Percutaneous anterior transarticular screw fixation for atlantoaxial instability

A CASE SERIES

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We reviewed the outcome of a retrospective case series of eight patients with atlantoaxial instability who had been treated by percutaneous anterior transarticular screw fixation and grafting under image-intensifier guidance between December 2005 and June 2008.

The mean follow-up was 19 months (8 to 27). All eight patients had a solid C1-2 fusion. There were no breakages or displacement of screws. All the patients with pre-operative neck pain had immediate relief from their symptoms or considerable improvement. There were no major complications. Our preliminary clinical results suggest that percutaneous anterior transarticular screw fixation is technically feasible, safe, useful and minimally invasive when using the appropriate instruments allied to intra-operative image intensification, and by selecting the correct puncture point, angle and depth of insertion.

Atlantoaxial instability resulting from dislocation, the nonunion of an odontoid fracture, or an odontoideum, is usually treated by fusion of C1-2 through a posterior approach.1-6 This can cause considerable damage to the extensor muscles and bleeding. Transarticular screw fixation from the front can achieve comparable biomechanical stability to that performed from behind,7,8 and, when carried out using a percutaneous technique, should be less injurious and cause less bleeding.

We have previously described our experience of managing odontoid fractures using a percutaneous anterior transarticular screw-fixation technique.9 We now report the results of using a similar technique in eight patients with atlantoaxial instability.

Patients and Methods

Between December 2005 and June 2008, we treated eight patients (five men, three women) with atlantoaxial instability by percutaneous anterior transarticular fixation under image-intensification. Their mean age was 41 years (29 to 56). Radiographs of the cervical spine comprising anteroposterior (AP), lateral and open-mouth views, and a CT scan of the atlantoaxial motion segment were obtained pre-operatively. We received permission from the ethics committee of our hospital as this represented an extension of our previous work on the management of odontoid fractures using a similar technique.9

All the clinical and radiological data (Table I) were collected and reviewed retrospectively.

The instruments used to introduce the cannulated screws percutaneously are shown in Figure 1.

Operative technique. After fibre-optic intubation the patient is placed supine on the operating table and has traction of 2 kg applied to Gardner-Wells calipers. A radiolucent dental pad is placed inside the mouth to facilitate an open-mouth view. The lateral masses of the atlas, the vertebral body of the axis and the odontoid process are identified on AP and lateral image-intensification.

In order to fuse the left side an initial incision of 5 mm is made at the level of the C4-5 disc space, medial to the right sternocleidomastoid muscle. If necessary, this is extended to a maximum of 10 mm. The platysma and the fascia of the sternocleidomastoid are dissected along its medial border. The anterior border of the spinal column is approached by blunt dissection with artery forceps. Then, under image intensification a 3.0 mm guide is inserted down to the anterior border of C2. This is used to develop the avascular plane around the vertebral body. Only by doing this can the carotid sheath be displaced laterally enough to avoid damage.

The tip of the guide is placed at the inferior border of C2 between 5 mm and 10 mm from the vertebral body. This is checked for correct position by image intensification. The position of the guide is then confirmed by palpation of the transverse process and the odontoid process. The correct puncture point is then marked, and a 3.0 mm cannulated guide is drilled up to the level of the C2 transverse process under image-intensification guidance. The 3.0 mm guide is removed and a 4.5 mm cannulated guide is inserted, with the tip placed at the inferior border of C2, under image-intensification guidance. The direction and depth of insertion is confirmed by palpation of the transverse process and the odontoid process. The final cannulated guide is then used to place the screw. The tip of the screw is placed at the inferior border of C2, with an angle of 15 degrees to the tangential plane of the atlantoaxial joint.
the mid-line as seen on an AP image. Next, a 1.2 mm Kirschner (K-) wire (Zhejiang Guangci Medical Equip-ments Ltd., Zhejiang, China) with a sharp tip is passed through the guide to the entry point and advanced through the centre of the lateral mass of C1 with a power drill (Fig. 2). The drill is aimed towards the centre of the lateral mass at an angle of 20° to 30° to the mid-line on the AP view (Fig. 3a, angle A, Fig 4a) and 20° to 28° to the vertical on the lateral view (Fig. 3b, angle E, Fig. 4b). These angles were derived from the CT data from 40 patients treated at our hospital. Once the K-wire is positioned satisfactorily, its depth of penetration is determined by comparison with a second identical K-wire inserted alongside it. The screw chosen is of the same length as the depth of penetration. Next, a 6.0 mm guide is inserted over the 3.0 mm guide and a protective sleeve (7 mm outer diameter, 6.1 mm inner diameter) inserted over the 6.0 mm guide. The two guides are then removed leaving the K-wire in place. A recess for the screw head is fashioned with a cannulated drill bit taking care to avoid advancing the K-wire further while drilling. A 3.5 mm partially-threaded self-tapping cannulated screw is then placed over the K-wire, inside the protective tube, and advanced into the tip of the lateral mass (Fig. 4c). The K-wire is removed once the screw is well positioned. Next, a subperiosteal dissection is carried out with an electric scalpel or curettage to expose the bony structure of the C1-2 articular process. Cancellous bone is obtained from the anterior superior iliac spine through a 15 mm incision and grafted to the front of the C1-2 articular process through the protective sleeve. Only at this stage is the protective sleeve removed. The procedure is then repeated on the opposite side.

<table>
<thead>
<tr>
<th>Case</th>
<th>Age (yrs)</th>
<th>Gender</th>
<th>Cause of disease</th>
<th>Symptoms</th>
<th>Clinical diagnosis</th>
<th>Follow-up (mths)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>56</td>
<td>M</td>
<td>Motor-vehicle accident</td>
<td>Neck pain</td>
<td>Os odontoideum combined with atlantoaxial dislocation</td>
<td>17</td>
</tr>
<tr>
<td>2</td>
<td>32</td>
<td>F</td>
<td>Fall</td>
<td>Neck pain and numbness of the hands</td>
<td>Os odontoideum combined with atlantoaxial dislocation</td>
<td>22</td>
</tr>
<tr>
<td>3</td>
<td>42</td>
<td>M</td>
<td>Pedestrian-struck accident</td>
<td>Neck pain</td>
<td>Os odontoideum combined with atlantoaxial dislocation</td>
<td>27</td>
</tr>
<tr>
<td>4</td>
<td>41</td>
<td>M</td>
<td>Motor-vehicle accident</td>
<td>Neck pain</td>
<td>Nonunion of odontoid fracture type II</td>
<td>8</td>
</tr>
<tr>
<td>5</td>
<td>29</td>
<td>F</td>
<td>Fall</td>
<td>Neck pain</td>
<td>Nonunion of odontoid fracture type II</td>
<td>24</td>
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<tr>
<td>6</td>
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<td>Neck pain</td>
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<td>7</td>
<td>53</td>
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<td>Motor-vehicle accident</td>
<td>Neck pain and numbness of the hands</td>
<td>Atlantoaxial dislocation</td>
<td>26</td>
</tr>
<tr>
<td>8</td>
<td>33</td>
<td>M</td>
<td>Motor-vehicle accident</td>
<td>Neck pain</td>
<td>Atlantoaxial dislocation</td>
<td>16</td>
</tr>
</tbody>
</table>
Haemostasis is secured and closure completed in layers. Cefuroxime given routinely for 48-hours post-operatively. The patients are mobilised in a soft collar or cervical brace after three to five days. Their orthoses are removed after 12 weeks.

Results
Successful positioning of the anterior transarticular screw and immediate spinal stabilisation were achieved in all the patients. The mean operating time was 116 minutes (90 to 132). The mean intra-operative blood loss was 25 ml (6 to 44). There were no major complications.

AP and lateral radiographs were taken after 12 weeks. CT was sometimes necessary to assess union (Fig. 5). The mean follow-up was 19 months (8 to 27). No breakage or cutting-out of screws occurred. Solid union was seen in all patients, and generally took place between the lateral masses of the atlas and anterior body of the axis. All patients had pre-operative neck pain or numbness of the hands. Six had immediate relief from their symptoms and two had some residual numbness of the hands. All were asymptomatic at the final follow-up.
Anterior transarticular screw fixation for patients with atlantoaxial instability after an odontoid fracture was first reported by Barbour in 1971. This has been shown to achieve a similar degree of biomechanical stability as percutaneous transarticular screw fixation and subsequent reports have shown a high rate of clinical success. These open procedures require extensive dissection and care has to be taken to avoid injuring the adjacent nerves and blood vessels. The wounds also need to be drained post-operatively.

Minimally-invasive techniques are becoming more widely used throughout surgery, not least for fixation of the upper cervical spine. In 1999 Kazan et al first reported a percutaneous technique for closed anterior fixation of an odontoid fracture. Börn et al described the use of percutaneous cannulated screws from a posterior approach to fuse the C1-2 level in patient with atlantoaxial instability. El Saghir et al used a limited exposure for posterior C1-2 fusion with percutaneous transarticular fixation. This reduced the exposure and the surgical trauma to the cervical segments, but had a high rate of fusion (98%). Schmidt et al compared the operating time, screw angulation and blood loss between the open and percutaneous posterior atlantoaxial techniques, and found that the percutaneous technique reduced the operating time and blood loss and was at least as successful in achieving satisfactory screw placement.

Our previous cadaver study of 13 cases has also demonstrated the safety of this technique. At the level of the C4-5 disc, the percutaneous puncture cannula passes below the superior thyroid artery, medial to the right sternocleidomastoid muscle, lateral to the oesophagus and larynx and above the middle thyroid veins. We have also reported our experience with the percutaneous anterior fixation technique for odontoid fracture, and our results indicate that it is feasible, safe, useful and minimally invasive. However, there are few reports of the use of percutaneous anterior transarticular screw fixation for the treatment of atlantoaxial instability. To the best of our knowledge, this is the first...
Our specially-designed instrumentation allows anterior transarticular screw fixation percutaneously and has several advantages. It requires less dissection and exposure of normal tissue which gives decreased blood loss, less postoperative pain and a quicker recovery. We have had no significant complications with this approach.

As with the open procedure, we believe that the indications for this technique include an odontoid fracture with an unstable Jefferson fracture,\(^{22}\) a comminuted or oblique type-II odontoid fracture, nonunion of an odontoid fracture, a pathological fracture of the odontoid, a traumatic atlantoaxial subluxation with rupture of the ligamentum transversum, subluxation or dislocation of the atlantoaxial joint caused by rheumatoid disease, hypoplasia of the odontoid process or congenital absence of the posterior arch of the atlas. Some physical characteristics such as a short neck, considerable cervical kyphosis or concomitant thoracic kyphosis may interfere with the fixation of the screws.\(^{23}\) Clearly, this technique is not appropriate for a patient with an irreducible atlantoaxial dislocation, which will usually need an extensive release during surgery. It is also important to note that previous surgery to the front of the neck is not a contra-indication for an open anterior transarticular screw fixation, but is an absolute contra-indication for the percutaneous procedure.

Potential complications of the percutaneous technique include a puncture injury to the carotid artery. Should this occur, firm compression should be applied for several minutes and, only when there is no further bleeding, should the procedure be continued.

Another potential complication is injury to the oesophagus. In order to prevent this, before insertion of the K-wire, the guide should be moved up and down on the medial side of the carotid sheath to separate the oesophagus from its surrounding structures. Other possible complications are injury to the vertebral artery or spinal cord. These are usually damaged by misdirected screws or K-wires. Careful monitoring with image intensification of the direction of drilling and screw insertion may help to prevent these complications.

Fortunately, we have not encountered these problems to date. From our early clinical experience, we find that this technique is feasible, safe, useful and minimally invasive.

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**References**