SURGICAL TECHNIQUE

Posterior screw-plate system for treating old fracture of the odontoid process

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Objective: To assess the efficacy of a screw-plate system for the treatment of old fracture of the odontoid process.

Methods: Twenty-six patients with old fracture of the odontoid process were treated by a posterior screw-plate system. There were 17 men and 9 women ranging in age from 17 to 58 years (mean, 32.8 years). According to the Anderson-D'Alonzo classification, 19 patients were classified as type II, and 7 as type III. According to the Frankel classification, there were 3 patients of grade C, 21 of grade D and 2 of grade E.

Results: All operations were successfully performed. The operation time was 75–120 min (mean, 90 min) and the intraoperative blood loss 50–200 ml (mean, 125 ml). There were no postoperative complications. All patients were followed up for 24–36 months. At the final follow-up, one patient had improved from grade C to grade D, two from grade C to grade E, and 15 from grade D to grade E. The other cases had remained stable. There was no breakage of nails or failure of internal fixation during follow-up. Stable bone union was observed in all cases, the average healing time being 7.8 months.

Conclusion: Posterior screw-plate system is a safe and effective method for treating old fracture of the odontoid process.

Key words: Bone transplantation; Internal fixators; Odontoid process; Spinal fusion

Introduction

Fracture of the odontoid process, which is the most common upper cervical spine fracture, was first described by Lambotte and D'Alonzo more than one century ago¹. Since then, attention has often been drawn to the fact that fracture of the odontoid process is mostly detected long after the traumatic event, and is prone to non-union. Even now many emergency departments worldwide still use classical X-rays in the initial evaluation. Low odontoid fracture is therefore frequently missed, especially in unconscious patients where an open mouth view is not available. A posterior atlantoaxial fixation with C₁ lateral mass screws and C₂ pedicle screws has been introduced as an effective and safe technique which offers immediate, strong support while minimizing hardware complications. From May 2007 to May 2009, 26 patients with old fracture of the odontoid process were treated by this method.

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Materials and methods

Case data

Twenty-six patients with old fracture of the odontoid process were treated by posterior atlantoaxial fixation with C₁ lateral mass screws and C₂ pedicle screws. The series included 17 men and 9 women, aged from 17 to 58 years (mean, 32.8 years). All 26 patients had symptoms of neck pain and stiffness of cervical movement. According to the Anderson-D'Alonzo classification¹, there were 19 patients with type II, and 7 with type III. According to the Frankel classification², 3 patients were classified as grade C, 21 as grade D and 2 as grade E.

Surgical technique

General endotracheal anesthesia was used for all patients. Each one of them was placed prone under cervical traction with the head elevated approximately 15–30 degrees. Cervical traction stabilizes the head in an optimally reduced extension position and prevents any rotation. A midline incision was made and the posterior arch of the C₁ and C₂ exposed.

For C₁ lateral mass screws, the medial surface of the C₁ lateral mass and the transverse foramen of C₁ were identified using a 4# Penfield dissector (Tianjin, China),

providing proper anatomical orientation for the screw entry point and trajectory. Venous bleeding was easily stopped using homeostatic agents and gentle packing. An entry point directly on the posterior arch of the atlas, at the midpoint between the medial edge of the transverse foramen and the medial surface of the lateral mass was then chosen. A starting point using a 3 mm burr was made on the posterior arch, while an assistant protected the vertebral artery with a Penfield dissector. The C₁ lateral mass was perforated under fluoroscopy using a hand-held drill with a 2.5 mm K-wire and the drill bit angled medially 5°–10°, stopping just short of the anterior arch cortex. After drilling a pilot hole and feeling the trajectory with a blunt 1.0 mm probe, the hole was tapped and a 3.5 mm screw inserted. The length of the screw ranged from 18 to 30 mm, depending on the size of the lateral mass and whether the starting point was on or below the posterior arch.

For C₂ pedicle screws, the atlantoaxial membrane was detached on the sides and the upper surface of the posterior arch of C₂ exposed. Care was taken to avoid damaging the posterior branch of the second cervical nerve. With a punch, the drill entry site was marked in the upper medial quadrant of the posterior surface of the articular process. A 2.8 mm drill bit was fitted on a power drill, and advanced at low speed in the sagittal plane, routing the trajectory slightly cephalad and slightly medial (about 20° in both directions). The entire screw track was prepared with a 2.8 mm bit. The screws had to be sufficiently long to engage the anterior fragment of the pedicle, going as far as the vertebral body without penetrating the anterior cortex. All patients were managed with screws of a length between 30 mm and 35 mm.

After the screws had been placed into C₁ and C₂, a well-shaped stainless steel plate was used to connect the screws. A high-speed burr was used to decorticate the surface of C₂ lamina and C₁ arch. Twenty-gram cancellous graft from the posterior iliac crest was morselized by chisel and scissors to granules of 2–3 mm in size and the space between C₁ and C₂ packed fully. Finally, a kieselgel drainage tube was put in place and the incision closed in layers.

Postoperative management

Patients were allowed to turn in bed on the first postoperative day, to sit on the second, and encouraged to stand or walk on the third. Anti-inflammatory drugs were used for three days after surgery. Neither soft collar nor orthosis was needed after surgery.

Results

All the patients withstood surgery well. The operation time was between 75–120 min (mean, 90 min) and blood

loss during operation between 50 and 200 ml (mean, 125 ml). No complications of infection, neurological deficits or vertebral artery injury were found. The average follow-up period was 29 months (range, 24–36 months). No significant clinical sequelae, hardware complications or adjacent segment degenerative changes were observed during follow-up. There was no screw fracture, loosening, or backout. Improvement in motor deficit was noted in those who had presented with radiculopathy or myelopathy. At final follow-up, one patient had improved from grade C to Grade D, two from grade C to grade E, and 15 from grade D to grade E. Other cases remained stable. All patients attained solid fusion, and no pseudoarthrosis occurred. All cases had achieved solid fusion at the 3 month follow-up. Imaging results of one typical case are shown in Fig. 1.

Discussion

Brief introduction to old odontoid process fracture

Odontoid process fracture accounts for 10–16% of all cervical spine fractures³. This region is responsible for the majority of the segmental axial rotation of the neck. It is well documented that this is a unique area from a biomechanical standpoint and is inherently predisposed to traumatic injuries⁴. The mechanism responsible for odontoid process fracture is generally agreed to be hyperextension or hyperflexion of the cervical spine⁵. Odontoid fracture occurs in a bimodal age distribution; and in contrast to the usual high-velocity mechanism in younger patients, odontoid process fracture in elderly patients generally results from a low energy mechanism⁶.

Odontoid process fracture has been divided into three groups depending on the anatomical location of the fracture by Anderson and D'Alonzo¹ and this classification has been widely accepted. Type I fracture is an avulsion of the superior tip of the odontoid, while the transverse ligament remains intact. This fracture, being mechanically stable, is managed non-surgically. Type II fracture occurs at the base of the dens and is the most common odontoid fracture. A type III odontoid process fracture occurs when the fracture line extends into the body of the axis.

Types II and III are therapeutically very important. Following a type II odontoid process fracture, the stability afforded by an intact transverse ligament complex is abolished, allowing movement of the C₁-odontoid complex. This movement can cause compression of the cervical spinal cord and result in a spinal cord injury. Type II has a high rate of nonunion, 40–75% in conservatively treated cases. Some authors believe that the major cause of the high nonunion rate in type II is interruption of

Figure 1 A 47-year woman with old fracture of the odontoid process who had been injured in a traffic accident achieved good recovery after posterior screw-plate system surgery. (A,B) Preoperative X-ray films and (C,D) CT scan show atlantoaxial dislocation caused by old fracture of the odontoid process. (E) MRI shows a spinal cord compression in the corresponding segment. (F,G) Postoperative X-ray films and (H,I) CT show completely reduction of the atlantoaxial joint dislocation and the good location of the titanium plate. (J) MRI shows effective decompression of spinal cord compression.

blood supply to the proximal part of the odontoid. The following risk factors for nonunion have been identified: fracture gap of more than 1 mm, posterior displacement of more than 5 mm and delayed treatment of more than four days^{7,8}. Age and sex are not significant risk factors. Essentially, almost half of conservatively treated odontoid fractures (especially type II) will develop non-union.

Anatomic reduction of subluxation of C₁-C₂ is necessary to ensure that there is space available for the cord. Patients with old fracture of the odontoid process can present a wide clinical spectrum. The patient's symptoms may include neck pain, limited range of movement of the cervical spine, difficulty in holding their heads in an upright position, and other myelopathic symptoms.

Necessity of posterior atlantoaxial arthrodesis for obsolete odontoid process fracture

For patients with old fracture of the odontoid process, inadequate bony fusion carries the risk of severe spinal cord damage due to instability at the atlantoaxial joint⁹. As this complication may result in progressive myelopathy, many authors recommend surgical stabilization of mobile odontoid non-unions, even in the absence of neurological deficits. Nonoperative management of an instability or subluxation at the atlantoaxial joint would increase the risk of further neurological compromise to the point of severe spinal cord damage and quadriplegia. Younger and more active patients should particularly benefit from operative treatment as, without fixation,

delayed radicular or myelopathic symptoms are common clinical findings.

Anterior odontoid screw fixation is a safe and effective method for treating acute fracture of the odontoid process. Anterior odontoid single screw fixation has been noted to preserve normal rotation at C₁/C₂, provide immediate stability, and obviate the need for postoperative halo immobilization^{10,11}. However, there are limitations to this approach in the case of unreduced nonunion of fracture of the odontoid process. In particular, in neglected fracture of the odontoid process with fixed angulations, anterior odontoid screw fixation is contraindicated because of the risk of complications from inserting screws into the angulated odontoid. If the fracture is more than 4 weeks old or the patient possesses a short neck and barrel-shaped chest, an alternative treatment approach, such as transarticular screw fixation or posterior screw-plate system, should be considered.

The Magerl technique can also be used for reducible odontoid process fracture. However, in an odontoid fracture with fixed deformity it is much more difficult to insert the screws in the right direction so as to catch the lateral mass of C₂ and C₁. In Magerl's interarticular screw fixation technique, only one screw is used, screw implantation in the atlas is not performed under direct visualization, and only part of the screw engages the lateral masses of the atlas and axis. In our technique, because the screw implantation is not as acutely angled superiorly as in Magerl's interarticular technique, the skin incision does not need to be as extensive. In addition, because there is no need for flexion of the patient's neck during the procedure to obtain the proper trajectory, inadvertent injury to the hypoglossal nerve is avoided. In our technique, longer purchase of screws in both the atlas and the axis is possible than in Magerl's technique. The entire length of the screw is introduced into the atlas and axis, and the implantation procedure can be performed with direct visualization of these vertebrae.

Old fracture of the odontoid process can cause atlantoaxial instability. The primary indication for posterior fusion of the atlantoaxial joint is instability. Fusion between the C₁ and C₂ vertebrae due to instability and dislocation has traditionally been performed with the Gallie or Brooks methods using wire or cable fixation. Both these methods depend on bone blocks put in compression between the C₁ arch and the C₂ lamina. However they are ineffective against translatory or rotatory forces, and a high failure rate has been reported¹². In order to achieve successful C₁-C₂ fusion, mechanical stability between the vertebrae combined with bone grafting is necessary¹³.

In the present study, 26 patients with old fracture of the odontoid process were treated by a posterior screw-plate system. This technique ensures immediate stability of the spinal column. The most recent follow-up studies demonstrated solid bony fusion in all patients. With a significant improvement in clinical results and neurologic function, posterior atlantoaxial arthrodesis by this method seems to be an appropriate option for old fracture of the odontoid process.

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