Minimally Invasive Disc Preserving Surgery in Cervical Radiculopathies: The Posterior Microscopic and Endoscopic Approach

Angelo Franzini, Giuseppe Messina, Paolo Ferroli, and Giovanni Broggi

Abstract The aim of this paper is the report of the long-term results of a prospective study on spinal cervical lamino-foraminotomy via posterior route for the surgical treatment of cervical radiculopathies due to spondylodiscoarthrosis. The goal of the described surgical procedure is the bony decompression of the involved root leaving the intervertebral protruded or herniated discs intact. Indication, surgical technique, outcome and complications are discussed. Although anterior spinal cervical approach is the standard for centrally-located disc herniations with myelopathy, posterior foraminotomy appears to be a safe, minimally-invasive and effective treatment for postero-lateral radicular compression in the cervical spine. In our opinion, microscopic and/or endoscopic minimally invasive lamino-foraminotomy must be included within the surgical options for degenerative disc diseases of the cervical spine. This approach allowed us to reduce about 30% of the number of patients treated by the anterior approach, thus consistently reducing the need for intersomatic fixation.

Keywords Cervical lamino-foraminotomy · Cervical radicular compression · Posterior foraminotomy

Introduction

The posterior cervical approach to degenerative disc herniation was originally introduced by Scoville and Whitcomb in 1966 to treat cervical root compression due to disc fragments and/or foraminal stenosis at cervical levels [7]. Also Verbiest [9] described the antero-lateral approach aimed to obtain root decompression avoiding the risks of the anterior approach introduced by Smith and Robinson [5].

Nevertheless, the anterior approach, popularized by Cloward [2] became the gold standard for the treatment of intracanalar median or paramedian disc herniation.

In the era of minimally invasive surgery of the spine the posterior approach was revaluated either through microsurgery or through endoscopy to avoid in selected cases the risks of the anterior approach (such as vascular, visceral or neural lesions) and the need for anterior instrumentation [4]. We think that in cases, in which the cause of compression is not located centrally but instead posterolaterally, such as intraforaminal cervical herniated disc, the posterior foraminotomy has showed to be effective and safe [11].

In 1998 we designed a prospective study in which patients affected by lateral disc herniations were treated by posterior foraminotomy while patients affected from median disc herniation were treated by anterior approach and fusion. The prerequisite of such study considered also the clinical picture which consisted in radicular pain and deficits for the first group of patients and in the presence of spinal cord signs and changes in the second group. The indications for employing posterior foraminotomy included (1) clear clinical symptoms and signs of cervical radiculopathy confirmed by neurophysiological studies (2) neuroradiological evidence of compression of the clinically symptomatic cervical root such as a soft posterolateral herniated disc or foraminal stenosis, due to arthrosis of the structures delimiting the neural foramen (3) absence of myelopathy.

Contraindications to posterior cervical foraminotomy included (1) significative instability or kyphotic deformity at the involved level (in such cases removal of a relatively small amount of the posterior spinal elements can lead to a worsening of instability [1]); (2) local skin infection; (3) doubtful or absence of congruity between clinical and instrumental findings with regard to the spinal level affected and to be approached; (4) presence of clinical and radiological signs of spinal myelopathy.

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The immediate and long-term results of such procedure on pain and neurological deficits in a considerable number of patients are reported along with complications.

Materials and Methods

From 1998 to 2008, 140 patients with cervical radiculopathy were treated with posterior cervical foraminotomy at the Istituto Nazionale Neurologico "C. Besta" in Milan. The mean age was 49 years (23–71 years); surgery was performed at one spinal level in 126 patients and at two levels in 14 patients. Three patients had already undergone previous anterior microdiscectomy and fusion at different spinal levels. Sixty-five patients were operated on at C5–C6 level, 40 patients at C6–C7 level, 15 patients at C4–C5 level, 15 patients at C7–D1 level and 5 patients at C3–C4 level.

All of the patients presented clear-cut clinical signs of a cervical radiculopathy, which was further confirmed by neurophysiological studies. CT and MRI were performed in all of them disclosing a soft disc herniation at the congruous level in 75% of patients and a foraminal stenosis in the remaining 25%. Clinical examination included assessment of motor strength, sensitivity and osteotendinous reflexes, along with research of Spurling's sign and evaluation of pallesthesia. An irritative radicular syndrome including pain and paresthesia at the affected dermatome was the most common finding in our series and was present in 95 % (n = 133) of patients. Light-touch hypoesthesia was the second most common finding, affecting 80% (n = 112) of our patients; osteotendinous hyporeflexia, upper limb motor strength deficit, and hypopallesthesia were present in 70% (n = 98), 40% (n = 56) and 30% (n = 42) of patients, respectively.

All of the patients had been complaining of the above-mentioned symptoms or signs for at least 2 months before admission to our Institute. Conservative treatments (including NSAIDs, corticosteroids, myorelaxant agents, with or without the use of cervical collar, at adequate dosages and therapy duration) revealed to be ineffective.

After admission all of the patients underwent pre-operative thin-slice spinal cervical CT or MRI scan to appropriately visualize the root involved and the structures (bony or ligamentous) responsible for compression. From 2004 we also used pre-operative three-dimensional images of CT-derived reconstructions of cervical spinal column to further asses the bony components of foraminal stenosis. In some cases we also use such image modality in the postoperative period in order to verify and better delineate the degree of decompression.

Surgery

The patient is positioned prone on the operating table; we do not use the sitting position for such intervention because of the increased risk of air embolism and vascular hypotension that such position entails.

A Mayfield three-point-fixation system is routinely used; we think it offers the double advantage of assuring a rigid position of the neck and avoiding eyeball compression, which could lead to retinal ischemia and subsequent amaurosis [8] with usage of horse-shoe head frames. The chin is slightly retropositioned to obtain a "martial" posture of the neck, which is very useful for stretching the posterior cervical skin. The minimal distance between the sternum and the chin should be of two fingers' breadth.

Superior thoracic and iliac crests' foam rolls are used after turning the patient into the prone position to avoid inappropriate abdominal compression during the intervention. The operating table is then set to a slight Trendelenburg's position to facilitate venous drainage from lower limbs. Compressive stockings are used to minimize the risk of deep venous thrombosis. Before incision a C-arm fluoroscope is employed for confirmation of the correct spinal cervical level and of adequate cervical spine's alignment; sometimes, and especially for lower cervical levels, it can be necessary to pull down the shoulders of the patients along the operating table with adhesive tapes for maximizing the radiographic visualization of the affected spinal levels.

We perform the preoperative control with a 16 gauge needle (either inserted perpendiculary to the long axis of cervical spine directly on the articular facets, or simply laid down along the cutaneous surface corresponding to the level to be approached).

For microendoscopic procedure, after adequate disinfection and draping of the operating field, a 2 cm-long paramedian skin incision is made. The muscular fascia is incised and insertion of the Kirschner needle pointing to the interarticular space is performed under fluoroscopic control. Sequential dilating METRx (Medtronic Sofamor Danek; Memphis, TN) rigid cannulas are then inserted along the guiding needle to the lateral mass of the affected level. The 18 mm working-channel, that is to say the definitive tubular rectractor, is lastly inserted and secured by fixing it to the operating table with the use of the appropriate self-retaining retraction's system.

At this point, an ad-hoc designed fixed endoscope can be connected to the tubular rectractor or, better in our opinion for the quality of images and operative flexibility, a hand-hold rigid 0° endoscope used by the assistant to visualize the operative space can be employed.

For open procedures, after a slightly longer skin incision (3 cm), the muscular fascia is largely opened to avoid an excessive muscle retraction and subsequent muscular ischemia and postoperative pain. Paravertebral muscles are

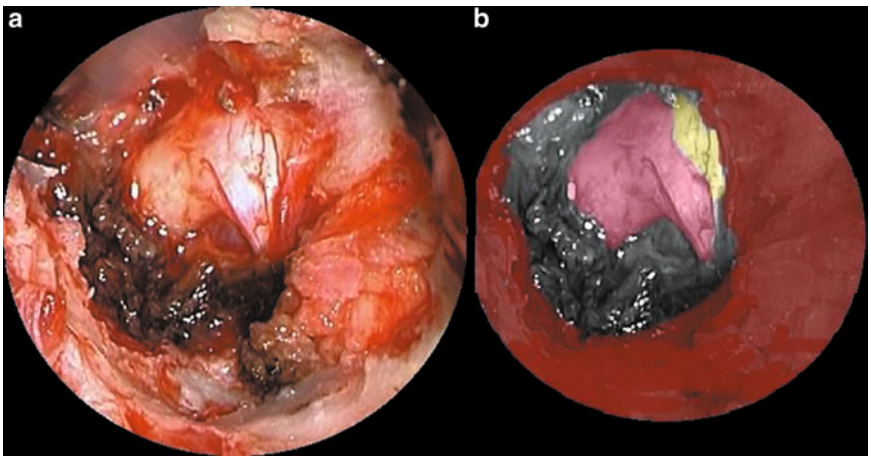

Fig. 1 (**a**) The nerve root is visualized after the bone drilling in microscopic view. (**b**) colour superimposition drawing of the same photo, where the root is in *pink*, bone is in *brown* and yellow ligament is in *yellow*

detached from the spinosus processes and the hemilamina and articular processes are skelotonized and exposed. A self-retaining Caspar retractor is then positioned. The operative microscope is brought into the operative field at this stage of the procedure.

Endoscopic and microscopic open procedures at this time point follow a similar course: a 4-mm diamond drill is used to remove the bone of the lateral part of the two adjacent hemilaminae, and the medial half of the corresponding articular facet. The yellow ligament is then removed by using a Kerrison rongeur thus exposing the lateral part of the dural sac. Bony removal usually begins at the junction between the medial portion of the articular facet and cervical lamina, and then carried on to the medial portion of the corresponding articular joint. Bone drilling then continues at the level of the articular facets until the dural sleeve of the root is evident and the root itself well decompressed. If an extruded and free disc fragment is present, it can be generally accessed enlarging a little bit the root exposure in the axillary region. At this stage, dural sac and emerging ipsilateral dural radicular pocket containing the motor and sensitive nerve roots should be visualized (Fig. 1).

To obtain an adequate visualization of the inferior vertebra's pedicle (where radicular pocket passes at the inferior margin of the neural foramen), further removal of the superior portion of the inferior lamina may be carried out.

The nerve root is inspected along its course from emergence off the spinal dural sac to its exit site at the neural foramina using a small nerve hook; such procedure allows for better clarifying the sites of more pronounced radicular compression. The nerve hook is used to elevate the axilla of the root, so as to expose ventral sites of compression of radicular pocket, such as intraforaminal disc herniation. If inferior vertebra's pedicle is identified as a significant cause of radicular compression, it can be partially removed in its superomedial portion [10] with careful trephination at this stage, taking into account the proximity of transverse cervical foramen (containing the vertebral artery and vertebral venous plexus), which is located just lateral to the pedicle. Removal of about 50% of articular facets (medial portion) is usually sufficient to obtain radicular decompression; anyway, when hypertrophy of this structure or extraforaminal disc herniation is clearly involved in radicular compression it could be entirely removed, taking into account the eventuality of posterior instability and prolonged postoperative pain. Anyway, in our experience such manoeuver has never been required. It has to be noticed that we always respect the disc, remove discal tissue and never pierce the annular ligament containing the disc soft tissue. We perform really a bony decompression of the radicular foramen leaving the disc intact.

Finally haemostatic agents such as Surgicel, Surgiflo (Johnson and Johnson New Brunswick, NJ Inc.) or Floseal (Baxter Inc) can be used to refine the haemostasis when an oozing bleeding from the peridural venous plexus is noticed. Surgical wound is closed in layers in a standard fashion. We do not routinely use postoperative subfascial drainage systems. Prophylactic antibiotics are only administered intraoperatively to reduce the risk of growth of multi-resistant bacterial lines; they are eventually continued in the postoperative period in cases of otherwise unexplained hyperpyrexia and after antibiogram confirmation of the most adequate therapeutic agents.

Results

Mean hospitalization post-operative time was 48 h.

Follow-up evaluations were carried out at hospital discharge, and then at 3 months, 6 months, 1 year and 3 years after the intervention. Three-year-follow-up is only available for 50 patients. In 98 patients (70% of total cases) radicular pain immediately disappeared on the first postoperative day; such benefit was maintained until the last

follow-up visits for all of them. In 40 patients (28.8%) radicular pain completely remitted within 1 month from surgery and, again, the clinical improvement was still present at the last clinical evaluation carried forward.

In patients also suffering from sensitive and/or motor signs, such findings disappeared within 2 months from surgery in all of them.

Persistence of radicular pain was observed in two patients (1.4% of total cases), as evaluated in the last follow-up examination.

Post-operative pain at the surgical site was present in 20% (n = 28) of our patients; anyway, it remitted within 1 week from surgery in all of them, with or without use of prolonged analgesic pharmacological therapy.

No infective, neurological or haematological complications (such as deep-venous thrombosis) were encountered in our series. As mentioned above, since 2004 we have employed (though not for all of the cases) three-dimensional CT reconstructions of the cervical spine (Figs. 2–3). We think such a tridimensional image reconstruction is a useful

Fig. 2 *Left*: Postoperative three-dimensional CT image showing the site of foraminotomy. In this case bone removal was not extended to the medial facet joints. *Right upper/lower*: axial CT slices showing the level of nerve root compression, before (*upper*) and after (*lower*) surgery

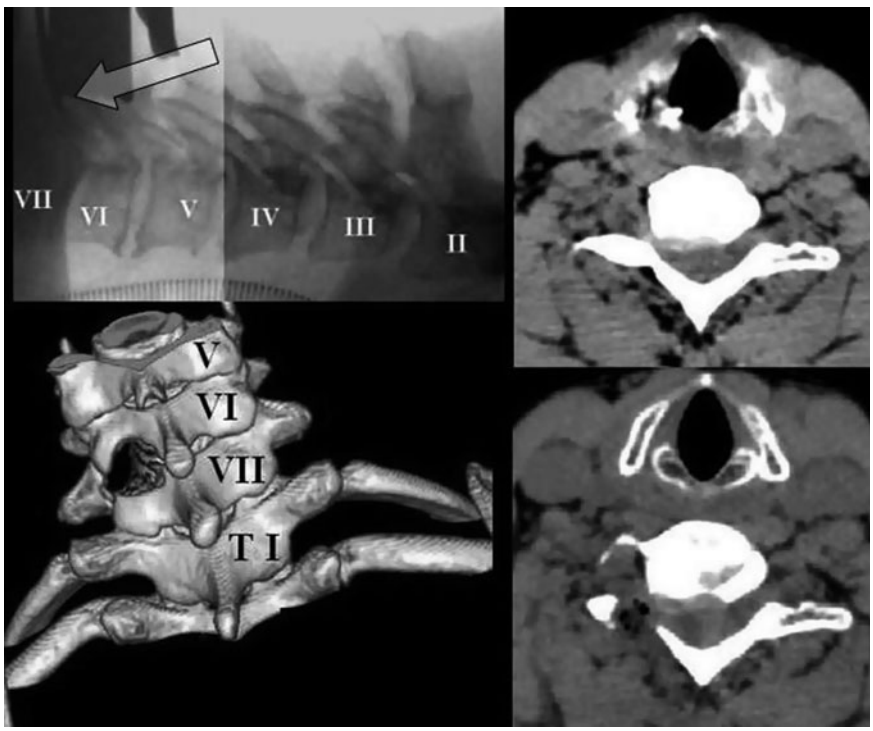

Fig. 3 *Upper left*: intraoperative X-rays control showing the Cobb's elevator used as a marker of the space. *Lower left*: Postoperative three-dimensional CT image showing a more laterally-extended foraminotomy with inclusion of the medial half of corresponding facets' joint into bone removal. *Right upper/lower*: axial CT slices showing the level of nerve root compression, before (*upper*) and after (*lower*) surgery

adjunct for a more detailed and accurate confirmation of adequate radicular decompression.

We did not find any substantial differences between the endoscopic and the open-procedure patients' groups in terms of amount of bone removal, clinical outcome, length of hospital stay or duration of post-operative neck pain, as advised by other authors [3].

Conclusion

The described "disc preserving" procedure in patients affected by cervical radiculopathies due to lateral disc herniation or foraminal stenosis had successful results in all but two of the treated patients.

Before this prospective study was started, those patients would have been treated with the anterior approach, which in our institution was currently utilized for all patients affected by herniated cervical disc.

The following remarks are stressed:

1. The selected cohort of patients was successfully treated without any kind of prothesis usually employed to stabilize the cervical spine or substitute the disc when the anterior approach is chosen.
2. The procedure was riskless and cost effective versus the anterior approach.
3. The long-term successful outcome and the recovery from radicular motor and sensory deficits was confirmed both in endoscopic and microsurgical procedures without any major difference regarding hospital stay and postoperative course.
4. The postoperative 3D reconstruction of CT slices is useful to check that the correct procedure was done.

So we stress the role of minimally invasive cervical foraminotomy in the management of degenerative disc disease of the cervical spine if a careful selection of patients is performed fulfilling the criteria of this reported study.

Finally it is important to stress that a correct indication to such a treatment cannot abstract from exclusion criteria, such as symptomatic posterior instability at the affected level (in which case conservative measures or spinal instrumentation could be valid and time-proved first-line treatments) and clear signs of myelopathy, when anterior approach is preferred.

In conclusion, posterior cervical foraminotomy, in our opinion, is a safe and effective modality for the surgical treatment of cervical radiculopathies where intraforaminal compression constitutes the main cause of pathology and when conservative treatments fail to relieve symptoms [6]. Congruity between clinic and neuroradiological findings is mandatory for choosing such an approach.

Conflict of interest statement We declare that we have no conflict of interest.

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