

## Fixation of Type II Odontoid Fractures with Anterior Single Screw

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### ABSTRACT

**Objective:** Anterior single screw fixation is one of the surgical options providing sufficient immediate stabilization of the spine and preserving normal C1-2 motion. In this study the indications, the surgical technique, and outcome of patients who underwent this procedure were reviewed. **Methods:** Thirty consecutive patients (25 males and 5 females) who underwent anterior single screw fixation for recent Type II odontoid fractures at King Fahd Hospital, Al-Madina Al-Munawarah, in Saudi Arabia (SA) between January 2004 and December 2007 were included in this study. Data including clinical examination, imaging studies and operative technique were used to analyze the results of this surgical technique. **Results:** The clinical and radiological results, in our series, were conclusive. The use of single screw for fixation of type II odontoid fracture was found easier and simpler than common method at which the double screws were used with the same advantages. The surgical technique resulted in immediate spinal stability and preserves normal rotation at C1-2 in all patients (100% of cases). Radiological evidence of bone union achieved in 22 patients (73% of cases); and nonunion in 8 patients (27% of cases). Complications related to surgical procedure and hardware failure were recorded in 4 patients (13% of cases). **Conclusions:** Direct anterior single screw fixation is an effective, simple, and safe method for treating type II odontoid fractures. It is associated with rapid patient mobilization, minimal postoperative pain, and shorter hospital stay. By this technique, the required anatomical and functional outcome can be obtained through immediate stability of the axis, preserves C1-2 rotatory motion, and achieved high union rate.

**Key Words:** Odontoid - Odontoid fracture - Anterior fixation - Single screw

### INTRODUCTION

More than 60% of spinal injuries affect the cervical spine, and approximately 20% of all cervical spine injuries involve the axis. The most common axis injury is odontoid fracture<sup>1</sup>. The management of odontoid fractures became less controversial than before. A motor vehicle accident and falls are responsible for the majority of C2 fractures<sup>3</sup>. These fractures were classified into three distinct types by Anderson and D'Alonzo in 1974<sup>2</sup>. The Type II odontoid fracture represented approximately two thirds of all odontoid fractures. It occurred at the junction between the odontoid process

and the body of C-2, resulting in potentially disastrous instability. The morphometry of the dens demonstrated a reduction in cortical thickness, trabecular bone volume, and trabecular lattice formation at the base of the dens, which may contribute to the frequency of this fracture type. This fracture may be caused by a flexion moment through the occiput. A lateral bending force has been proposed as the additional mechanism causing the development of Type II fracture. The motion at C1-2 is primarily rotational, accounting for 60% of the axial rotation of the neck. Translational motion is restricted by the strong transverse ligament containing the odontoid process in the anterior portion

of the ring of C-1. When the odontoid is fractured, there is no longer significant restriction of translational movements<sup>4</sup>. The clinical manifestations range from asymptomatic to frank paralysis. If a significant degree of displacement occurs, the function and integrity of the spinal cord may be jeopardized, possibly resulting in significant neurological deficit. Plain radiography remains the mainstay for identification of odontoid fractures. Both lateral-view and open mouth view radiography may demonstrate the fracture<sup>5</sup>. The disruption of transverse ligament suspected if the distance between the dens and the anterior C1 ring > 3 mm<sup>6</sup> and/or the lateral masses of the atlas overhanged the superior articular facets of the axis<sup>7</sup>. The use of CT scanning is quite helpful in demonstrating the fracture line as well as the degree of displacement. However, CT scanning occasionally fails to demonstrate a fracture in the transverse plane if the gantry angle is parallel to the fracture line. Magnetic resonance imaging has a limited role in evaluating patients who had sustained odontoid fractures without neurological injuries<sup>8</sup>. A variety of external immobilization techniques and operative procedures has been described in the management of the Type II odontoid fractures. The external immobilization has been applied in patients who cannot tolerate general anesthesia or have sustained other severe concurrent injuries prohibiting surgical intervention<sup>9</sup>. The posterior atlantoaxial fusion procedures in which instrumentation is placed has been used for treating odontoid fractures in patients who are not suitable for anterior approach as those with short-neck, obese, increased AP chest diameter (barrel chest), and disrupted the transverse ligament or adequate alignment cannot be restored

before screw insertion<sup>8</sup>. Although the posterior surgical fusion techniques does not directly address the fracture location, stability of the atlantoaxial joint is achieved but at the expense of cervical rotation. Generally up to 50% of rotation is lost with posterior techniques<sup>10,11</sup>. The direct fracture fixation has been achieved by performing the anterior approach in which the union rate is quite high with maintained of the atlantoaxial rotation movements. The risks of nonunion, malunion, and pseudoarthrosis formation are lessened with anterior rather than posterior surgical approach. As with any surgical procedure, risk of infection always exists. Neurovascular injury and airway compromise are a risk associated with the anterior surgical approach. Hardware failures including break of screw, pullout, backout, and lose of implants were reported<sup>12</sup>.

## PATIENTS & METHODS

### *Patient Population*

Over a 4-year period (2004–2007) 30 consecutive patients underwent direct anterior single screw fixation for recent (within one month of trauma) type II odontoid fractures. The procedure was performed at the King Fahd Hospital, Al-Madinah Al-Munawarah, SA. There were 25 male, and 5 female patients. The mean patient's age was 35 years (ranged from 15 - 52 years).

### *Clinical and radiological assessment*

The assessment of the patients was based upon a clinical examination (neurological status) and a radiological workup (cervical plain X-rays, CT, and occasionally MRI). The two chief symptoms were reported in our patients; neck pain in all patients (100% of cases) and headaches in 24 patients (80% of cases) while neurological deficits reported in 5

patients (17% of the cases). In 3 patients (10% of the cases), the diagnosis was not made in the first few days after the accident. This underlines the importance of repeat radiographs, with dynamic (flexion-extension) views, on the following days after any trauma in patients with persistent neck pain. All patients were preoperatively assessed by evaluating the initial preoperative lateral and open mouth plain X-ray films, cervical CT scans in different reconstructions planes. Fracture orientation and direction of displacement were determined according to the AP direction of the fracture line. The degree of displacement was determined by the distance in mm of the fractured fragment relative to the underlying body of C-2 (ranged from 2 to 6 mm). The direction of odontoid displacement was classified as posterior, anterior, or neutral relative to the body of C-2. Anatomical bone fusion was considered successful if there was trabeculation across the fracture site, the absence of movement on lateral dynamic radiographic studies, and anatomical alignment of the fracture fragment. Nonanatomical bone union was considered with previous criteria except the presence of anatomical alignment of the odontoid process. The presence of fibrous union was expected if a visible fracture line was present and movement was absent on flexion-extension X-ray films.

#### ***Operative Technique***

After fiberoptic intubation, C-arm fluoroscope is brought into position and the patient is placed in the supine position with the neck slightly extended. All these steps are made to minimize more displacement and restore the alignment to facilitate the screw placement into the apex of the odontoid process. A small, transverse midcervical skin incision is made over the level of the cricothyroid junction

(opposite C5–6 interspace). Sharp dissection is performed down within the avascular plane to the prevertebral area and then extended cephalad to the C2–3 disc space by using of Langenbeck retractor which placed in the submandibular area (Fig. 2B, 2C). The anterior-superior angle of C3 is drilled to create a shallow groove, without removing any of the C-2 body, to facilitate positioning of the screw in the ideal trajectory plane. Preservation of the anteroinferior portion of the C-2 body is needed to provide the resistance to screw displacement. A hole is then drilled into the C-2 body with hand or slow air drill to cross the fracture line into the apical cortical surface of odontoid process. Before the fracture line is crossed, additional head manipulation can be attempted to reach the final realignment of the fracture line before screw placement. The length of the screw is determined through measurement of the odontoid process in CT sagittal reconstruction. A 3.5 or 4-mm nonself-tapping, partially threaded lag screw is then gradually inserted under direct fluoroscopic guidance. The tip of the screw should barely penetrate the apical cortex of the odontoid process if possible, and it should be just adequately tightened to engage the distal odontoid fragment. It is important to choose a slightly shorter screw than was measured by approximately 2 mm because the lag effect derives only from final tightening of the screw to increase compression and reapproximation of the fracture line. Serial postoperative AP, open mouth, and lateral flexion-extension plain X-ray films of the cervical spine were obtained concurrently at clinical visits to evaluate screw position, fracture alignment, and union status. The mean follow-up was 10 months (ranged from 3 to 36 months).

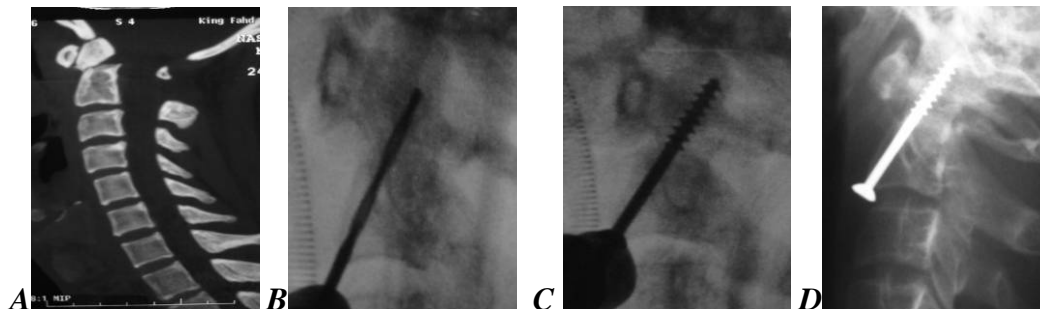
## RESULTS

Thirty patients underwent direct anterior single screw fixation for type II odontoid fractures at the King Fahd Hospital, Al-Madinah Al-Munawarah, Saudi Arabia. The majority of patients were male (83% of the cases), with 5:1 male/female ratio. The overall mean age at surgery was 35 years (15–52 years), and the mean follow-up period was 10 months (3–36 months). The most common mechanism of injury was motor vehicle accident in 27 patients (90% of cases), while the others were due to fall from height. The preoperative clinical findings were in the following frequency; neck pain in all patients, headache in 80% of the patients, and neurological deficits in 17% of the patients ranged from paraesthesia of upper limbs in 3 patients, monoparesis of upper limb in one patient, and quadriplegia in one patient. The plain cervical X-rays are still the mainstay investigation in detection of odontoid fractures; as it detected 90% of fractures in our patients at the time of presentation, while cervical CT are able to detect the fractures in all patients with precise determination of the degree and direction of the odontoid displacement. The fracture line was horizontal in 14 patients (46%), anterior oblique in 11 patients (36%), and posterior oblique in 5 patients (16%) (Fig. 1,2,3). While anterior displacement of the odontoid process was found in 12 patients (40%) (Fig. 1A), posterior displacement in 6 patients (20%) (Fig. 2A, 3A), and the fracture odontoid process was undisplaced in 12 patients (40%). Associated cervical fractures had been found in 6 patients (20% of the cases), while 12 patients (40% of the cases) suffered from multiple injuries. The displacement distance ranged in all our patients between 2 to 6 mm. By using a single anterior screw fixation in our

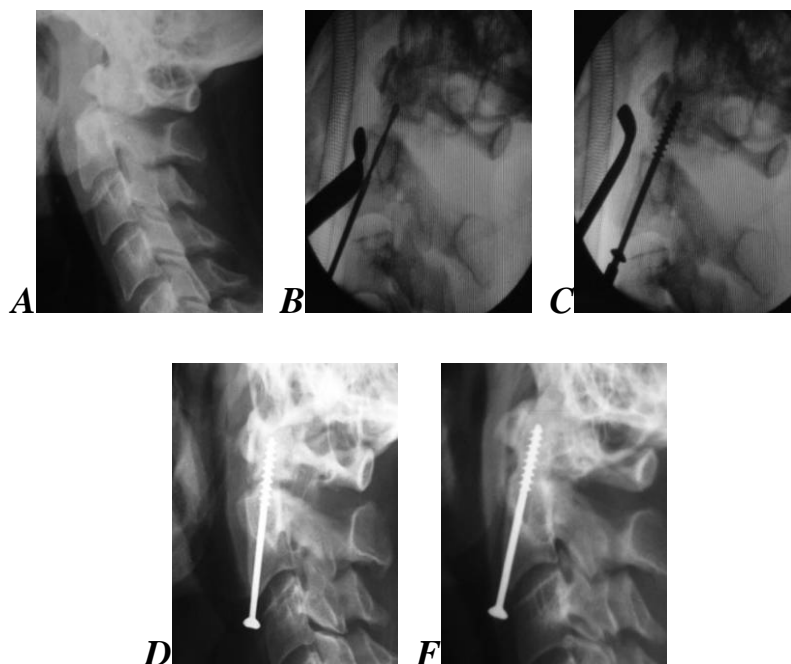
patients, immediate spinal stabilization was achieved in all patients, as evidenced clinically and radiologically. Successful positioning of the odontoid screw was obtained in all patients. At the beginning we measured the length of odontoid screw on plain X-ray resulting in inaccurate screw length (Fig. 1C, 2C) in 11 patients (3 long and 8 short). To solve this problem, we used CT sagittal reconstruction to determine the proper screw length resulting in 100% accurate results (Fig. 3C, 3D). All patients were neurologically stable after surgery and remained so as of last follow-up visit. No additional neurological deficits occurred to our patients. While patients who had a motor deficits improved post-operatively. Also the patients with paraesthesia took a longer time (> 6 months) to get improvement. Radiological follow up studies showed successful anatomical bone union (Fig. 2E) in 15 patients (50%), nonanatomical bone union (Fig. 3C) in 4 patients (13%), fibrous union in 3 patients (10%), and nonunion in 8 patients (about 27%) who had a short (< 6 months) follow up period. The patients with nonanatomical bone union were treated conservatively by hard cervical collar, and they did not require additional surgical intervention. The 8 patients with fracture nonunion were treated conservatively in hard cervical collars with evidence of progress toward bony union but they did not complete their follow up. The anterior orientation was more likely to result in mal/nonunion (6 out of 12 patients). While the posterior and horizontal oriented fractures were more likely to be fused early (6 out of 18 patients). The postoperative hardware-related failure in our study was the partial screw pullout from the body of C-2 prior to development of union. This complication occurred in 2 patients, successful union was

achieved without neurological sequelae by using a hard cervical collar. Screw backout was seen in one patient because the screw only partially engaged the odontoid process. This patient underwent direct anterior screw replacement, and union was subsequently achieved. In addition to

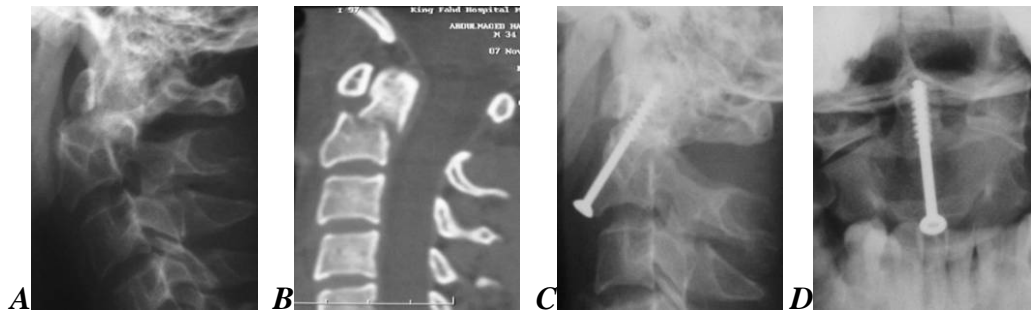
hardware-related complications, one patient suffered a small esophageal leak at C5–6, as evidenced after the patient ingested contrast medium. This patient was treated successfully by denial of oral intake and placement of a nasogastric tube for one week.



**Figure 1:** (A) Pre-operative cervical sagittal reconstructions showed anterior displacement fracture of odontoid process. (B) Fluoroscopic image of the drill into the body of C2 and crossing into the fractured odontoid process. (C) Intra-operative odontoid screwing. (D) Post-operative follow up X-ray (one year) showed anatomical fusion of the fractured odontoid process.



**Figure 2:** (A) Initial plain X-ray showed posterior displacement of odontoid process. (B) Intra-operative drilling after correction of fracture alignment. (C) Intra-operative screwing. (D) Immediately post-operative X-ray showed correct screw position. (E) Follow up plain X-ray (one year) showed anatomical bone fusion of odontoid process.



**Figure 3** (A) Initial plain X-ray showed marked posterior odontoid displacement (posterolisthesis). (B) Pre-operative CT sagittal reconstructions showed partial correction of odontoid displacement. (C and D) Follow up plain X-ray (6 months) showed non-anatomical bone fusion of the odontoid process.

## DISCUSSION

Anterior odontoid screw fixation was first reported by Nakanishi in 1980<sup>13</sup> and later by Bohler<sup>14</sup> who, in 1982, independently reported his experience dating back to 1968. Since the publication of early reports, multiple authors<sup>11,15,16,17</sup> have achieved successful outcomes by undertaking this procedure in patients with acute type II and rostral type III odontoid fractures. Anterior screw fixation provides immediate spinal stability; preserves normal rotation at C1–2 and is associated with a high union rate without requiring the patient to undergo rigid halo immobilization postoperatively; and allows the best anatomical and functional outcome for type II odontoid fractures<sup>11</sup>. However, the anterior approach has some limitations like if the patients had short necks, barrel shaped chest and old fracture which causes the screw trajectory very difficult. Also the transverse ligament must be intact, and the fracture line ideally should be in a horizontal plane. In cases of chronic type II odontoid fractures and in patients with transverse ligament disruption, the posterior transarticular facet screw fixation supplemented by bone graft and interspinous C1–2 wiring are considered as alternative

options<sup>12</sup>. In more than half of the patients with these lesions displaced fractures was revealed on the initial cervical radiograph. An anterior displacement was most common and seen in 66% of patients with displaced type II fractures<sup>17</sup>. While in our study the displacement was noticed in 18 patients (60% of cases), 12 patients with anterior displacement and 6 patients had posterior displacement. In the anterior screw fixation procedure, one or multiple screws may be used. The authors of early studies<sup>11,17,18</sup> had emphasized the concept of multiple points in fracture fixation and advocated the use of two screws whenever possible. Theoretically, using of two screws should augment the structural strength of the union and prevent rotation of odontoid on the body of C-2. The results of biomechanical studies performed in cadaveric models by Sasso, et al.<sup>19</sup> had suggested that the second screw failed to demonstrate a significant increase in load-bearing capacity compared with a single screw. Moreover, in more recent studies investigators had concluded that no significant difference in union rates was associated with a single-screw technique<sup>20</sup>. Jenkins, et al.<sup>21</sup> found no difference in union rate in the patients treated with single or double odontoid screws. The results of biomechanical studies suggest that

acceptable stabilization is provided by a single-screw technique<sup>19</sup>. Because the second screw provides no obvious biomechanical advantage, in our study we used only a single screw to minimize surgical time, and in the majority of patients, the odontoid process was not large enough to accommodate the second screw. Different types of screws were used, including cortical and cancellous bone screws; self-tapping and nonself-tapping screws; lag screws or cannulated screws; and fully or partially threaded screws<sup>23</sup>. In our study, partially threaded cancellous lag screws were used to fix the odontoid fracture. Lag compression is an important concept in odontoid fixation to anneal the fracture line under compressive force. This effect not only provides rigid fixation but also couples the fractured fragments to promote union. The cannulated screw systems are better suited for the precise placement of screws but not used in our series. The screws may be constructed of stainless steel, titanium or its alloy. Titanium has 90% of the strength of steel and is magnetic resonance imaging compatible, allowing postoperative neuroimaging studies of the spine and its contents. In our study a single 3.5 or 4 mm nonselftapping, partially threaded stainless steel lag screw was used in all patients. The results of clinical studies have shown that anterior screw fixation can preserve normal C1–2 rotatory motion<sup>24</sup>. Montesano, et al.<sup>25</sup> have reported that in 83% of their patients seen in follow up, full range of motion was maintained after anterior screw fixation of odontoid fractures. In our study 27 patients (90% of cases) demonstrated a full rotatory free pain movement immediately post-operative and in 3 patients same result obtained after 6 months of post-operative physical therapy. In the article written

by Apfelbaum, et al.<sup>16</sup> they found a high rate of union regardless of patient age or the magnitude and direction of fracture displacement. In addition, screw-related complications (screw pullout and backout) occurred in 11% of their cases. In our patients these complications were reported in three patients (10% of cases). Nonunion, malunion, and pseudoarthrosis formation are potential major complications. Factors affecting this are amount and position of displacement, degree of angulation, ability to obtain and hold a reduced fracture, and age of the patient. While, some reports have demonstrated nonunion rates approaching 80% in certain subsets of patients. In our study nonunion was reported only in cases with short follow up period (< 6 months). In article of Shilpakar SK, et al.<sup>12</sup> they looked at all treatment options and associated rates of complications and concluded that anterior odontoid screw fixation is a procedure of choice over the last years in cases with acute type II and rostral type III odontoid fractures. A meta-analysis was performed and showed that anterior single screw used for odontoid fixation, yielded better results than those found with multiple screws, transarticular fusion, or closed reduction with halo vest immobilization<sup>22</sup>.

## CONCLUSIONS

The use of a single, instead of two screws, has been proven to be an effective, simple, safe, and cost-effective in the management of patients with recent type II odontoid fractures. Anterior single screw fixation for type II odontoid fractures; provides immediate spinal stability; preserves normal rotation at C1–2 and is associated with a high union rate, achieving the required anatomical and

functional outcome. It is also associated with rapid patient mobilization, minimal postoperative pain, and shorter hospital stay.

## REFERENCES

1. **Ersmark H, Lowenhielm P:** Factors influencing the outcome of cervical spine injuries. *J Trauma* 1988, **28**:407–410
2. **Huelke DF, O'Day J, Mendelsohn RA:** Cervical injuries suffered in automobile crashes. *J Neurosurg* 1981, **54**:316–322
3. **Anderson LD, D'Alonzo RT:** Fractures of the odontoid process of the axis. *J Bone Joint Surg (Am)*: 1974, 1663–1674
4. **Amling M, Posl M, Wening VJ, et al:** Structural heterogeneity within the axis: the main cause in the etiology of dens fractures. A histomorphometric analysis of 37 normal and osteoporotic autopsy cases. *J Neurosurg* 1995, **83**:330–335
5. **Ehara S, el-Khoury GY, Clark CR:** Radiologic evaluation of dens fracture. Role of plain radiography and tomography. *Spine* 1992, **17**:475–479
6. **Fielding JW, Cochran GVB, Lawsing JF III, et al:** Tears of the transverse ligament of the atlas: a clinical and biomechanical study. *J Bone Joint Surg (Am)* 1974, **56**:1683–1691
7. **Spence KF Jr, Decker S, Sell KW:** Bursting atlantal fracture associated with rupture of the transverse ligament. *J Bone Joint Surg (Am)* 1970, **52**:543–49
8. **Althoff B:** Fracture of the odontoid process. A clinical and radiographic study. *Acta Orthop Scand Suppl* 1979, **177**:1–95
9. **Wang GJ, Mabie KN, Whitehill R, et al:** The nonsurgical management of odontoid fractures in adults. *Spine* 1984, **9**:229–230
10. **Stillerman CB, Wilson JA:** Atlanto-axial stabilization with posterior transarticular screw fixation: technical description and report of 22 cases. *Neurosurgery* 1993, **32**:948–955
11. **Aebi M, Etter C, Coscia M:** Fractures of the odontoid process. Treatment with anterior screw fixation. *Spine* 1989, **14**:1065–1070
12. **Shilpakar SK, McLaughlin MR, Haid RW, Rodts GE, and Subach BR:** Management of Acute Odontoid Fractures: Operative Techniques and Complication Avoidance. *Neurosurg Focus*. 2000, **8** (6): Article 3
13. **Nakanishi T, Sasaki T, Tokita N, Hirabayashi K:** Internal fixation of the odontoid fracture. *Orthop Trans*, 1982, **6**:176–182
14. **Böhler J:** Anterior stabilization for acute fractures and non unions of the dens. *J Bone Joint Surg*, 1982, **64A**: 1, 18–27
15. **Benzel EC, Hart BL, Ball PA, et al:** Fractures of the C-2 vertebral body. *J Neurosurg* 1994, **81**:206–212
16. **Apfelbaum RI, Papadopoulos, SM, Polinsky M, et al:** Treatment of Type II odontoid fractures, in Al-Mefty O, Origitano TC, Harkey HL (eds): **Controversies in Neurosurgery**. New York: Thieme, 1996, pp 286–293
17. **Hadley MN, Dickman CA, Browner CM, et al:** Acute axis fractures: a review of 229 cases. *J Neurosurg* 1989, **71**:642–647
18. **Apuzzo MLJ, Heiden JS, Weiss MH, et al:** Acute fractures of odontoid process. An analysis of 45 cases. *J Neurosurg* 1978, **48**: 85–91
19. **Sasso R, Doherty BJ, Crawford MJ, et al:** Biomechanics of



- odontoid fracture fixation. Comparison of the one- and two-screw technique. *Spine* 1993, **18**:1950–1953
20. Subach BR, Morone MA, Haid RW Jr, et al: Management of acute odontoid fractures with single-screw anterior fixation. *Neurosurgery* 1999, **45**:812–820
21. Jenkins JD, Coric D, Branch CL Jr: A clinical comparison of one- and two-screw odontoid fixation. *J Neurosurg* 1998, **89**:366–370
22. Graziano G, Jagers C, Lee M, et al: A comparative study of fixation techniques for Type II fractures of the odontoid process. *Spine* 1993, **18**:2383–2387
23. Etter C, Coscia M, Jaberg H, et al: Direct anterior fixation of dens with a cannulated screw system. *Spine* 1991, **16**:S25–S32
24. Geisler FH, Cheng C, Poka A, et al: Anterior screw fixation of posteriorly displaced Type II odontoid fractures. *Neurosurgery* 1989, **25**:30–38
25. Montesano PX, Anderson PA, Schlehr F, et al: Odontoid fractures treated by odontoid anterior screw fixation. *Spine* 1991, **16** (Suppl 3):S33–S37.
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