Anterior odontoid screw fixation using Acutrak screw: Report of 19 patients

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ABSTRACT

BACKGROUND: This paper aims to present clinical and radiological results of patients who underwent anterior odontoid screw fixation (AOSF).

METHODS: In this study, 19 consecutive patients with an unstable odontoid fracture were operated on using an Acutrak screw.

RESULTS: The patients were followed for a mean duration of 12.5 months. Radiological fusion on CT scans was detected in 87.5% of the patients.

CONCLUSION: Acutrak screws can be used for AOSF. This study contains the maximum number of patients using the Acutrak screw in the literature. However, larger prospective clinical studies can provide more accurate information about the effectiveness of the Acutrak screws for odontoid fractures.

Keywords: Acutrak screw; anterior odontoid screw fixation; odontoid fracture.

INTRODUCTION

Odontoid fractures are relatively common injuries, account for approximately 15–20% of all cervical spine fractures.[¹-⁴] Contemporary treatment strategies of odontoid fractures can vary from conservative management with an external immobilization (cervical collar, halo-west and other cervicothoracic orthoses) to operative methods.[²] However, the most appropriate management for these fractures remains controversial. The classification systems are helpful to decide the treatment method. Odontoid fractures are reported by Anderson and D’Alonzo in 1974.[⁵] The classification system divides odontoid fractures into three types according to the level of the fracture plane. Type I fracture through the upper portion of the dens, type II fracture at the base of the dens and type III fracture extending into the body of the axis.[⁵]

It is believed that type I and type III fractures will be successfully treated non-operatively.[⁵] However, type II odontoid fractures are the most difficult to treat.[⁶] Type II fractures are associated with a high rate of nonunion when managed conservatively.[²] Sometimes, it can be challenging to precisely define when a type II odontoid fracture extends inferior enough to be considered a type III fracture. These fractures fall into a grey zone. Many authors refer to such intermediate fractures as “shallow” or “high” type III fractures. It is also widely accepted that type II and rostral “shallow” type III odontoid fractures represent highly unstable entities.[⁷-¹⁰] Also, type II odontoid fractures were reclassified by Roy-Camille et al.[¹¹] The authors divided the fractures into three types according to the direction of the fracture line, anterior oblique (oblique...
downward and forward), posterior oblique (oblique downward and backward) and horizontal. Potential surgical indications for unstable (type II and rostral “shallow” type III) odontoid fractures are primarily based on the risk of nonunion with conservative treatment. Factors that are effective in deciding on surgery can be listed as fracture displacement (>5–6 mm) and fracture gap (>2 mm), high-grade angle, patient age (>40–65 years), delay in diagnosis (>6 month), long term traction and severe neurological deficits.[1,2,7,10] Two main approaches for the surgical treatment of unstable odontoid fractures include the anterior odontoid screw fixation (AOSF) and posterior C1-C2 instrumented fusion techniques. Both surgical approaches have a high success rate.[2,3,4,8,12] In this paper, we reported 19 patients with unstable odontoid fractures who were treated with the AOSF method by using Acutrak 3/5 screw.

MATERIALS AND METHODS

This retrospective study included 19 consecutive patients with an unstable odontoid fracture who underwent AOSF using Acutrak screws with a specially designed guide cannula which we reported previously.[1] Local ethics committee approval (No: 20.478.486) was obtained from Manisa Celal Bayar University School of Medicine.

Surgical Technique

The surgical technique we used has been reported previously.[1] Briefly, all patients are positioned in a neutral supine position with a slight extension of the neck on the radiolucent operating table. A 3–4 cm transverse skin incision is made on the medial border of the right sternocleidomastoid muscle at the C4-C5 disc space level. Minimal dissection was made to expose the C4-C5 disc level by separating planes between the carotid artery laterally and the trachea and esophagus medially. After exposing the anterior cervical spine, the entry point, the anterior aspect of the inferior margin of the C2 vertebral body, is marked under fluoroscopy control, and the sharp end of the guide tube is placed. The estimated trajectory of the guide tube is checked under fluoroscopy whether it reaches the tip of the odontoid. The K-wire is placed through the inner guide tube. K-wire is advanced through the fracture line into the distal fragment of the dens until it catches and fixes the fractured odontoid process. Then, the screw with the appropriate length is placed over the K-wire and inserted with the screwdriver into the fractured fragment.

RESULTS

The age, gender, mechanism of injury, fracture type and line, direction and degree of fracture displacement (millimeter),

<table>
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<th>Case no</th>
<th>Age</th>
<th>Gender</th>
<th>Mechanism of injury</th>
<th>Fracture type</th>
<th>Fracture line</th>
<th>Fracture direction and degree (mm)</th>
<th>Neur. Deficits</th>
<th>Additional cervical fracture</th>
<th>Screw type</th>
<th>Length of follow-up (month)</th>
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M: Male; F: Female; TA: Traffic accident. 1*: Patient who came for control in the 1st month after surgery but did not come to the controls later.
length of follow-up (month), were evaluated and data are summarized in Table 1.

There were 12 male and seven female patients. The ages of the patients ranged from 15 to 87 years (mean 52 years and two months). The mechanism of injury was fall and traffic accident in five and 14 patients, respectively. All patients underwent detailed neurological and radiologic examination. Radiologic evaluation included neck flexion/extension radiographs, 3D cervical computed tomography (3DCT) scans and magnetic resonance imaging (MRI) of cervical spine.

According to Anderson and D’Alonzo,[5] our patients’ fracture types were classified as type II and III. Also, the fracture line was determined in all patients according to Roy-Camille[11] classification system. Fracture line was anterior oblique, posterior oblique and horizontal in one, 13 and five patient respectively. In addition, anterior displacement, neutral and posterior displacements were detected in six, four and nine patients, respectively.

Seven of 19 patients had multiple cervical vertebrae fractures, such as odontoid, atlas and lower cervical vertebrae. One of the seven (Case 3) had atlantoaxial joint instability and this patient was treated with triple anterior screw fixation. Fourteen (73.6 %) patients were neurologically intact. However, five of 19 patients were presented with neurological deficits. One of these five patients had severe neurological deficits. Patient was 32 years old male. He was unconscious after the trauma and was tetraplegic (Case 11). He remained clinically the same in the postoperative period.

There was no complication, such as vascular injury, infection or additional neurological deficits. Successful positioning of the odontoid screws and spinal stabilization was achieved in 18 patients. One of 19 patients had screw malposition in the postoperative CT scan. In this patient, the screw was longer. She underwent revision surgery and a screw with suitable length was inserted (Case 1).

One of the 19 patients (Case 12) died for another cause in the follow-up period. In remaining two of the 18 patients (Cases 5 and 17) did not come to the controls in the postoperative period. Radiological fusion on CT scans was detected in 14 of the remaining 16 (87.5%) patients. Two of 16 patients had nonunion during follow-up time (Cases 9, 10). These two patients underwent posterior C1 lateral mass C2 pedicle screw fixation and fusion surgery.

The patients were followed for a mean duration of 12.5 months.

Case Presentations

Case 6– A 44 years old female patient was admitted to our emergency department with a complaint of neck pain after fall from two meters in height. Her neurological examination was normal. Cervical CT demonstrated type III shallow fracture (Fig. 1a, b). On the posttraumatic 3rd day, she underwent surgery. AOSF was performed, and she was discharged on the postoperative 3rd day. In the 6th months control, cervical CT demonstrated the fusion (Fig. 1c, d).

Case 11– A 32-year-old male patient was brought to the emergency service with intubation, and Glasgow Coma Score was 3. In anamnesis, we learnt that cardiopulmonary resuscitation was done for eight minutes due to cardiac and respiratory arrest after a traffic accident. Radiological examinations demonstrated the type III odontoid fracture. The fracture line was anterior oblique (Fig. 2a, b). Cervical MRI demonstrated the spinal cord injury at the C1-2 vertebra level. He hospitalized in the anesthesia intensive care unit. In the following period, he opened his eyes, but he was quadriplegia. Cervical X-ray was taken. Although he was in cervical color, the odontoid fracture was observed to make significant pressure on the brainstem in a neutral position (Fig. 2c). Thus, the patient was taken to Gardner well traction and the cervical alignment was tried to be corrected (Fig. 2d). During this time, the wound was opened on the patient’s neck. Thus, although the anterior approach is not preferred for anterior or oblique fractures, transodontoid screw fixation was done.

Figure 1. Type III Shallow fracture was seen in coronal and axial CT sections (a, b). Fusion was seen in c and d.
using the anterior approach. On the follow-up period, CT demonstrated the fusion (Fig. 2e, f).

DISCUSSION
AOSF was first described by Böhler in 1982. This approach is an attractive option for stabilizing unstable odontoid fractures, but it requires an intact transverse ligament and a favorable fracture line to achieve adequate fracture compression. This method has some advantages, such as immediate stabilization with the preservation of rotation in the atlantoaxial joint, lowering the risk of vertebral artery injury, as well as obviating autologous bone grafts and allows a physiological treatment that enables a direct osteosynthesis, with fusion rates from 85 to 100 percent. Many clinical studies have been published in the literature to document the effectiveness of the AOSF technique in the stabilization of unstable odontoid fractures. Fountas et al. have reported the fusion rate as 87.1% in unstable odontoid fractures after AOSF. In our clinical series, the long-term fusion rate was 87.5%, and it was comparable with the literature. In elderly patients, Platzer et al. reported an 89% union rate with relatively low complication rates by AOSF of dens fractures. Similarly, seven of our 19 patients were 65 years old or older. Five of seven patients could be followed up. One of the five patients was non-union. The fusion rate was 80%, and no patient had perioperative complications.

Vascular or neural structure injuries or transient complications, such as postoperative hematoma, dysphagia, and hoarseness, vocal cord paralysis, may occur during AOSF operations. However, spinal surgeons familiar with anterior cervical approaches will have lower complication rates in these stabilization procedures. The most severe potential complication of AOSF remains injury to adjacent vascular and neural structures resulting from over penetration of the apical cortex. There were no perioperative or postoperative complications, such as hematomas, dysphagia, hoarseness, or vascular or neural injuries, in our case series. However, one of the 19 patients had postoperative complications related to the stabilization procedure. Namely, the screw tip penetrated the odontoid tip (Case 1). A screw with suitable size was placed with revision surgery.

To date, various screw types, such as lag screw and Herbert screw, have been used to treat unstable odontoid fractures for AOSF (Fig. 3). Screw properties can be as follow: completely or partially cortical or cancellous bone screws, fully or partially (double partially or single partially) threaded screws, cannulated screws and self-tapping or non-self-tapping screws. These are made of stainless steel or titanium with diameter of 2.7 mm, 3.0 mm, 3.5 mm, 4.0 mm or 4.5 mm screws. All screw types may have different biomechanical properties. The lag screws (Headed single threaded cannulated screw) are usually used for AOSF to reduce the fracture gap of the

Figure 2. Cervical CT demonstrated type III anterior oblique odontoid fracture (a, b). Lateral cervical X-Ray demonstrated that the odontoid fracture was observed to make significant pressure on the brainstem (c). The patient was taken to Gardner well traction and the cervical alignment was corrected (d). AOSF was done and fusion was detected in cervical CT (e, f).
odontoïd process. The most typical and widely used of this group is 3.5 mm cannulated lag screw.\textsuperscript{3,7,13,14} Theoretically, after the cannulated lag screw has crossed the fracture line, the threads engage the fragment and the lag effect of the screw reduces the fracture gap. Further tightening of the lag screws pulls the odontoïd in a caudal direction, compressing the fracture site and enhancing fracture stability, which results in improved healing of the fracture.\textsuperscript{3,7,14} Many authors recommended surgical techniques that include perforation of the implant to obtain bi-cortical purchase to enhance the lag effect during inter-fragmentary compression.\textsuperscript{3,7,12,14} In this technique, penetration of the apical cortex could increase the risk of injury of adjacent structures including the brainstem and vertebrobasilar circulation.\textsuperscript{3,7,12} In addition, lag screw fixation generally required burr drilling at the upper part of the C3 to make place for the head, and the screw head led to irritation in the anterior upper region of C3 in flexion.\textsuperscript{3,9} Herbert screws are headless, cannulated and double-threaded, with different pitches on the distal and proximal ends compression screws. It has other unique design features, such as being double-threaded with a different pitch on the leading and trailing thread for inter-fragmentary compression.\textsuperscript{7,9,10,14} In 1994, Chang et al.\textsuperscript{6} described Herbert screw fixation of displaced type II odontoïd fracture. They reported 12 patients using 4.5 mm or 3.0 mm screw with 100% union rate. Also, Sung et al.\textsuperscript{10} reported 100% union rate by Herbert screw after AOSF in 10 patients. The Acutrak screws are a headless, cannulated, self-tapping, tapered and fully threaded with variable pitch designed screw to provide sufficient compressive force across fracture line with insertion.\textsuperscript{15,16} Acutrak screw is available in various sizes. The diameter of the Acutrak standard screw is 3.3 mm at the distal end and 3.8 to 4.6 mm at the proximal end. These screws are often used in the treatment of scaphoid fractures by orthopedic surgeons.\textsuperscript{15} However, in our literature review, we can found two published article which used Acutrak screw for odontoïd fracture. Tonosu et al.\textsuperscript{15} treated a 66 years old female patient with Acutrak 4/5 screw who had type II odontoïd fracture with anterior displacement. Authors reported that CT scan taken three months after the surgery showed bone union.\textsuperscript{15} In other study, Xin et al.\textsuperscript{16} identified 14 and 16 patients with odontoïd fracture who were treated using the lag screw and Acutrak 4/5 screw respectively. Authors reported the union rate as 78% and 75% for lag screw and Acutrak screw, respectively.\textsuperscript{16} In our clinical series, Acutrak 3/5 screw was used in all patients. We do not know the result of radiological examination for three patients (One patient died and the other two could not be followed). In other 16 patients, evaluation of radiological examinations demonstrated that, 14 of 16 patients (87.5%) had union in long term follow-up.

In the literature, there are few published biomechanical studies that compare these screws. McBride et al.\textsuperscript{17} demonstrated the biomechanical superiority of a single 4/5 mm Herbert screws than 3.5 mm cannulated lag screws for rotational stiffness and compressive force in odontoïd fracture models of human cadaver. Wheeler et al.\textsuperscript{18} reported that the compression force of standard Acutrak (3/5 mm) screws was stronger than that of both 4.0 mm lag screws and Herbert screws. Magee et al.\textsuperscript{19} compared the biomechanical comparison of Acutrak 4/5 screws and 3.5 mm lag screws in type II odontoïd fractures in human cadaveric model. Authors demonstrated that stiffness and load to failure were greater for the Acutrak 4/5 screws when compared with the 3.5 mm lag screws. Although headless (Herbert and Acutrak) screws seem biomechanically more durable than lag screw, there are also some disadvantages. Namely, Acutrak screws are the higher cost than lag screws and if the screws must be removed in the future, it would be difficult to remove.\textsuperscript{15,16} In our study, we removed three of the 19 patient’s screws (Case 1, 10, 17). In one of three patients, radiological examinations demonstrated the intracranial migration of screw on the postoperative 14th months, and there was no problem with the screw removal procedure (Case 10). In one of three patients (Case 1), we removed screw on the postoperative 3rd day. In the remaining one patient (Case 17), the screw extraction process was required during the first surgery, and we could only perform the screw extraction with the reverse threaded screwdriver.

**Conclusion**

AOSF is a safe and effective surgical treatment option for unstable (type II and rostral “shallow” type III) odontoïd fractures. We have noticed that Acutrak screw could be chosen in the treatment of odontoïd fracture in addition to the lag screw and Herbert screw. This study contains the maximum number of patients using the Acutrak screw for odontoïd fracture in the literature. However, larger prospective clinical studies can provide more accurate information about the effectiveness of the Acutrak screws for odontoïd fractures.
Acknowledgement

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Ethics Committee Approval: This study approved by the Manisa Celal Bayar University Health Sciences Ethics Committee (Date: 11.03.2020, Decision No: 20.478.486).

Peer-review: Internally peer-reviewed.


Conflict of Interest: None declared.

Financial Disclosure: The authors declared that this study has received no financial support.

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Acotrak vidası kullanarak yapılan anterior odontoid vida fiksasyonu: 19 hastanın sunumu

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AMAC: Bu makale, anterior odontoid vida fiksasyonu (AOF) uygulanan hastaların klinik ve radyolojik sonuçlarını sunmayı amaçlamaktadır.

GEREÇ VE YONTEM: Unstabil odontoid kırığı olan toplam 19 hastada Acutrak vidası ile ameliyat edildi.

BULGULAR: Hastaların ortalaması 12.5 ay takip edildi. Hastaların bilgisayarlı tomografi incelemelerinde %87.5 oranında radyolojik füzyon saptandı.


Anahtar sözcükler: Acutrak vidası; anterior odontoid vida fiksasyon; odontoid kırık.