Anterior odontoid lag screw fixation in type II odontoid fractures

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Background
Odontoid fractures are common cervical spine fractures, lead to atlantoaxial instability, and constitute 10–20% of all cervical fractures. Almost two-thirds of all dens fractures are classified as type II according to the Anderson and D' Alonzo classification system. An increased rate of nonunion of type II odontoid fractures with conservative measures has been reported. The technique of direct anterior screw fixation of the odontoid fracture has become increasingly popular since Bohler reported its use in 1982, and it is now widely used to treat type II.

Purpose
To evaluate the safety and efficacy of the anterior transodontoid screw fixation in odontoid fractures.

Patients and methods
Ten patients underwent anterior transodontoid single screw fixation for type II odontoid fractures according to the Anderson and D' Alonzo classification system. All patients were operated on less than 3 months following trauma. All patients were males apart from one female with their ages ranging from 20 to 59 years with a mean age of 33.9 years. Patients were evaluated clinically and neurologically according to the American Spinal Injury Association scale, and radiologically using plain radiograph, computed tomography scan, and MRI.

Results
Good clinical and radiological (bony or fibrous) outcomes were achieved in all patients with no screw loosening, backing out, or proximal migration. There were no complications related to surgical procedure or neurological deterioration.

Conclusion
Direct single anterior screw fixation has proved to be a very successful treatment method for type II odontoid fractures.

Keywords:
cervical spine fractures, odontoid fractures, odontoid screw fixation

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Introduction

Fracture of the odontoid process of the axis is a common injury, and comprises up to 20% of all cervical spine fractures [1]. Most of these odontoid fractures involve the odontoid process at its base or extended into the body of C2 (59%). Odontoid fractures are usually precipitated by a blow to the vertex or upper portion of the skull and usually cause atlantoaxial instability placing the patient at significant risk of immediate or delayed catastrophic spinal cord compromise. Thus, accurate diagnosis and spinal stabilization, when needed is imperative [1].

Odontoid fractures has been classified into three types according to the Anderson and D'Alonzo classification: type I fracture rarely occurs and involves the apical portion of the odontoid process, type II occurs through the waist of the odontoid, these are the most common, and may be either anteriolisthesed or retrolisthesed. Type III is a fracture extending through the cancellous body of C2 and involves a variable portion of the C1–C2 joint [2]. In 2005, Grauer and colleagues further described a modification of type II odontoid fracture based on the anterior–posterior direction of the fracture line. Type II A is a nondisplaced or minimally displaced transverse fracture with no comminution, which could be treated conservatively by external immobilization. Type IIB is a displaced fracture with a fracture line from the anterosuperior to the posteroinferior. It could be managed with an anterior odontoid screw. Type II C is a fracture from the anteroinferior to the posterosuperior, or with significant comminution and requires posterior stabilization [3].

Current nonoperative management includes cervical orthosis, halo vests, and jackets. These do not provide rigid immobilization, having nonunion rates of between 4 and 64% and are poorly tolerated in both the elderly and multiply injured patients. Other complications include pin tract infection, loosening of the pins, penetration of the skull, secondary displacement, pressure sores, respiratory arrest, and death [4,5].

Surgical treatment of the dens fractures has usually been carried out by a posterior fusion of C1 and C2, joints with excellent rates of bony fusion between them. However, it is associated with considerable mortality and morbidity and eliminates 50% of the rotation of the head, a significant loss of motion. Consequently, the anterior odontoid screw fixation has been developed for treating some suitable cases of odontoid fractures attempting to preserve the head rotation [6].

The present study aims to evaluate the results of early reduction and internal fixation of the odontoid fracture using a single screw technique.

Patients and methods

This is an interventional prospective study in which 14 patients with odontoid fractures were examined for the possibility of anterior odontoid screw fixation between December 2019 and May 2022. From them 10 patients with type II transverse or posterior oblique odontoid fractures according to Grauer and colleagues modification of Anderson, and D' Alonzo classification were selected after informed consent. Exclusion criteria were patients with disrupted transverse ligament (anterior dens interval>4 mm), associated Jefferson's fracture (overhang of lateral masses of C1 on C2>7 mm), anterior oblique fracture, old fractures more than 3 months, short neck, excessive cervical kyphosis, concomitant thoracic kyphosis, and barrel-shaped chest. All patients were operated in less than 3-month duration following trauma. Patients were initially evaluated clinically and neurologically according to the American Spinal Injury Association (ASIA) scale, and radiologically with an initial plain radiograph, computed tomography, and MRI (to assess both upper cervical ligamentous and spinal cord integrities). Associated injuries, any perioperative untoward events, and complications related to the procedure were recorded.

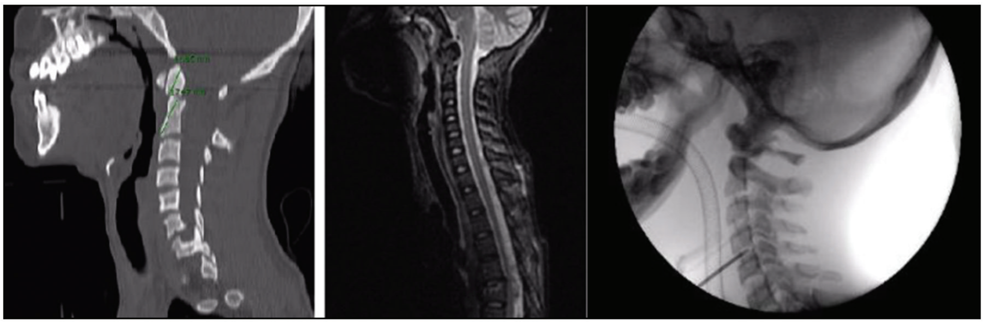
Surgical technique

Patients were placed supine on a standard operating table. General anesthesia was given using the fiberoptic intubation technique to avoid neck manipulation during intubation. A folded sheet or blanket, about 2–4 inches thick is placed on the table to support the patient's shoulders, allowing neck extension. The patient's head is secured using Gardner-Wells tongs with 2 kg of traction applied and stabilized on a padded headrest attached to a radiolucent orthopedic table. A single image intensifier was used and anteroposterior (open mouth, using a radiolucent cylindrical bite gauge block maintaining both mandibles wide part) and lateral images were taken.

Reduction is then achieved with gentle flexion and extension maneuvers. The screw trajectory is checked on the lateral view with a Kirschner wire laid alongside the neck, to ensure that the sternum is clear of the pass of the instruments and for appropriate screw placement (Fig. 1). The patients were operated on through the anteromedial retropharyngeal approach as described by Louis, Robinson, and Smith with a few modifications that are mentioned below [2].

The skin incision was made unilaterally at C5, C6. Only handheld Langenbeck retractors were used to keep the operative area exposed, and no specialized retractors were used. Instrumentation supplied by Synthes for introducing the cannulated screw was used in all patients. The C3 vertebral body is notched, and the anterior annulus of the C2–C3 disk is partially removed in the midline. Approximately 2 mm posterior to the anterior edge of the C2 endplate in the midline, the threaded pin was directed toward the tip of the dens under image intensifier guidance. Once the pin was in the correct position, just below the odontoid tip, a high-speed cannulated drill system was passed over it and a drill tunnel made up to the dens tip. The length

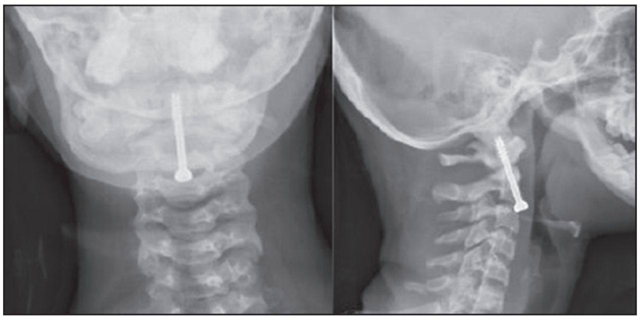
Figure 1



Preoperative initial computed tomography, MRI, and intraoperative postreduction radiograph.

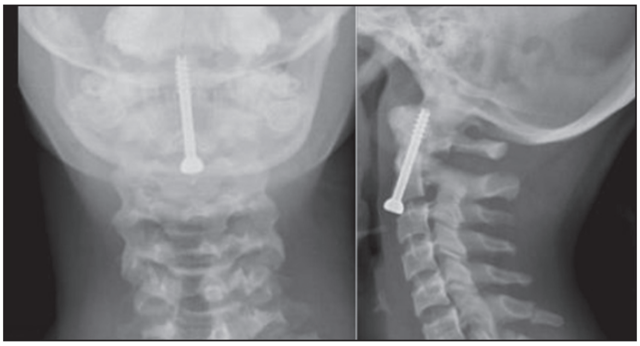
of the screw needed is measured, and an appropriate partially threaded 4 mm cannulated screw was selected and introduced under image guidance. The pin is then removed. The drain was kept in all patients and the wound closed in layers. We used cannulated, partially threaded 4 mm lag screws from the Medtronic implant system for all patients apart from one asymmetric dwarf female patient with short stature with a short C2 body, odontoid length where we used a 28 mm cannulated 4 mm malleolar screw.

Figure 2



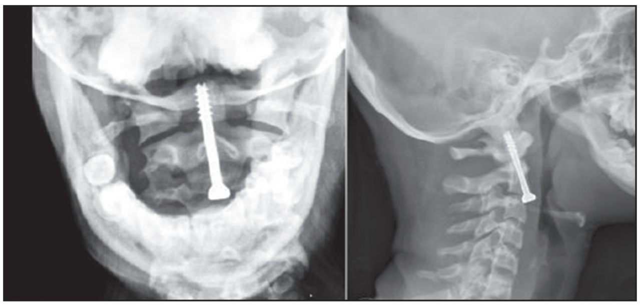
Immediate postoperative radiograph.

Figure 3



Follow-up radiograph after 3 months.

Figure 4



Follow-up radiograph after 24 months.

Following the procedure, the patients were encouraged to wear a Philadelphia neck collar for the first 3 months after surgery and to mobilize early from postoperative day 2, after ensuring good implant position, with reduction adequacy with postoperative radiograph. Patients were advised for follow-up visits, 1 week after for suture clips removal, then at the 1st, 3rd, 6th, and 12th month, and then yearly to rule out evidence of pseudarthrosis (anterior translation or angulation at the fracture site) or any instances of implant failure as screw backing out, breakage, and proximal migration. The mean follow-up period was 6 months (Fig. 2-4).

Postoperative CT scan cervical spine was obtained for four patients for more clarification of the degree of bony union where plain radiograph was questionable. The primary outcome was the appropriate screw position, while the secondary outcome included operative mortality and morbidity rates, long-term functional outcome, fracture union, and stability. Long-term functional outcome was assessed using a modification of the Smily-Webster scale (Table 1) [7]. Bone union was defined by evidence of bone trabeculae crossing the fracture site and the absence of sclerotic borders adjacent to the fracture site. Fracture stability was indicated by the absence of secondary displacement.

Results

There was a male predominance in our study (male: female ratio of 9: 1). Age of patients ranged from 20 to 59 years with a mean age of 33.9 years. Road traffic accident was the most common mode of injury in eight (80%) patients followed by fall injuries in two (20%) patients. There were polytraumas associated with the condition in four (40%) patients. The presence of associated cord injury was in one (10%) patient. The preoperative neurological status of the patient was graded using the ASIA. Most of the patients were ASIA grade E (90%), apart from one (10%) patient that was grade C. According to the modification of Smiley-Webster scale nine (90%) patients had excellent outcomes apart from one patient with good outcomes with occasional pain and noticeably decreased range

Table 1 Functional outcome scale (modification of Smiley-Webster scale)

Scores	Functional	Functional ability
1	Excellent	No pain, no noticeable changeable change in the range of movement, return to full premorbid activities, neurologically intact
2	Good	Occasional pain, noticeably decreased range of movement, any change from premorbid activity, neurologically intact
3	Fair	Moderate pain, change in range of movement, which adversely affects daily activities, or any isolated neurological event
4	Poor	Significant pain, incapacity, catastrophic neurological event, or death

Table 2 Clinical profile of all patients in the study

Numbers	Age/sex	Mode of injury	Medical comorbidities	Symptoms	ASIA grade	Smiley-Weber scale postoperative	Associated injuries
1	24/F	RTA	None	Neck pain	E	1	Head injury, #T7
2	32/M	FFH	None	Neck pain	E	1	#distal radius (right)
3	36/M	RTA	None	Neck pain	E	1	None
4	20/M	FFH	None	Neck pain	E	2	Compression # L1, L2
5	22/M	RTA	None	Neck pain	E	1	None
6	59/M	RTA	Hypertension	Neck pain	E	2	None
7	30/M	RTA	None	Neck pain	E	2	Head injury
8	26/M	RTA	None	Quadriparesis	C	1	C2–C3 cord contusion
9	40/M	RTA	None	Neck pain	E	1	None
10	50/M	RTA	Hypertension	Neck pain	E	1	None

ASIA, American Spinal Injury Association; F, female; M, male; RTA, road traffic accident.

of movement with 30% rotation loss. One of these patients was with neurological deficit (ASIA grade C: useless motor, improved to grade E: normal motor and sensory function). All patients had a good union (80% bony and 20% fibrous) with no instances of wrong trajectory, or false location of screws with no reported cases of implant failure or fracture displacement. Mild discomfort during swallowing was initially reported in all patients immediately postoperatively, which resolved within days secondary to operative pharyngeal retractions. We do not have any wound-related complications (Table 2).

Discussion

The nonunion rate following conservative treatment of type II odontoid fractures varied between 0 and 64% with a mean of ~25% [8]. One reason for this low figured union rate is attributed to the lack of obtaining absolute stable immobilization with external fixation devices [9-11]. Moreover, conservative treatment could lead to the development of delayed myelopathy in patients with nonunited odontoid fractures [12]. Anterior screw fixation in our study proved that it is a practical method of treatment of type II dens fracture with excellent union rate. This result is compared with nonoperative treatment and with C1–C2 fusion operated posteriorly. In spite of obtaining more than 80% union rate with the use of Gallie Brooks fusion of C1–C2 and a mean complication rate of 19%, there is a loss of 47% of the axial rotation and 10° of flexion/extension [13].

Grob and Magerl have combined a Gallie Brooks fusion with a posterior trans-articular screw [14,15]. They reported a 100% rate of fusion but at the expense of a rigid C1–C2 junction. This is in agreement with other studies showing limitation of movement following successful C1–C2 fusion [16,17]. Many studies recommend surgical treatment using single odontoid screw fixation, especially in the elderly with poor tolerance to external fixation and being less traumatic than posterior procedures [18].

In our study, a single screw is used to internally fix and stabilize type II odontoid fractures achieving an excellent fusion rate. A two-screw technique has been advocated by some authors for better screw fixation and rotation control [2]; however, Sasso *et al.* [19] reported in their study that there is no biomechanical difference between one screw and two-screw fixation with the more added surgical time and technical difficulties. Our results also support the above technique of single screw fixation with 82% fusion rate and in agreement with the result of the study conducted by Srinivasan *et al*. [6]. It stabilizes the C1–C2 rotatory motion and also achieves bony union. Anterior odontoid screw fixation should be avoided when the transverse ligament is disrupted. Anterior odontoid screw fixation is a demanding procedure and can invariably lead to major complications. Most of these are related to implant malpositioning and failures.

In one study, the procedure was abandoned in two cases, and there was screw loosening in two patients [20,21]. Critical neurovascular compromise and severe dysphagia have been also reported [21]. We did not have such complications in our study. Our surgical technique using handheld Langenbeck retractors for cannulated dens screw insertion have proved to be successfully used with no necessary need for use of specialized retractors for vital structures. Langenbeck retractors also prevented visceral complications like an esophageal tear, which was reported by Apfelbaum using specialized retractors [22]. It also allows frequent intermittent retraction release while obtaining an radiograph, minimizing the incidence of tracheal and esophageal edema. Proximal threaded pin migration above the odontoid tip toward the brain stem is prevented in our study by first introducing the pin across the odontoid fracture site passing proximally toward the odontoid segment not passing the odontoid tip but short of 1 to 2 mm till reaming with a drill bit to the proximal odontoid tip. The reported rate of mortality and morbidity in our study was nil, while mortality and morbidity rates in the literatures after the odontoid fracture surgery reached 10% in other studies [23].

Conclusion

Direct internal fixation of type II odontoid fractures using a single. Cannulated, partially threaded screw can be considered as the choice of surgical treatment in selected cases (<3 months old type II odontoid fractures). A good fusion rate of about 80% without significant complications could be achieved using this technique. Mobilization could be achieved without the need for other external fixation devices as a halo vest or a more complicated surgery as the posterior C1–C2 fusion with associated complications.

Recommendations

Due to the relatively small sample size, a multicentric study using the same technique could be recommended for significant statistical data.

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Nil.

Conflicts of interest

No conflict of interest.

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