Cervical transpedicular fixation aided by biplanar fluoroscopy

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ABSTRACT

Purpose. To evaluate the accuracy of fluoroscopy-assisted cervical transpedicular fixation in different pathologies.

Methods. 28 men and 17 women aged 34 to 65 (mean, 41) years underwent 210 one-stage cervical transpedicular fixations. The indications were trauma (n=35), degenerative disease leading to cervical spondylotic myelopathy (n=4), tumours (n=4), and Pott’s disease (n=2). Regarding the 35 trauma patients, fractures were at C5–C6 (n=22), C4–C5 (n=8), and C3–C5 (n=5); 16 of them had dislocated vertebrae, of whom 13 had cervical disc herniation. Two of the patients with degenerative disease underwent additional laminectomy. Both anterior and posterior surgeries were performed for the 2 of the patients with tumours; all other patients underwent posterior surgery only. The length, diameters, and frontal, sagittal, and longitudinal angles of all pedicle screws were calculated. The dominant vertebral artery was detected using Doppler ultrasonography. Biplanar fluoroscopy was also used. Postoperatively, patients were allowed to mobilise at day 1; a collar was not used. The position of the pedicle screws was graded.

Results. The mean operating time was 105 (range, 90–155) minutes. The mean follow-up period was 26 (range, 17–34) months. Of the 210 pedicles fixed, 192 (91%) were at the correct screw position (grade I), 16 (8%) were at an acceptable position (grade II), and 2 (1%) were completely perforated but without morbidity (grade III). The overall perforation rate was 9%. There were no neurovascular injuries or instrumentation-associated complications (failure of implant components, screw loosening, or lucent zone formation around the pedicle screws). The fusion rate was 100%.

Conclusion. Cervical transpedicular fixation provides strong stabilisation. With the aid of biplanar fluoroscopy, the risk of pedicle perforation was about 8%, but no neurovascular injury was ensued.

Key words: bone screws; cervical vertebrae; fracture fixation

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INTRODUCTION

The lamina is not used as a stabilising anchor in fixation with pedicle screws or lateral mass screws. Fixation using pedicle screws provides more stability than lateral mass screws.\(^1\,^2\) Cervical transpedicular fixation has been used for treating degenerative disorders\(^3\) and trauma.\(^4\,^5\) To enhance its safety and accuracy, the use of image-guided systems is recommended.\(^6\,^7\,^8\,^9\) Nonetheless, pedicle perforation cannot be completely avoided in any technique,\(^10\,^11\,^12\,^13\) even using stereotactic\(^15\) or computed tomographic (CT) guidance. We evaluated the accuracy of fluoroscopy-assisted cervical transpedicular fixation in different pathologies.

MATERIALS AND METHODS

Between March 2006 and December 2009, 28 men and 17 women aged 34 to 65 (mean, 41) years underwent 210 one-stage cervical transpedicular fixations. The indications were trauma (n=35), degenerative disease leading to cervical spondylotic myelopathy (n=4), tumours (metastasis from renal clear cell carcinomas [n=2] and lung carcinomas [n=2]), and Pott’s disease (n=2). Regarding the 35 trauma patients, fractures were at C5–C6 (n=22), C4–C5 (n=8), and C3–C5 (n=5); 16 of them had dislocated vertebrae, of whom 13 had cervical disc herniation. Two of the patients with degenerative disease underwent additional laminectomy. Both anterior and posterior surgeries were performed for the 2 patients with metastatic clear cell carcinoma; all other patients underwent posterior surgery only.

Preoperative evaluation was performed using magnetic resonance imaging so as to calculate the length, diameters, and frontal, sagittal, and longitudinal angles of all pedicle screws. The dominant vertebral artery was detected using Doppler ultrasonography. Biplanar fluoroscopy was also used. For the first 18 patients, the C2 vertebra was not included, and a mini-laminotomy technique was used, with the spinal canal visualised during fixation. The patient was placed in a natural sitting position. Paravertebral muscles were stripped through a classical midline incision. The affected facet joint surfaces were decorticated to thoroughly clean up the capsule. Other facet capsules were maintained. The first screw was inserted in the side with the non-dominant vertebral artery; the second screw was

Figure 1  Postoperative computed tomographic scans demonstrating (a) grade I accurate placement of pedicle screws in different levels, (b) grade IIb malposition of the left C5 pedicle screw, and (c) grade III malposition of the right pedicle screw with contact with neurovascular structures.
then inserted in the dominant side. This enabled observing the position of the screws inside the spinal canal in cases of laminectomy or laminoplasty. The entry points for C2 were the superior edge of the C2 lamina. A keyhole was opened prior to tapping/drilling. A high-speed burr was oriented at 40° toward the cranial, and 20° toward the medial side. If C1 was also fused, the screw was oriented to reach the lateral mass of the atlas. The entry point of the pedicles for C3 to C7 was 2 mm lateral to the superior articular process midpoint. In the sagittal plane, it was angled nearly 10° at C3, whereas it was neutral or angled 2° at C7. The mean medial orientation angle of the pedicle was 45°. Under biplanar fluoroscopy, iliac bone grafts were placed at the decorticated areas. In trauma patients with dislocated vertebrae, the facet was reduced after the pedicle screws were placed using a bypass technique. Postoperatively, patients were allowed to mobilise at day 1; a collar was not used.

The position of the pedicle screws was inspected using axial computed tomography (2 mm slices). Grade I was defined as screws centering in the pedicle, with only minor plastic deformation of the pedicle cortex at most. Grade IIa was defined as screw threads (or <25% of the screw cross-section) penetrating the cortex, but no contact of the screw with the spinal cord, nerve root or vertebral artery. Grade IIb was defined as >25% of the screw cross-section penetrating the cortex, but no contact with neurovascular structures. Grade III was defined as screw positioning as in grade II, but with contact with neurovascular structures (Fig. 1).

RESULTS

The mean operating time was 105 (range, 90–155) minutes. The mean amount of blood loss was 140 cc; no patient received a transfusion. The mean lengths of the screws were 38.8 mm for C2, 31.4 mm for C3 to C7; the mean screw thicknesses was 3.0 mm (Table). The mean follow-up period was 26 (range, 17–34) months.

Of the 210 pedicles fixed, 192 (91%) were at the correct screw position (grade I), 16 (8%) were at an acceptable position (grade II), and 2 (1%) were completely perforated but without morbidity (grade III), in which the pedicle screws were in the vertebral foramen. The overall perforation rate was 9%. There were no neurovascular injuries or instrumentation-associated complications (failure of implant components, screw loosening, or lucent zone formation around the pedicle screws). The fusion rate was 100%. Single distance cervical transpedicular fixation was applied in 34 patients, double distance in 10, and triple distance in one.

In the 35 trauma patients, the mean anterior translation of the cranial vertebra of the injured segments improved to 0.1 (range, 0–2) mm from 9 (range, 4–16) mm. In 9 patients, the mean kyphotic deformity at the affected segments was corrected to 1.2° lordosis immediately after surgery and 0.8° lordosis at the final follow-up from 23° (range, 16°–43°).

DISCUSSION

The lamina is used as a stabilising anchor for various posterior fixation techniques such as spinous process wiring, the triple-wire technique, and sublaminar wiring. These techniques enable simultaneous decompression and stabilisation for patients with previous cervical laminectomy. Nonetheless,

<table>
<thead>
<tr>
<th>Level</th>
<th>Mean screw length (mm)</th>
<th>Mean screw thickness (mm)</th>
<th>Mean±SD sagittal angle</th>
<th>Mean±SD axial angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>C3</td>
<td>30</td>
<td>3</td>
<td>10°±2.1°</td>
<td>46°±3°</td>
</tr>
<tr>
<td>C4</td>
<td>32</td>
<td>3</td>
<td>8.2°±1.9°</td>
<td>448°±2.9°</td>
</tr>
<tr>
<td>C5</td>
<td>32</td>
<td>3</td>
<td>4.4°±1.1°</td>
<td>437°±3.1°</td>
</tr>
<tr>
<td>C6</td>
<td>32</td>
<td>3</td>
<td>2.1°±0.4°</td>
<td>39º±4.2º</td>
</tr>
<tr>
<td>C7</td>
<td>32</td>
<td>3</td>
<td>0°</td>
<td>405°±3.5°</td>
</tr>
</tbody>
</table>

Table Pedicle screw length, diameter, and application angles

Figure 2 Postoperative computed tomographic scan with contrast enhancement showing both vertebral arteries in the foramen magnum.
a rigid external support such as a halo vest becomes necessary. The use of rods as longitudinal connectors may provide some stabilising effect, but not sufficient to preclude the need for external support. Posterior devices are superior to anterior devices for fixation of posterior instability after laminectomy. Anterior approaches do not provide sufficient correction for post-laminectomy cervical spine kyphosis. Of all fixation devices, only the pedicle screw system provides adequate stability in a 3-column injury model. Pedicle screws have greater resistance to pullout than lateral mass screws. In addition, pedicle screws provide adequate stability for cervical lordosis, as the gravity axis passes through the reconstructed posterior structures. Therefore, cervical transpedicular fixation may obviate the need for the anterior surgery in patients with metastatic vertebral tumours who might otherwise require combined (anterior and posterior) surgery.

After fixation using lateral mass screws, pseudoarthrosis and loss of kyphosis correction (secondary to screw loosening) have been reported. Fixation using pedicle screws provides a more rigid anchor than fixation with lateral mass screws. In our study, there was no pseudoarthrosis or screw loosening. Fixation with pedicle screws is particularly useful for cervical spine stabilisation, as it enables application of a distraction force to the injured cervical spinal segment. In our study, there was no discontinuity of the posterior vertebral body (on magnetic resonance imaging), indicating that ligamentous continuity of the injured disc level was preserved, and no patient experienced postoperative neurological deterioration. Cervical transpedicular fixation can safely reduce disc herniation and stabilise the cervical spine in one stage, precluding the need for anterior decompression.

Comparing 3 different techniques for pedicle screw placement in cadaveric cervical spines, 65% of pedicle screws were breached critically when only morphological data were used for guidance. The rates were 40% when suplemental visual and tactile cues were provided by minilaminotomy, and 11% when a computer-assisted guidance system was used. The rate was 18% when frameless stereotactic guidance was used, and down to 12% when a fluoroscopically assisted technique of probing and tapping of the pedicle was used. The accuracy was 92% using image-guided drilling of 2.5 mm holes in the C3 and C4 pedicles in cadavers. In our study, the cortical breach rate was 9% (including a critical breach rate of 1%), which was similar to that in other study. Using intra-operative image-guided or stereotactic guidance may improve accuracy and reduce the risk of neurovascular injury, especially in the cervical pedicles.

No patient dying from vascular complications secondary to cervical transpedicular fixation has been reported. Nine patients had lateral perforation of the foramen by a screw but sustained no vertebral artery injury. The vertebral artery does not occupy the entire foramen (Fig. 2); careful drilling and tapping of screws may displace the vertebral artery without damaging it. The risk of injury may not be as high, although devastating sequelae may occur. This low rate of vertebral artery injury may be due to: (1) the artery does not occupy the entire transverse foramen space; (2) upon initial contact stimulation, nerves and vessels might spontaneously escape from the broken pedicle or screw; (3) even if the medial pedicle cortex is generally thicker, screw perforation more often occurs on the lateral side; and (4) the artery is very pulsatile and mobile within the transverse foramen space.

The nerve roots are located in the inferior half of the disc within the cervical foramen. In our study, there was no cranial or caudal violation of the pedicle, as cervical pedicles have an oval shape with a greater height than width at all levels. Neural injury or damage is rare (about 1%), and can be reduced with minilaminoforaminotomy to enable exploration in the lateral spinal canal on the same side.

REFERENCES


