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A new minimally invasive posterior approach for the treatment of cervical radiculopathy and myelopathy: surgical technique and preliminary results

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Abstract Degenerative cervical disorders predominantly lead to anterior spinal cord compression (by bony spurs at the posterior margin of the vertebral body or by degenerated disc), which may be central and/or foraminal. In a smaller percentage of cases, there is encroachment of the canal mainly from posterior by bulging yellow ligaments or bony appositions, resulting in compression syndromes of roots or spinal cord. The aim of this work is to present a minimally invasive posterior approach avoiding detachment of muscles for the treatment of cervical radiculopathy and myelopathy. Thirteen patients suffering from cervical radiculopathy (four patients) or myelopathy (nine patients) were operated according to this technique. In principle, the technique secures access to the diseased spinal segment via a percutaneously placed working channel (11 mm outer diameter and 9 mm inner diameter). The cervical paraspinal muscles are not deflected, but just spread between their fibres by special dilators. All further steps are performed through this channel under control of three-dimensional vision through the operating microscope. The mean follow-up period was 17 months (one patient died

9 months postoperatively), and patients were evaluated using a modified version of the Oswestry Index, called the Neck Disability Index (NDI), and the visual analogue scale (VAS) for neck and arm pain. The mean NDI ($P<0.0001$) improved from 13.2 (preoperatively) to 4.8 (postoperatively). The VAS for arm pain ($P<0.001$) and for neck pain ($P<0.001$) also showed marked postoperative improvement. Complete recovery of the preoperative neurological deficit was found in four patients, while the remaining eight patients showed improvement of the neurological symptoms during the follow-up period. There were no intra-operative or postoperative complications and no re-operation. The preliminary experience with this technique, and the good clinical outcome, seem to promise that this minimally invasive technique is a valid alternative to the conventional open exposure for treatment of lateral disc prolapses, foraminal bony stenosis and central posterior ligamentous stenosis of the cervical spine.

Keywords Minimally invasive posterior approach · Radiculopathy · Myelopathy · Foraminotomy · Cervical spine

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Introduction

Various anterior and posterior operative approaches for the treatment of cervical radiculopathy and myelopathy

have been reported [1, 2, 4, 6, 8, 14, 15]. Frykholm [10] and Scoville [20] described posterior foraminotomy through partial resection of the medial part of facet joint to relieve the compression of the cervical nerve root in radiculopathy patients. Conventional posterior approaches

Table 1 The clinical data of 13 patients who were operated upon for cervical radiculopathy or myelopathy (NDI Neck Disability Index, VAS visual analogue scale)

Patient no.	Age (years)	Sex	Neurological deficits (preop)	Imaging findings	Level	Operative time (min)	NDI (preop)	NDI (postop)	VAS Neck (preop)	VAS Arm (preop)	VAS Neck (postop)	VAS Arm (postop)	Neurological deficits (postop)	Follow-up (months)
1	65	Male	Sensory C8	Bony foraminal stenosis	C7/T1	60	65	10	7	8	3	2	Complete recovery	42
2	51	Male	Sensory+ motor C8	Bony foraminal stenosis	C7/T1	70	70	50	6	8	5	6	Improved	36
3	76	Female	Myelopathy	Central stenosis (lig. flavum hypertrophy)	C3–6	90	70	40	8	8	2	3	Improved	25
4	80	Male	Myelopathy	Central stenosis (lig. flavum hypertrophy)	C5/6	85	55	20	8	7	4	1	Improved	19
5	43	Male	Sensory C8	Bony foraminal stenosis	C7/T1	45	65	0	6	7	2	1	Complete recovery	16
6	69	Female	Myelopathy	Central stenosis (lig. flavum hypertrophy)	C2/3	50	65	25	9	7	6	4	Improved	14
7	76	Male	Myelopathy	Central stenosis (lig. flavum hypertrophy)	C3/4	45	80	45	5	5	5	4	improved	12
8	52	Female	Myelopathy	Central stenosis (lig. flavum hypertrophy)	C5/6	105	70	45	8	6	6	4	Improved	11
9	72	Female	Myelopathy	Central stenosis (lig. flavum hypertrophy)	C5/6	65	60	0	3	5	1	1	Complete recovery	12
10	73	Male	Myelopathy	Central stenosis (lig. flavum hypertrophy)	C3–5	110	75		9	6			Died 9 months postop	9
11	57	Female	Myelopathy	Central stenosis (lig. flavum hypertrophy)	C3/4	60	60	20	5	7	1	3	Improved	9
12	55	Female	Sensory+ motor C7	Intra-foraminal disc prolapse	C6/7	80	60	5	6	8	2	2	Complete recovery	7
13	75	Male	Myelopathy	Central stenosis (lig. flavum hypertrophy)	C3/4	45	65	30	7	7	3	5	Improved	5

have the disadvantage of detaching the extensor cervical muscles from the laminae and the spinous processes [7, 11]. This operative trauma to the cervical paraspinal muscles is a major cause of postoperative complications that may be in the form of persistent neck and shoulder pain, and sometimes spinal instability may be the end result [3, 12, 13, 23].

Roh et al. [19] described the use of microendoscopic posterior cervical foraminotomy in a cadaveric study (four cadavers), and Burke and Caputy [5] reported on the use of the same technique in a combined cadaveric and clinical study (three cadavers and three patients). The microendoscopic technique has the advantage of providing a minimally invasive approach through transmuscular dilatation. However, one major disadvantage of the endoscopic technique is that it only allows two-dimensional visualisation. The second obstacle is that vision often gets blurred by bleeding or obscured by fragments during removal.

The aim of this work is to present a minimally invasive posterior approach for the cervical spine that can maintain the paraspinal muscles (semispinalis cervicis and splenius cervicis) and their attachments relatively intact and that can avoid the disadvantages of the microendoscopic technique.

Materials and methods

This study consisted of 13 patients (16 cervical segments) admitted to our centre in the period from October 1998 to October 2001 (Table 1). The mean age was 64 years; 53% of the patients were male. The patients were strictly selected according to the offending pathology. Nine patients (seven monosegmental, one bisegmental and one trisegmental pathology) suffered from cervical myelopathy resulting from hypertrophied ligamentum flavum (Fig. 1A). The other four patients presented with monoradicular symptoms due to

either bony foraminal stenosis or intraforaminal disc prolapse. The indication for surgery was failure of conservative treatment with pain over a period of 6 weeks and/or neurological deficits.

The clinical data of the patients are presented in (Table 1). The patients were assessed preoperatively as well as postoperatively using a modified version of the Oswestry Index, called the Neck Disability Index (NDI) [22, 24] and the visual analogue scale (VAS) for neck and arm pain [24]. The follow-up period ranged from 5 to 42 months with a mean of 17 months. The results of the scoring systems were analysed statistically using student's *t*-test. At the end of follow-up, the neurological deficits (whether myelopathy or radiculopathy) are described as improved (when some of the preoperative neurological deficits persist postoperatively), or complete recovery (when the preoperative neurological deficits disappear completely).

Surgical technique

The operation is done under general anaesthesia and in prone position with optimal head inclination. All patients were monitored intra-operatively using somatosensory evoked potentials (SEP). After skin disinfection and draping, the position between the two laminae at the desired level is determined and documented by image intensifier (lateral view). A stab incision of 1.5 cm length, about 2 cm lateral to the midline, is made and two soft tissue dilators are applied in sequence. This allows gentle spreading of the fascia and the fibres of the paraspinal muscles to the extent that allows the introduction of the working channel (Fig. 2). The introduction of dilators and the working channel is performed under C-arm guidance. An important anatomical landmark is the lower border of the upper lamina of the affected cervical segment. The working channels (Fig. 3) are made of titanium with 9 mm inner and 11 mm outer diameter, and are available in three lengths (45, 55, 65 mm). A handle at the working channel allows angulating movements, providing optimum direction of vision and access. Threads at the outer circumference of the portal enable a smooth insertion by rotation and secure anchorage at the surgical site. After correct positioning of the working channel, all further steps are done using illumination and visual control through the operating microscope. Depending on the underlying pathology, the technique is differentiated into either intervertebral foraminotomy or interlaminar decompression.

Fig. 1 **A** Preoperative T2-weighted magnetic resonance imaging (MRI) section showing stenosis (mainly posterior) at the level of C3/4. **B** Postoperative T2-weighted MRI section after interlaminar decompression

Fig. 2 Intra-operative radiograph (by C-arm) showing the working channel at the level of C3/4

Fig. 3 The working channel in three lengths

Intervertebral foraminotomy

This technique was used in foraminal stenosis caused by bony spurs or disc prolapse. The ligamentum flavum was excised together with a small part of the medial aspect of the facet joint and the upper lamina. This nicely exposed the nerve root (Fig. 4) which, when mobilized, gave good access for removal of the herniated disc. In case of bony decompression of the nerve root, not more than 25% of the facet joint was removed.

Interlaminar decompression

Decompression of central posterior cervical canal stenosis is technically not difficult. Resection of the medial part of the ligamentum flavum will expose the dura, which can be well decompressed by undercutting of the lamina. By redirecting the working channel,

Fig. 4 Intraoperative photograph showing the partially resected facet joint (FJ) and the nerve root (NR)

it is possible to resect the ligamentum flavum of the opposite side (cross-over technique) without damaging the interspinous ligament or the splenius cervicis muscle. In cases of multiple level stenosis, separate skin incisions were used.

Bleeding from the epidural venous plexus, especially in the intervertebral foraminotomy technique, can be controlled by bipolar coagulation (after mobilisation of the nerve root) and collagen sheets. A suction drain proved not to be necessary. The fascia and the subcutaneous layer were closed by a single suture, while the skin was approximated by a sticking plaster.

Since no muscle needed to be deflected, there was no need for a neck support; remobilisation of all patients started uneventfully after 4 h.

Results

The average operation time per segment was 61 min. There were no intra-operative or postoperative complications. The intra-operative somatosensory evoked potentials showed no changes. None of the patients underwent re-operation. The average follow-up period was 17 months. One patient died 9 months postoperatively due to other medical reasons and, accordingly, the data of only 12 patients will be analysed statistically.

The postoperative NDI and VAS for the patients are shown in Table 1). The mean NDI improved from 64 (pre-operatively) to 24 (postoperatively), and this was statistically highly significant ($P < 0.0001$). Corresponding improvement of VAS for neck and arm pain was also recorded. VAS for neck pain improved from 6.7 to 3.3 and VAS for

Fig. 5 The scar, 3 months after the minimally invasive approach

arm pain improved from 6.8 to 3, which again was statistically highly significant ($P < 0.001$ and $P < 0.001$ respectively).

Regarding the neurological deficits, four patients (33%) showed complete recovery of the preoperative neurological deficits, while improvement of the neurological deficits was detected in eight patients (67%).

In summary it can be stated that improvement of preoperative pain and neurological deficits together with excellent cosmetic outcome (Fig. 5) was achieved in all patients.

Discussion

Many studies have described the effectiveness of the anterior approach for the treatment of cervical disc prolapse and spondylotic cervical canal stenosis [2, 4, 6, 14]. Although the anterior approach is more commonly performed for the treatment of cervical disc disease, the posterior approach has distinct advantages in selected cases of foraminal stenosis and postero-lateral disc herniation [18, 19]. The posterior approach avoids many of the hazards of the anterior exposure, e.g. recurrent laryngeal nerve

injury, oesophagus injury, and injury to the carotid sheath or other prevertebral structures. On the other hand, the conventional posterior approach may endanger the stability of the cervical spine, especially when more than 50% of the facet joint at one side or 25% of the facet joint on both sides are resected [23]. The muscles of the head and neck region are characteristically rich in proprioceptors that send afferents directly to the vestibulo-spinal and the vestibulo-oculomotor neurones [17]. So, subperiosteal dissection of the paraspinal muscles can result in muscular pain and spasms, which are common with the conventional posterior approach [3, 5, 12, 13, 19, 21]. Consequently, a technique that minimises trauma to the posterior paraspinal muscles of the neck offers many advantages and a better functional outcome.

The interfibrous dilatation minimises the operative trauma to the paravertebral muscles, as has been proven for the lumbar spine by the study on microendoscopic discectomy (MED) [9] by Muramatsu et al. [16].

In comparison to MED, this new minimally invasive technique has the advantage of three-dimensional vision provided by the operating microscope. By a simple tilting manoeuvre, the working channel can be adjusted for optimum visualisation. This compares well to the visualisation of the 15° endoscope used in the MED-system [19], and is advantageous to conventional foraminotomy.

This made us feel secure to expand the scope of surgery beyond that reported so far for the cervical spine. To our knowledge, there have been no previous reports on minimally invasive techniques for interlaminar decompression of central posterior stenosis.

Since there is no real trauma of an approach by this technique, the patients can get up again a few hours post-operatively. In this age group (mean 64 years) this means more than just improving the patient's comfort; it also avoids complications resulting from immobilisation.

The main limitation of this procedure is in the treatment of severe bony stenosis that necessitates laminectomy in order to decompress the spinal cord. In this condition we prefer to use the conventional open technique.

Conclusion

Despite the small number of patients, and short period of follow-up, the experience so far encourages us to consider this posterior cervical minimally invasive microscope-assisted technique as a valuable option in the treatment of predominantly posterior-based stenosis. It proved to be a practical and cost-effective way to treat cervical radiculopathy and myelopathy resulting from intraforaminal disc prolapse, bony foraminal stenosis and posterior central ligamentous stenosis. Its main advantages include: minimal surgical trauma, minimal or no effect on the stability of the spine, rapid rehabilitation, short hospital stay and excellent cosmetic outcome.

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