ORIGINAL ARTICLE

Management of acute combination atlas—axis fractures with percutaneous triple anterior screw fixation in elderly patients


Department of Orthopaedic Surgery, Second Affiliated Hospital of Wenzhou Medical College, 109#, XueYuan Western Road, WenZhou, 325027 ZheJiang, China

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KEYWORDS
Percutaneous; ORIF; Minimally invasive; Atlanto-axial fracture; Upper cervical fracture; Elderly

Summary

Introduction: Patients with combined C1-2 fractures were often treated by posterior arthrodesis. However, elderly patients with multiple injuries (such as brain injury), the large surgical trauma of posterior arthrodesis will increase the risk of perioperative mortality. A minimally invasive technique may be better for them, and decrease the risk of perioperative mortality.

Materials and methods: Seven patients with combined C1-2 fractures underwent percutaneous anterior odontoid screw and anterior C1-2 transarticular screws (percutaneous triple anterior screws fixation). The surgical technique of percutaneous triple anterior screws fixation is described.

Results: The operation performed on all patients successfully without technical difficulties, and no intra-operative surgery-related complications such as vertebral artery, nerve injury and soft tissue complications occurred. No pullout, loosening, or breakage of internal screws was observed. C1/2 stable was found in all cases and radiographic union achieved in all odontoid fractures.

Conclusion: Using the appropriate instruments allied to intra-operative image-intensification, we suggest that percutaneous triple anterior screw fixation is reliable, effective and minimally invasive procedure for elderly and brain injured patients suffering of combined atlas—axis fractures.

Level of evidence: Level IV. Retrospective study.

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* Corresponding author. Tel.: +86 0577 88002814.
E-mail addresses: aiminwu@163.com (A.M. Wu), knightman@yeah.net (X.Y. Wang), zjspinecenter@126.com (Y.L. Chi), spinehuazixu@yeah.net (H.Z. Xu), sj88wz@163.com (W. Weng), 514956340@qq.com (Q.S. Huang), wenfeini@yeah.net (W.F. Ni).
Introduction

Acute combination fractures of atlas and axis represent nearly 3% of cervical spine injuries and 12% of upper cervical fractures [1–3], and they frequently occur in elderly populations. Compared to isolated atlas or axis fractures, they are higher incidence of neurological impairment and mortality [4–6], requiring early surgical stabilization. Elderly patients are at high risk for nonunion and age-related complications, especially those associated with brain injury and conscious disturbance, cannot tolerate long-term skull traction or Halo-Vest fixation, early surgical intervention is recommended.

There have been four reports about the technique of triple anterior screw fixation [1,7–9], all of them are case reports. To the best of our knowledge, no report inserts the screw percutaneously. We describe the techniques and report the successful results obtained from percutaneous triple anterior screw fixation in seven elderly and multiple injury (main are brain injury) patients with acute combination atlas–axis fractures.

Materials and methods

Between March 2006 to February 2011, seven elderly patients with combined C1/2 fractures underwent percutaneous triple anterior screw fixation in our department. Six of them were men and one was woman with the average age of 72.4 years old (range: 64–84 years). Fracture types including two Jefferson/Type II odontoid, two anterior ring/Type II odontoid, two anterior and posterior ring/Type II odontoid, and one anterior and posterior ring + lateral mass/Type III odontoid. Five of them with brain injury in varying levels of conscious disturbance, and two cases of hypertension, one case of diabetes, two cases of old cerebral infarction. The clinical and radiological data of them are showed in Table 1.

Anterioposterior (AP), lateral and open-mouth views were obtained preoperatively, CT scans/3-dimension CT scans and MR images were obtained preoperatively. Iliac autogenous bone was grafted to the front of the C1-2 articular process and the space between the basal part of odontoid and the anterior tubercle of C1 in four cases.

Surgical techniques

After fiber-optic nasotracheal intubation, the patient is positioned supine on the operating table with the head and neck stabilized and traction of 2–3 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 atlas, the vertebral body of the axis and the odontoid process are identified on high-resolution AP and lateral views.

An initial 5–10 mm incision is made at approximately the level of the C4-5 disc space, medial to the right sternocleidomastoid muscle. The anterior border of the spinal column is approached by blunt dissection with artery forceps along the medial border of sternocleidomastoid muscle. A guide tube with 5.8 mm outer diameter and 1.2 mm inner diameter is inserted to the anterior border of C2, and blunt dissection is performed slightly within the avascular plane by using the guide tube under intra-operative image intensification.

Anterior odontoid screw fixation procedure [10]

Situate the tip of the guide tube at the anteroinferior border of C2, a 1.2 mm K-wire is then inserted inside the guide tube. Locate K-wire in the middle of the AP view, and parallel with the axis line of the odontoid process. If the trajectory deemed appropriate, then the K-wire is advanced into the odontoid distal fragment with a power-drill. After the K-wire is positioned satisfactorily, the depth of penetration is determined by comparison with a second identical K-wire inserted alongside it. Along the guide tube, a protective tube with 7.0 mm outer diameter and 6.0 mm inner diameter is advanced, and the guide tube is taken out subsequently. A recess for the screw is fashioned with a cannulated drill bit sliding over the K-wire. Care must be taken to avoid advancing the K-wire further as the drilling is performed. A 3.5 mm self-tapping cannulated screw is inserted over the K-wire, inside the protection tube, into the odontoid process.

Anterior transarticular screw fixation procedure

To insert the left screw, situate the tip of the guide tube at the anteroinferior border of C2, about 5 mm left from the mid-line under AP image. K-wire with 1.2 mm diameter is then inserted inside the guide tube. If the angle is deemed about 20° to 30° to the mid-line on the AP view and 20° to 28° to the vertical on the lateral view [11], the K-wire is advanced into the entry point and through the centre of the lateral mass of C1 with a power drill. The method to determine the depth of penetration is the same as anterior odontoid screw fixation procedure above. Along the guide tube, a protective tube with 7.0 mm outer diameter and 6.0 mm inner diameter is advanced, and the guide tube is taken out subsequently. A recess for the screw is fashioned with a cannulated drill bit sliding over the K-wire. A 3.5 mm or 4.0 mm partially threaded self-tapping cannulated screw is inserted over the K-wire, inside the protection tube, and advanced into the tip of the lateral mass, then remove the K-wire if the screw is well-positioned. A similar procedure is then repeated on the opposite side.

After the triple anterior screw successful fixed, the tip of protective tube is placed at the front of the C1/2 articular process. The bony structure of the C1/2 articular process is exposed by an electric scalpel or curette, and cancellous bone obtained from the anterior superior iliac is grafted to the front of the C1/2 articular process as well as to the space between the basal part of odontoid and the anterior tubercle of C1 through the protective tube. Only at this stage is the protective tube removed.

The wound is checked for hemostasis and closure completed in layers. Prophylactic antibiotic is given intravenously post-operatively. Patients are immobilized in a Philadelphia collar for 3 months post-operatively.
Table 1 The details of seven patients of whom underwent percutaneous triple anterior screw fixation.

<table>
<thead>
<tr>
<th>Case</th>
<th>Gender</th>
<th>Age (yrs)</th>
<th>Fracture combination</th>
<th>Main associated injury</th>
<th>Pre-operative consciousness</th>
<th>Follow-up (mons)</th>
<th>Atlantoaxial joint</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M</td>
<td>68</td>
<td>Anterior ring + Type II</td>
<td>Extradural hematoma Hemopneumothorax</td>
<td>Coma</td>
<td>13</td>
<td>Stable</td>
</tr>
<tr>
<td>2</td>
<td>M</td>
<td>67</td>
<td>Anterior/posterior ring + Type II</td>
<td>Brain contusion</td>
<td>Coma</td>
<td>12</td>
<td>Stable</td>
</tr>
<tr>
<td>3</td>
<td>F</td>
<td>70</td>
<td>Anterior/posterior ring + Type II</td>
<td>Intracerebral hematoma</td>
<td>Coma</td>
<td>12</td>
<td>Stable</td>
</tr>
<tr>
<td>4</td>
<td>M</td>
<td>84</td>
<td>Anterior ring + Type II</td>
<td>Traumatic wet lung</td>
<td>Delirium</td>
<td>5</td>
<td>Stable</td>
</tr>
<tr>
<td>5</td>
<td>M</td>
<td>82</td>
<td>Anterior/posterior ring/lateral mass + Type III odontoid</td>
<td>Intracerebral hematoma</td>
<td>Lethargy</td>
<td>22</td>
<td>Stable</td>
</tr>
<tr>
<td>6</td>
<td>M</td>
<td>72</td>
<td>Jefferson’s + Type II odontoid</td>
<td>Brain contusion</td>
<td>Delirium</td>
<td>18</td>
<td>Stable</td>
</tr>
<tr>
<td>7</td>
<td>M</td>
<td>64</td>
<td>Jefferson’s + Type II odontoid</td>
<td>Facial contusion</td>
<td>Conscious</td>
<td>10</td>
<td>Stable</td>
</tr>
</tbody>
</table>

Results

The operation successful performed on all patients, the duration of operation range from 36 to 78 minutes (averaged 56 minutes). Four patients given iliac autogenous bone graft had blood loss of nearly 50 mL, others had less than 10 mL which could be negligible. No intra-operative surgery-related complications such as vertebral artery, nerve injury and soft tissue complications occurred. The tail of screws were in the level of C2/3 intervertebral disc in two patients, no dysphagia and no discomfort when pushing the trachea. The mean follow-up period was 13.1 months (5 to 22 months). No pullout, loosening, or breakage of internal screws was observed during the follow-up. C1/2 stable was found in all cases and radiographic union achieved in all odontoid fractures. The neck activities of flexion and extension were no significant limited while the rotation was reduced about 40° at last follow-up, and two patients said they had a mild pain when neck rotating, other five patients could rotat their neck with painfree.

Typical case

This is a 68-year-old man. Oubnabiliation after vehicle accident, he was diagnosed as bilateral extradural hematoma by CT scans in another hospital, and underwent intracranial decompression surgery before transferred to our hospital. Coma was increased when the skull traction applied on him, therefore, the skull traction was removed immediately. The skull flap displacement was observed on emergency CT scan at this time. The preoperative CT/3-D CT scan showed type II odontoid fracture (Fig. 1a) and atlas fracture (Fig. 1b). We treated him with percutaneous triple anterior screw fixation under intra-operative image-intensification (Fig. 1c), the post-operative AP and lateral views (Fig. 1d/e) and the film of 13 months (Fig. 1f) after operation showed atlantoaxial joint stability, without screws loosening or breakage.

Discussion

Acute combination fractures of atlas and axis usually occurred in elderly patients. Vehicle accident and fall are the most common causes [7,8,12,13]. In this study, six cases are injured by vehicle accidents, and one case caused by fall. The stability of atlantoaxial structure is provided mainly by ligaments and bone support. Osteoporosis is considered as the main reason for the tendency to fracture of elderly population [14,15]. The most common association is an atlas fracture combined with type II odontoid fracture [1,3,7—9], and six patients in this study are type II odontoid fracture. The mechanism seems to be a sudden axial load inducing atlas fracture [7].

The Halo-Vest is well known as conservative treatments for upper cervical spine fractures, but the risk of nonunion of the type II odontoid fracture treated by conservative treatments reached about 50% [16,17], and higher nonunion rates in elderly patients, moreover, a mortality rate of 26% to 47% in elderly patients has been reported, perhaps as a result of respiratory-related complications due to prolonged external immobilization [18]. Additional, multiple injuries (such as brain injury) are common situation in patients after vehicle accident or fall, brain injury patients usually in varying levels of conscious disturbance. These patients cannot tolerate conservative treatments such as Halo-Vest and long-term skull traction, early surgical stabilization is recommended for them. If the posterior arthodesis procedure is preformed, the large surgical trauma will increase the risk of perioperative mortality, as case four in Ben Aicha’s report [3]; an 87-year-old patient, combination atlas—axis fractures with cranial injury, for the short neck and prominent thorax, anterior surgery could not be performed. At last, the patient died at 2 months after posterior surgery. It is a challenge for surgeons to manage these patients. We need a technique that could reach immediately stabilization of C1/2 at the same time with minimal trauma, and decrease perioperative mortality risk maximum.

There are four case reports about the successful attained of the triple anterior screw fixation treat for combination fractures of atlas and axis [1,7—9]. The details of them are showed in Table 2. None of them insert the screw percutaneously, the surgical trauma of above four open-procedure still need a longer recovery postoperatively. We extend our previous experience of percutaneous anterior odontoid screw fixation [10] into percutaneous triple anterior screw fixation and performed this technique on seven patients.
Figure 1  a, b: the preoperative CT/3-D CT scan showed type II odontoid fracture and atlas fracture; c: percutaneous triple anterior screw fixation procedure under intra-operative image-intensification; d, e: the post-operative AP and lateral views showed atlantoaxial joint stability; f: atlantoaxial joint stability, without screws loosening or breakage in view of 13 months after operation.
Compared to traditional open surgery, our percutaneous technique has several advantages. There is a virtual space anterior of cervical spine, the target site could direct access by blunt dissection using artery foreceps or finger with an initial incision only 5–10 mm length. Less dissection and exposure of normal tissue of this technique gives less blood loss, less postoperative pain, a quicker recovery and lower ratio of post-operative infection. The operation is performed at the area of pars laryngea pharyngis inside of protective tube, the esophagus and trachea is safe enough. Elderly patients with multiple injuries and basic diseases (such as diabetes, heart failure, cerebrovascular disease, hypertension) poorly tolerated to traditional open surgery. In this study, two cases of hypertension, one case of diabetes, two cases of old cerebral infarction. Although aged with basic diseases, multiple injuries and conscious disturbance of them, no intra-operative death occurred and all of them have a quicker recovery after this percutaneous procedure. We suggest that percutaneous technique is a simple, fast, safe, reliable and suitable method for them. Radiation exposure may be a concern for surgeons. Due to traditional open procedures is operated under the C-arm X-ray, radiation exposure of percutaneous procedure is only small more than open procedure.

With the previously literatures [1,7–9] and our clinical experience, we believe that the indications for this technique including following:

- atlas fracture with transverse ligament rupture + odontoid type II or shallow type III fracture of elderly patients. Atlantoaxial instability when transverse ligament rupture, and surgical fixation is recommended for these patients;
- elderly patients suffer atlas fracture + type II or shallow type III odontoid fracture, Associated with brain injury and conscious disturbance. They cannot tolerate long-term skull traction or Halo-Vest, sometimes the skull part where place for halo-Vest or skull traction screw is removed after intracranial decompression surgery. These patients underwent percutaneous triple screw fixation are easier for nursing care and have a quicker recovery;
- elderly patients with atlas fracture + type II or shallow type III odontoid fracture, associated with multiple injuries, especially thoracic injury. Respiratory-related complications is common occurred on them with prolonged external immobilization or traditional open surgical trauma. Percutaneous triple anterior screw fixation could decrease post-operative complications of these patients. We note that triple anterior screw fixation is performed on three elderly patients [1,7,8] and one middle-aged patient [9] in previously reports. In this study, all cases are elderly patients, and we suggest that triple anterior screw fixation is suitable for elderly patients while it is a dispute for this technique on young or middle-aged patients.

Another advantage of this technique is that the immediate atlantoaxial stability is attained after operation. Only the case reported by Guiot et al. [7] performed bone graft, other three cases [1,8,9] did not mention whether there is a bone graft procedure. In our study, bone graft procedure is not performed on three patients, atlantoaxial joint is stability in all of them at last follow-up. We presume that elderly patients under the internal screw fixation tend to easy form joint stiffness because of the joint degeneration and atlantoaxial joint activities are declined. The construct stability could be achieved readily by the joint stiffness and triple internal screws fixation.

Although the operation is performed inside of protective tube, potential risks of the carotid artery and oesophagus injury must be carefully avoided before the protective tube inserted. The guide tube should be moved up and down on the medial side of the carotid sheath to separate the oesophagus from its surrounding structures, and then insert the K-wire inside guide tube. Appropriate screw trajectory should be adjusted in case of damage to the spinal cord or vertebral artery, and the proper length of screw could avoid occipitocervical fusion if screws are too long.

It is important to note that this technique also has its limitations. Some physical characteristics such as a severe cervical kyphosis or concomitant thoracic kyphosis may interfere with the fixation of the screws [19], and it is also hard for surgeons to deal with the drill and thorax in short neck patients. It is also important to note that previous surgery to the front of the neck is not a contra-indication for an open triple anterior screw fixation, but is an absolute contra-indication for the percutaneous procedure [11]. In addition, there are only seven cases in this study, some patients just have short-term follow-up clinical data. In extended research, a larger population and longer follow-up study is necessary.

**Conclusion**

This case series demonstrates a feasible, safe and minimally invasive procedure method for elderly patients with acute combination atlas–axis fractures. This technique avoids the drawbacks of traditional open surgery, to be less trauma, decreased blood loss, less post-operative pain, easier for nursing care and a quicker recovery.

<table>
<thead>
<tr>
<th>Authors</th>
<th>Report time</th>
<th>Age</th>
<th>Fracture combination</th>
<th>Bone graft</th>
</tr>
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<tbody>
<tr>
<td>Apostolides et al. [1]</td>
<td>1997</td>
<td>85</td>
<td>Posterior ring + Type II</td>
<td>No mentioned</td>
</tr>
<tr>
<td>Guiot, Fessler [7]</td>
<td>1999</td>
<td>82</td>
<td>Jefferson’s + Type II odontoid</td>
<td>Yes</td>
</tr>
<tr>
<td>Agrillo, Mastronardi [8]</td>
<td>2006</td>
<td>92</td>
<td>Posterior ring + Type II</td>
<td>No mentioned</td>
</tr>
<tr>
<td>Dean et al. [9]</td>
<td>2010</td>
<td>39</td>
<td>Posterior ring + Type II</td>
<td>No mentioned</td>
</tr>
</tbody>
</table>
Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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