be taken.

In conclusion, the clinically suitable and unsuitable cases for posterior laminoforaminotomy can be listed as follows:

- **Suitable patient group:**
  - Clinical picture of mono-lateral radiculopathy
  - Posterolateral soft disc hernia appearance
  - Lateral osteophyte appearance

- **Unsuitable patient group:**
  - Axial pain getting ahead of the radiculopathy clinical picture
  - Myelopathy findings
  - Midline or hard disc herniation appearance
  - Widespread osteophyte appearance OPLL
  - Presence of instability

**Anatomy of Cervical Neural Foramina**

Being familiar with the 3-dimensional anatomy of the cervical neural foramen is required to achieve the optimal surgical success. The lateral faces of the superior and inferior laminae from the posterior surround lateral part of the spinal channel. Ligamentum flavum is attached to two-thirds of the superior lamina at the ventral aspect of the lamina, while the same is attached only to the upper portion of the inferior lamina in the inferior aspect. In the lateral, ligamentum flavum end at 1-2mm medial of the neural foramen.

The anterior border of the cervical neural foramen extends from rostral to the caudal following the posterolateral cortical side of the superior vertebral body, the intervertebral disc wrapped within the posterior longitudinal ligament, and a small portion of the posterolateral edge of the inferior vertebral body. In the posterior, neural foramen is limited from the rostral to the caudal with a portion of 1-2 mm of the superior facet, and the entire ventral face of the inferior facet follows this. Superior and inferior borders of the neural foramen consist of the pedicles of the superior and inferior vertebrae, respectively. (Figures 1a and 1b)

---

**Figure 1: a and b:** Relation with the facet joints of the cervical neural foramen and pedicles
**Surgical Technique**

**Position**
The best position for the patient is the one that will minimize blood loss and provide the best visual angle. Therefore prone or sitting positions can be used based on the experience and preference of the surgeon. Skull clamp with pins can be used for the sitting position, and crescent shaped halo or skull clamp again can be used for the prone position. Slight extension of the neck will provide comfort during the surgery, since it will cause opening of the distance between the facet joints. Fixing the position of the patient with the thought that position changes might be necessary during the surgery. Giving the reverse Trendelenburg position to the operation table in the last stage will be wise to direct the blood to the legs and abdomen. (Figure 2)

**Skin Incision and Muscle Dissection**
It is important to determine the surgical area under the guidance of fluoroscopy. After placing a metal object (e.g. K-wire) at the lateral of the patient’s neck, the projection of the fluoroscopy image of the wire on the skin will be marked, and will be determined as the midpoint of the skin incision for the single-space procedures. A skin incision at the midline or 1.5 cm lateral of the midline (ipsilateral) 2 cm in length will suffice for the single-space procedures. (Figure 3) If the intervention is made through a midline incision, the fascia is opened on the spinous process, and paravertebral muscles are dissected up to the lateral border of the lateral mass. For the interventions made from the lateral of the midline, the tubular dilatation systems of endoscopic systems are used to reach the lateral mass and lamina directly through the muscle fibers. The most important issue in this issue is to protect the capsule of the facet joint.

**Laminoforaminotomy**
After exposing the lamina and lateral masses, the microscope will be taken onto the field. The purpose is to expose the nerve root causing the clinical picture of radiculopathy. Using high-speed drill will facilitate the procedure in this stage. In the first place, the lower end of the lateral part of the lamina at the cephalic side of the space and the inferior articular process constituting the lateral mass will be resected with the help of the drill. In general, 1 to 2 mm resection of the inferior articular process will suffice. (Figure 4) Following the resection of the inferior articular process, the superior articular process constituting the lateral mass immediately beneath it will be exposed. The superior articular process will be resected till the pedicle making the lower border of the neural foramen is exposed. (Figure 5) In this stage, removal of the lateral part of the ligamentum flavum with the help of the Kerrison rongeur will ensure exposure of the nerve root. (Figure 6) Following the nerve root towards the lateral will contribute...
to the sufficient bone decompression. Disc herniation is often seen in the caudal of the nerve root. Although rare, it must be kept in mind that it can also be at the cephalic side, like in the lumbar disc herniation. When the nerve root is gently retracted to the cephalic side, the extruded disc hernia will be seen right below the nerve root, or the disc hernia will be seen under the posterior longitudinal ligament. The most important issue to be remembered at this state is that the nerve root must never be retracted to the caudal. Retracting the nerve root to the caudal can damage the nerve root or the spinal chord. In case working on the nerve root from the cephalic side will be needed because the disc herniation is located on the cephalic side, the best thing to do is to remove more bone instead of retracting the nerve root to enlarge the working area so that no nerve retraction will be needed.

Bleeding originating from the venous plexus is a condition commonly seen in this procedure after opening the foramen. Bleeding can be controlled with bipolar coagulation or with the help of small surgical pads. Use of materials like pads or cotton so as to compress the nerve root must be avoided.

If the disc hernia is extruded, the small disc will be removed with the help of a rongeur. Against the possibility of presence of more small fragments, proximal and distal and caudal and cephalic faces of the nerve root will be screened using a like a nerve hook. After removing the free disc fragments, procedure can be terminated at this stage if it is thought that sufficient decompression has been ensured. If the posterior longitudinal ligament is intact, the posterior longitudinal ligament will be opened with the help of a blade after retracting the nerve root gently to the cephalic side. Disc material will be removed until it is seen that the nerve root is decompressed sufficiently. At this stage, care must be given to whether or not there are any free disc fragments left.

Following sufficient hemostasis, layers will be closed like in any normal posterior cervical opening.

Figure 4: Resection border until the surface of the superior articular process of the inferior articular process

Figure 5: Removal of the inferior articular process up to the upper edge of the pedicle (P)
Complications

Laminoforaminotomy has some certain complications as well as the potential complications of any surgical procedures including bleeding or infection. Such complications include the following:

- Dura injury and related cerebrospinal fluid (CSF) fistulas
- Meningitis
- Air embolism (particularly in patients operated in sitting position)
- Pneumocephalus
- Instability
- Injury of the nerve root or dura

Taking certain measures or taking care about some issues can reduce the occurrence of the complications. Preferring the prone position instead of sitting position will reduce the air embolism risk. The reverse Trendelenburg position will reduce the bleeding risk.

If dura tear had occurred, it is very important to repair the dura very well in order to prevent complications including CSF fistulas and related meningitis in the postoperative period. Use of tissue adhesives or barriers is recommended to prevent the CSF fistula to assist if needed. The suspicion that instability can occur in case the facet joint is removed partially. The instability risk will be less if 50% of the facet joint is preserved. In addition, preserving the facet capsule is important that is outside the working area to the extent possible.

Another important complication is spinal chord or nerve root injury. Cephalic retraction of the nerve root must be avoided to reduce the risk of this complication. In addition, it is important to make the bone thinner with the help of high-speed drill when performing the bone decompression and to remove the bone using a very thin Kerrison rongeur. It has been reported that radicular complaints can increase temporarily in about 10% of the patients after laminoforaminotomy procedure, and temporary paresthesia can be seen. This is attributed to the possibility that dorsal sensorial and ventral motor roots within one dura fold or can be present in separate dura folds.1,2,6

Conclusion

Anterior surgical procedures are effective methods currently being carried out by many surgeons. However, it must be kept in mind that posterior laminoforaminotomy can also be an effective method with much greater safety in patients with radiculopathy related to soft disc with lateral localization as the principal complaint. Dorsal cervical laminoforaminotomy technique is a procedure that preserves motion in patients without instability, which does not involve risks seen in anterior surgical procedures related to the grafts and implants, and again with smaller costs as compared to the anterior procedures. Therefore, posterior cervical laminoforaminotomy technique is the method that must always be remembered for the carefully selected patient group with cervical radiculopathy.
References


