Transforaminal endoscopic discectomy with foraminoplasty for lumbar disc herniation

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Abstract. — In 1994, special foraminal reamers were developed by the author with the purpose of enlarging the spinal foramen through a far posterolateral approach. This made it possible to approach the spinal canal through the lateral foramen and to remove extruding and sequestrated disc fragments from the anterior epidural space. With the aid of a spinal endoscope, it became possible to safely decompress dura and spinal nerves in the lumbar area. Since 1999, all types of lumbar disc herniations have been removed in this fashion. As the method includes bony decompression (foraminoplasty) in case of stenosis, the procedure is also suitable in cases of a combination of spinal stenosis and herniated discs. Since 1999, the procedure has been performed by the author in over 1,500 patients with a recurrence rate in the first year of less than 5%, one case of discitis (less than 0.1%) and no patients with permanent nerve damage. The clinical results are at least comparable to the results of the dorsal open, microsurgical or micro-endosurgical techniques.

Keywords: spine, lumbar disc herniation, foraminoplasty, spine endoscopy, discectomy.

Introduction

Because of the fear of complications in lumbar disc surgery, minimally invasive procedures have gained significant interest for both patients and spine surgeons. In traditional dorsal surgery for herniated discs, it is necessary to remove a part of the ligamentum flavum and a part of the lamina; at the L4-5 level, parts of the facet ligaments and the facet joint capsule are sometimes removed in order to visualise the compressed nerve root. In the dorsal approach, usually performed under general anaesthesia, the nerve root has to be mobilised and is therefore at risk of damage. During the removal of loose disc fragments from the intervertebral space, there is a small risk of perforating the anterior longitudinal ligament or the abdominal aorta with serious and sometimes fatal consequences. The far posterolateral approach to the intervertebral disc and the epidural space presents significant advantages as compared to the dorsal approach, as there is no damage to significant structures that may cause scar tissue or instability.

Therefore, this approach reduces the chances of the so called “post-discectomy syndrome”. Kambin has described in detail the closed percutaneous posterolateral approach to the intervertebral disc. However, with the system described by Kambin, it is difficult to reach extruded and sequestrated disc fragments. Moreover, with this system there is a risk of compressing and irritated the exiting nerve root and its ganglion. Because of the limited size of the foramen, in cases of foraminal stenosis the risk of irritated the exiting nerve root is further increased.

With the THESSYS® (Thomas Hoogland Endoscopic Spine System), however, it is possible to enlarge the intervertebral foramen and to decompress foraminal stenosis. The subsequent guiding rods and cannulas are, first of all, placed in the inferior and more medial part of the foramen away from the exiting nerve root. The foramen is enlarged with special reamers, so that the inferior part of the foramen is also widened in a medial direction, making it possible to advance the working channel into the spinal canal. This means that despite the close proximity of the exiting nerve root, its damage can be avoided by a step-wise enlargement of the lateral intervertebral foramen, as the working instruments and reamers can be guided and directed inferiorly and medially away from the root.

Damage to the transiting nerve root, on the other hand, can be avoided because it is usually displaced medially and dorsally by the prolapsed or extruded disc. As the reamers are not advanced further than the guiding rod, dura and nerve root lacerations can be avoided.

With THESSYS® it is also possible to decompress foraminal stenosis. The procedure is performed under local anaesthesia, thereby eliminating the risks of general anaesthesia and thrombosis.

Moreover, the chances of infection are reduced. The procedure is performed under the guidance of the image intensifier and endoscopic visualisation. Dural fistulas and aortic perforations have not been encountered with the use of this technique.

This procedure requires that the surgeon have a perfect three-dimensional view of the spinal structures. The surgical technique involves many steps that must be checked by X-ray intensifier. The surgeon must be able to assess the amount of capsule and bone to be removed from the facet joint in order to achieve a safe portal for the working cannula, while the patient is administered only local anaesthesia. There
may be a long learning curve for the spine surgeon before he can reach all types of disc protrusions and sequestrations [7].

**Surgical technique**

This procedure requires extensive technical equipment including a radiolucent operating table, preferably without metal components in the imaging field, an adequate C-arm image intensifier, a lumbar support pillow, a spinal endoscope with a working channel including camera, monitor and video-recording.

The surgical instruments include an 18-gauge spinal needle, a 22-gauge spinal needle, three K-wires that pass through an 18-gauge spinal needle, a set of dilating rods of 2, 3, 4 and 5 mm, a set of dilating cannulas of 3.5, 4.5 and 5.5 mm, a set of special foraminal reamers ranging from 3 to 8 mm, a working cannula of 7.5 mm, a grasping forceps that fits through the endoscope with a working channel, and 3 different sized grasping forceps that fit through the working channel (fig 1).

**Pre-operative documentation**

Sagittal and axial T2 MRI images are necessary to verify the localisation of the protruded, extruded or sequestrated disc material (fig 2A, B).

A lateral X-ray of the lumbar spine is necessary to verify the precise level of the herniation and to judge the size of the involved foramen. The size of the foramen determines, in conjunction with the size of the patient, how far lateral the entrance point of the procedure will be. In case of a large foramen, as is usually present at the L3-4 and L2-3 level, the approach distance is no more than 10 cm from the midline. The L4-5 and L5-S1 levels are usually approached at least 12 cm from the midline.

This distance increases in cases where there is obesity, a very narrow foramen or facet arthrosis.

The patient is positioned on his side on a lumbar support pillow and stabilised with a strap over the trochanter. Anaesthesia is administered intravenously, with sedatives and morphine-type analgesia on standby. The level of anaesthesia should be not be deep and it should be possible to arouse the patient at any time. The patient’s back is disinfected and a sterile screen-type drape is applied.

The image intensifier should be able to swing freely in two directions without interfering with sterility.

**PROCEDURE FOR A L5-S1 EXTRUDED DISC HERNIATION**

The most important part of transforaminal endoscopic discectomy is to introduce through the lateral foramen, in a safe manner, a working cannula into the spinal canal just short of the location where the extruded or sequestrated disc herniation is located, as demonstrated on a plastic model (fig 3).

The procedure is presented below step by step. The first 13 steps are necessary to introduce the working channel in the correct position, after which the endoscope is introduced and removal of the herniation is performed.

**Step 1:** The entrance point of the procedure is determined by marking: a) the middle of the spine, b) the iliac crest, c) the estimated lateral distance at the L5-S1 level, usually at 14 cm. A long instrument is placed in the direction of the pathway and a lateral X-ray image is made.

A line is drawn towards the position of the extruding fragment in the lateral projection. The line of approach and the lateral distance are marked (fig 4).

**Step 2:** The skin is locally infiltrated with 5 cc of 2% lidocaine with adrenaline. Then, an 18-gauge needle is introduced, aiming at the lateral foramen. Usually, at first the facet joint is hit and the position of the needle is verified with the image intensifier in AP and lateral views. The best entrance point to the foramen is just above the facet joint (fig 5, 6).

**Step 3:** A curved 22-gauge needle is then introduced through this 18-gauge cannula and the tip of the second needle is directed caudally and medially, aiming for the extruding disc fragment (fig 7).

**Step 4:** The 18-gauge needle is now pushed over the 22-gauge needle. Then the 22-gauge needle is removed.

**Step 5:** A K-wire is now introduced through the 18-gauge needle and the 18-gauge needle is removed.

**Step 6:** A 6 mm skin incision is made over the K-wire and a 2 mm dilating rod is pushed over the K-wire.

**Step 7:** The 3 dilating cannulas are now pushed over the first dilating rod in a subsequent fashion.
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Step 8: The last dilating cannula remains, the other two are removed and 10 cc of local anaesthesia is now infiltrated around the facet joint and around the iliac crest.

Step 9: The first guiding rod is removed and the curved 2 mm guiding rod (fig 8A) is now pushed over the K-wire with the aid of a hammer and imaging control in two directions (fig 8B).

The tip of the curved dilating rod should now reach the centre of the extruded disc fragment (fig 9).
Step 1: The K-wire is left behind, all other instruments are now removed, and a 3 mm dilating rod is now introduced over the K-wire.

At this point the K-wire is removed and the tip of the guiding rod is carefully directed towards the extruded fragment, usually by pushing the rod more interior and more medial, again with the aid of a hammer.

Then the K-wire is once again inserted and a 4 mm dilating cannula is introduced. Over this cannula, the 5 mm reamer is introduced; with this reamer the foramen is enlarged, again up to the epidural space.

Step 2: Except for the K-wire, all instruments are removed and the 5 mm dilating rod is introduced. The K-wire is removed again and the tip of the rod is placed in the area of the extruded fragment. Then the K-wire is re-introduced, a 6.5 mm dilating cannula is introduced, and over this cannula the 7.5 mm reamer is introduced, again enlarging the foramen (fig 12).

Step 3: After removal of the reamer, the working channel is now put in place.

Step 4: The spinal endoscope is now introduced (fig 13) and the foraminal area is inspected, usually demonstrating the herniated fragment (fig 14), and, sometimes in the medial area, a part of the compressed nerve root as well. Through the working channel of the endoscope, a forceps is introduced, picking into the depth and removing loose disc fragments to exclude dura or nerve root at the end of the working channel.

Step 5: The endoscope is removed and a grasping forceps is now put on the extruded or sequestrated disc fragment. The position of the grasping forceps is checked with the image-intensifier and at this point X-rays are made in two directions (fig 15).

Step 6: The extruding fragment is now removed by means of the forceps.

With a needle holder, the direction of the curved 2 mm guiding rod is marked in order to check the direction of the curve.

Step 10: The first dilating cannula is pushed over the dilating rod and the first foraminal reamer is pushed over this rod, and then reaming is performed up to the epidural area (fig 10, 11).
11. Reaming is performed up to the epidural area by means of the foraminal reamer.

12. The 7.5 mm reamer is introduced over the cannula.

13. Introduction of the spinal endoscope.

14. Endoscopic view of herniated fragment and lateral facet capsule. 1. Lateral facet capsule; 2. herniated fragment.

15. The position of the grasping forceps is checked with the image intensifier and X-rays are made in two views. A. Lateral image view. B. AP image view.

With repeated manoeuvres all fragments are extracted. At this point the patient should be fully awake so that no neural elements are damaged.

Step 17: The endoscope is re-introduced, looking for the freed nerve.

At the same time, with the working channel forceps, remnants of the extruding fragments are removed. A free and pulsating nerve root must be verified (fig 16, 17).

Step 18: The open end of the working cannula is now turned 180° and with several forceps the posterior part of the disc is now cleared of loose fragments. Finally, with a curved 22-gauge needle, the intradiscal space is irrigated with an antibiotic solution and the cannula is removed. The skin is closed with one stitch.
Transformamin endoscopic discectomy with foraminoplasty for lumbar disc herniation

Results and complications

In a study of 246 patients treated with endoscopic discectomy, at two years an excellent or good result was reported by 86% of the patients, with an unsatisfactory rate of 7.7%. There were no serious complications, and in particular no deep infections. Three patients had disturbing postoperative paraesthesia and partial weakness of the foot and toe extensors, that in all cases resolved over a period of about 3 months. In one patient, a transient allergic reaction occurred due to a prophylactic cephalosporin antibiotic. The re-operation rate was 3.5% in the first year.

If there is strict adherence to the surgical protocol, no other serious complications are to be expected. Care must be taken to have adequate intravenous analgesia with sedation to a level that the patient will feel and report root pain. Each step of the procedure should be controlled in two directions by the image intensifier, particularly when the instruments approach the foramen and the spinal canal. Rarely, lacerations of the anterior dura may occur and, as a rule, remain without consequence. Postoperative headaches are extremely rare; when they occur, they are short-lived.

A recent publication on posteriorateral endoscopic excision for lumbar disc herniation by Yeung [13] reported a satisfactory result in 89.3% of the cases and a poor outcome rate of 10.7%. It combined a major and minor complication rate of 3.5%, including 0.6% disc space infections and one case of re-operation for a dural tear.

With a average follow-up of 19 months, there was a re-operation rate of 5%.

Hernantin [1] compared the results of open discectomy with those of endoscopic posterolateral discectomy. There were 97% good results in the endoscopic group (n = 30) and 93% good results in the open laminectomy group (n = 30). However, in this series extruded herniations at the L5-S1 level were excluded.

Indications and limitations

Endoscopic transformamin decompression can be used for any type of disc herniation that requires surgical intervention. It is obvious that contained disc herniations can be reached more easily than sequestered herniations, but with THESYS® the foramen can be sufficiently enlarged to allow introduction of an adequate working cannula into the spinal canal; thus all herniated fragments can be reached, with the exception of disc fragments that have moved on the dorsal (posterior) aspect of the dura, a very rare occurrence.

Limitations of the procedure include the need for specific operating room equipment and special instruments, as well as the long learning curve, particularly for sequestered fragments. The percutaneous approach is ideal for a 3-dimensional sight of the lumbar spinal contents and a stereotactic feeling when the instruments are introduced and when the foraminial reaming is performed.

Conclusions

The procedure described above has several advantages: it can be performed under local anaesthesia, thus eliminating the potential complications of general anaesthesia. As the affected nerve root is not anaesthetised, there is a much larger safety margin concerning the risk of neural damage with this procedure, compared to open procedures performed under general anaesthesia. The ligamentum flavum and dorsal joint capsule are not injured; therefore, there is much less scar formation compared to posterior procedures. There is very little postoperative pain and an early return to work is therefore possible. When the newly developed retractors are used, it is possible to remove all types of disc herniations. The incidence of re-operations is not higher than in dorsal approaches and the over-all results seem to be better than those of interlaminar approaches.

References