Cureus

Open Access Technical Report

DOI: 10.7759/cureus.225

Complication Avoidance and Management Using the O-arm for Odontoid Screw Fixation: Technical Note

Jau-Ching Wu [1] , Rishi Wadhwa [2] , Khoi Than [3] , Praveen Mummaneni [3]

1. Neurosurgery, Taipei Veterans General Hospital, Taipei, TWN 2. Department of Neurological Surgery, UCSF Medical Center 3. Department of Neurosurgery, University of California, San Francisco

Corresponding author: Khoi Than, thank@neurosurg.ucsf.edu
Disclosures can be found in Additional Information at the end of the article

Abstract

Objective: Odontoid screw fixation is an accepted surgical approach for Type 2 odontoid fractures with an intact transverse ligament. Typically, intraoperative bi-planar flouroscopy is used for placement of an odontoid screw. However, the quality of the images obtained with bi-planar fluoroscopy in the operating room is variable (due to patient body habitus) and screws may be misplaced. We report our technique for the use of the O-arm (Medtronic Navigation, Louisville, Colorado) to place and revise odontoid screw fixation.

Methods and Results: The O-arm is sterilely draped into the surgical field. Intraoperative navigation is not needed. Using anteroposterior and lateral fluoroscopic images obtained from the O-arm, the trajectory of the Kirschner wire, drill, tap, and screw can be visualized in real time. The final screw position can then be checked with a computed tomographic reconstruction view done with the O-arm while the patient is still draped sterilely in the operating room. We have utilized the O-arm to avoid a screw malposition in one patient with an odontoid fracture with osteopenia (which made visualization of the cervical spine difficult with standard fluoroscopy). We have also utilized O-arm visualization to retrieve a malpositioned and migrated odontoid screw placed outside of our institution.

Conclusions: Odontoid screw fixation and retrieval can be performed safely and efficiently using the O-arm. Our technique for use of the O-arm for this application does not require image guidance and replaces standard bi-planar fluoroscopy typically used for odontoid screw cases.

Categories: General Surgery, Neurosurgery, Orthopedics
Keywords: odontoid fracture, o-arm, odontoid screw

Received 10/12/2014
Review began 10/13/2014
Review ended 11/04/2014
Published 11/06/2014

Introduction

The Anderson Type 2 odontoid fracture is the most common axis fracture [1-2]. Since the 1980's, odontoid screw fixation has been used to treat odontoid fractures with fusion rates higher than 80% [3-6]. Odontoid screw fixation is currently a commonly accepted surgical approach for type 2 odontoid fractures with an intact transverse ligament [7-9]. Both one- and two-screw fixation techniques are valid and render similar clinical outcomes and arthrodesis rates [10-11]. However, placement of the screw is technically demanding and complications are not infrequent [12]. Besides non-union, there is also a risk of vascular injury reported with odontoid screw placement [8, 13-15].

How to cite this article
Wu J, Wadhwa R, Than K, et al. (November 06, 2014) Complication Avoidance and Management Using the O-arm for Odontoid Screw Fixation: Technical Note. Cureus 6(11): e225. DOI 10.7759/cureus.225

Intraoperative fluoroscopy is considered essential for placement of an odontoid screw [7]. Monitoring of both the lateral and anterior-posterior (AP) flouroscopic images assists safe placement of the screw. However, two C-arm fluoroscopy machines are space occupying, time-consuming to set up, and may not always be available. The authors replaced the two C-arm fluoroscopy setup with an O-arm (Medtronic Navigation, Louisville, Colorado) for intraoperative dual plane imaging. The advent of this technology allows movement of the X-ray tubes and detectors to rapidly switch between the lateral and AP views. Various spinal surgery procedures using the O-arm for three-dimensional reconstructed images in conjunction with image-guided navigation have been reported, but prior reports do not detail the use of this technology for odontoid screw fixation [16-18]. We sought to provide the technical details of using the O-arm for placement and retrieval of odontoid screws.

Technical Report

Patient positioning and image guidance setting

Following fiberoptic intubation, the patient is placed supine on the operating table under general anesthesia. The shoulders and the neck are usually positioned neutral or slightly extended. The patient's head may be immobilized with tape or with halo traction. A radiolucent mouth gag is placed into the oral cavity to facilitate an open-mouth fluoroscopic view of the atlanto-axial complex.

The O-arm is opened and positioned around the patient's head and neck. If the patient is in traction, the traction apparatus typically fits within the O-arm ring.

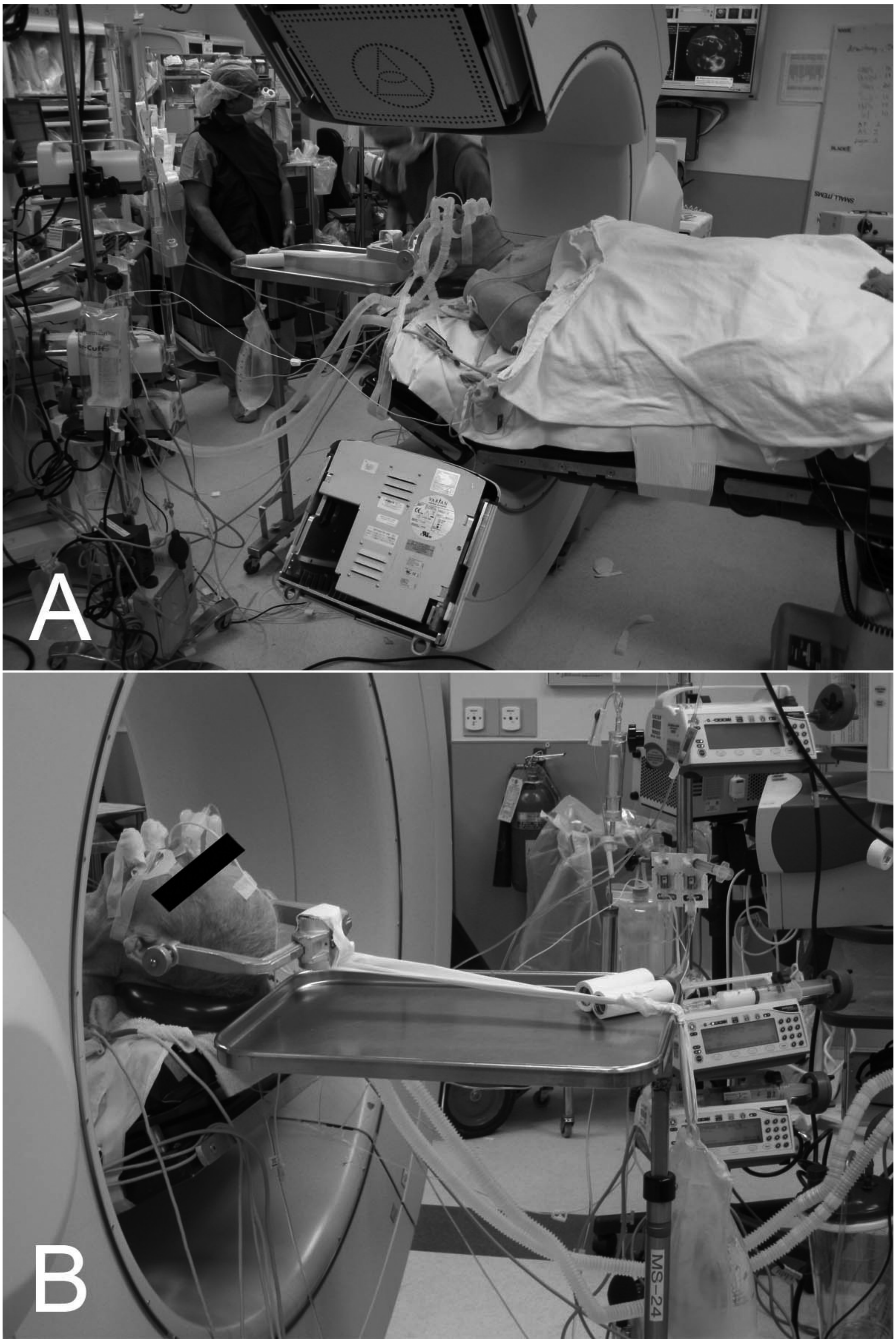

FIGURE 1: Setup of the O-arm

(A) The O-arm was positioned perpendicular to the long axis of the cervical spine. (B) The patient was placed in traction, and the traction apparatus fit within the O-arm opening.

The O-arm is tilted slightly cranially to acquire the open-mouth fluoroscopic image. The O-arm system allows rapid switching between the lateral and AP fluoroscopic views during operation, and these views are reviewed to ensure the fracture is reduced. Then the two alternating positions for the fluoroscopy are set into memory of the O-arm. The patient and the O-arm are then draped into the surgical field. The O-arm is shifted cranially to allow the surgeons to operate in the sterile field unhindered.

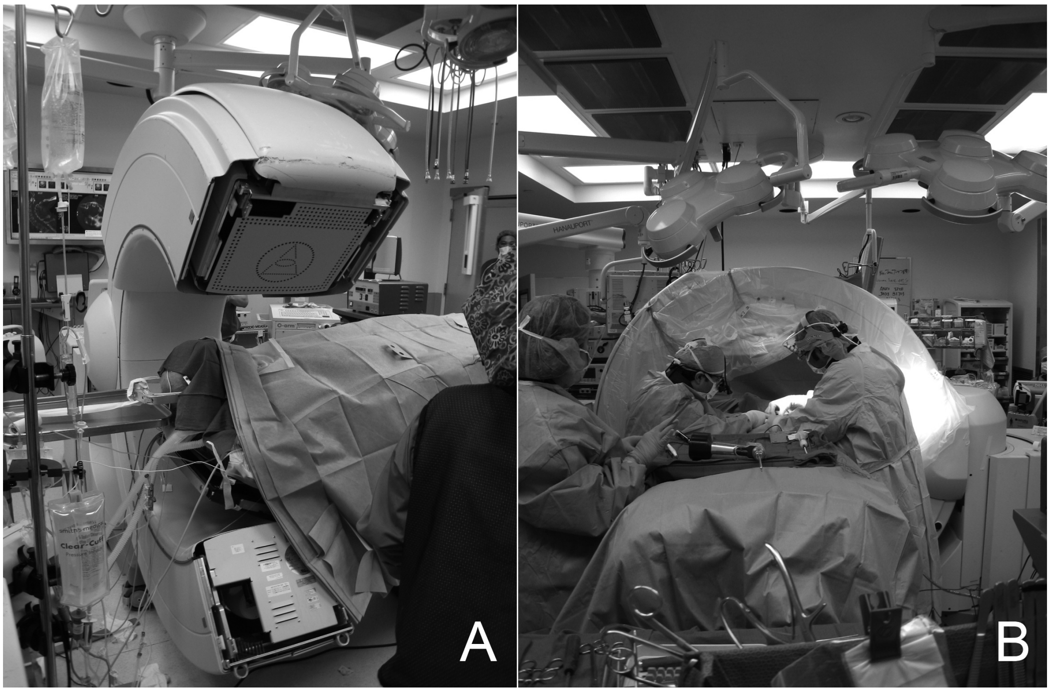

FIGURE 2: Draping of the patient and O-arm

The O-arm ring was opened (A) to allow sterilization and draping procedures. (B) Intraoperative photo of surgeons operating with the O-arm shifted cranially.

After a standard anterior cervical approach in the mid-cervical spine, the trajectory for the Kirschner wire (K-wire) to cross the odontoid fracture is planned and executed using fluoroscopic imaging with the O-arm.

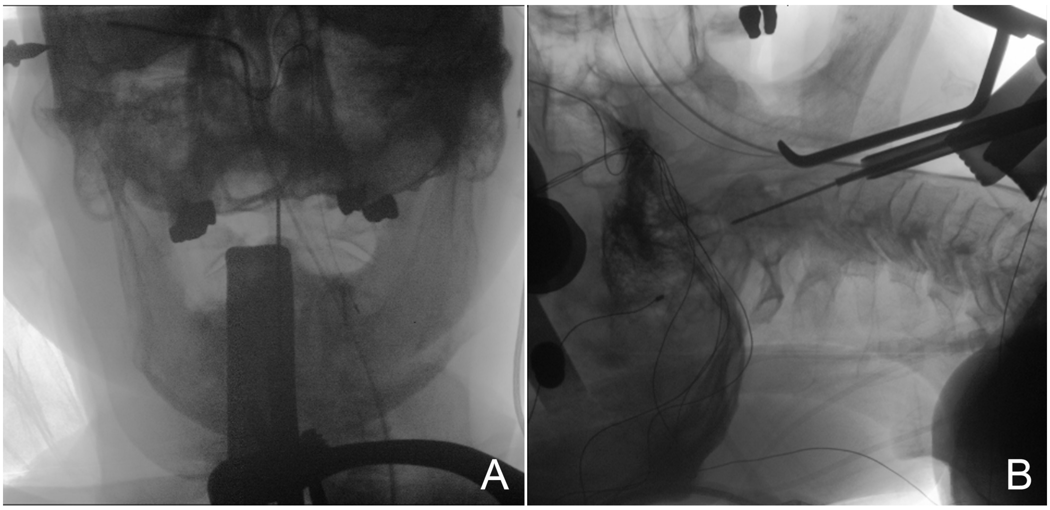

FIGURE 3: Intraoperative image guidance by the O-arm

A K-wire was placed through the dens fracture using anterior-posterior view (A) and lateral view (B) fluoroscopic image using the O-arm.

The use of image guidance is not necessary as "spot" fluoroscopic images in the antero-posterior and lateral plane are easily obtained with the O-arm. Following fracture capture with the K-wire, the screw path is drilled with a cannulated drill and then tapped. A lag screw is then placed to realign and secure the fracture. Lateral and AP fluoroscopic images are obtained during each of these steps using the O-arm. Since real-time fluoroscopic images are optimal to avoid incorrect K-wire and drill trajectories, we have chosen not to use any image guidance system in conjunction with the O-arm.

Case example 1 (complication avoidance in the placement of an odontoid screw)

This patient is an 83-year-old man who presented with a displaced C2 odontoid fracture following a fall. He was osteoporotic, and imaging of his cervical spine was difficult with standard X-ray and fluoroscopy as a result. Consequently, we utilized the O-arm system to place his odontoid screw as the image quality was superior to standard fluoroscopy. An odontoid screw was placed, and the trajectory and placement of the screw were immediately verified intraoperatively using an O-arm reconstructed CT scan.

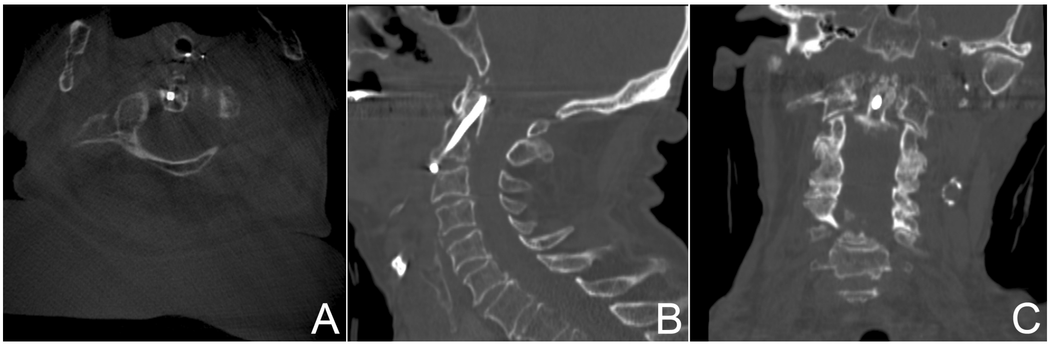

FIGURE 4: Postoperative computed tomography for an odontoid screw placement

The type 2 odontoid fracture was approximated with a single odontoid screw. (A: axial, B: sagittal, and C: coronal images taken intraoperatively with the O-arm)

Case example 2 (complication management: retrieval of a malpositioned odontoid screw)

This patient is a 27-year-old woman who sustained a Type 2 dens fracture in a motor vehicle accident. The patient underwent placement of an odontoid screw in another country. She underwent X-rays in our clinic which showed mal-alignment and nonunion of her fracture. The screw tip projected through the dens and terminated against the clivus

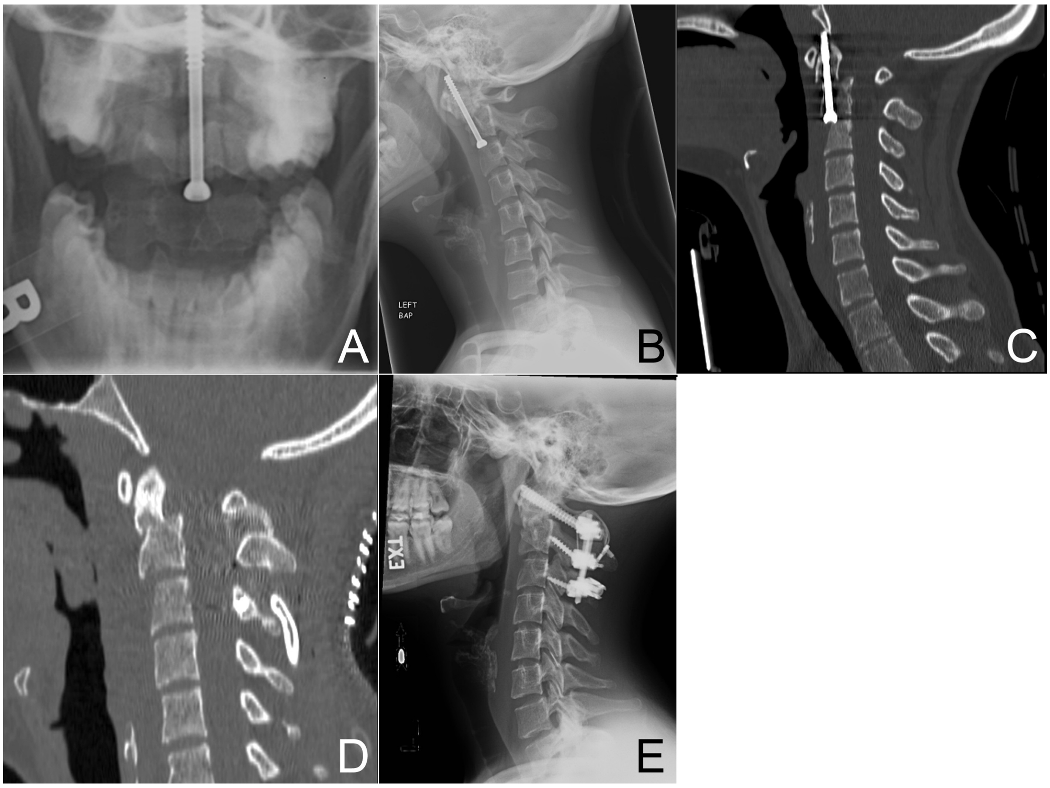

FIGURE 5: Serial images of a retrieval of an odontoid screw

Anterior-posterior (A) and lateral view (B) radiographs demonstrate a mal-positioned odontoid screw resting against the clivus. The odontoid fracture is not well aligned and the fracture did not heal (C). The odontoid screw was successfully retrieved using intraoperative imaging with the O-arm, and the patient underwent posterior fixation of C1-3 (D - postoperative sagittal CT scan, and E - postoperative lateral X-ray).

There was also a comminuted fracture of the left lateral mass of C2 with extension of the fracture into the left foramen transversarium.

She was taken to the operating room for removal of her odontoid screw and subsequent posterior spinal fixation and fusion. The patient was placed in extension, and the O-arm imaging was used to find the caudal end of the screw that was embedded in the C2-3 disc space. The position of the screw tip was difficult to visualize grossly, and the O-arm allowed for quick localization with biplanar imaging. The screw was successfully retrieved and a posterior C1-2-3 fixation was subsequently performed.

Discussion

The cornerstones for safety in the placement of an odontoid screw are appropriate selection of candidates (avoid patients with a barrel chest, poor bone quality, or cervical kyphosis), adequate reduction of the fracture (with positioning and traction), and use of bi-planar fluoroscopic image guidance. Often, two C-arm fluoroscopes are sufficient for intraoperative radiographic imaging with odontoid screw fixation. Although use of an O-arm is not mandatory, it can accelerate the procedure by reducing the time to set up a system of reciprocal fluoroscopes.

We have successfully placed odontoid screws in challenging patients (with osteoporotic spines that inhibit fluoroscopic imaging) using the O-arm. We have also successfully used this technology to retrieve malpositioned odontoid screws. We did not find image-guided navigation necessary for these procedures. The O-arm's biplanar imaging characteristics and intraoperative CT scan reconstruction of the screw position were adequate and quick and provided immediate feedback to the surgeon while still in the operating room. The O-arm allows fast sequential imaging of both the lateral and AP images and is well-suited for use in odontoid screw fixation cases. Although an O-arm system is somewhat bulky, it avoids the burden of positioning two C-arm fluoroscopes perpendicular to each other.

Conclusions

Odontoid screw fixation and revision can be performed safely and efficiently in osteoporotic patients using O-arm radiographic visualization. The O-arm allows for dual plane live imaging of K-wire, drill, and screw placement, and image guidance is not needed. The surgeon has immediate intraoperative feedback with a reconstructed CT image of the screw fixation using this technology.

Additional Information

Disclosures

Human subjects: All authors have confirmed that this study did not involve human participants or tissue. **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** Praveen V. Mummaneni declare(s) royalties from DePuy. Praveen V. Mummaneni declare(s) royalties and an alternate financial activity from Globus. Praveen V. Mummaneni declare(s) an alternate financial activity from Quality Medical Publishing. Praveen V. Mummaneni declare(s) royalties and an alternate financial activity from Thieme Publishing. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

References

1. Anderson LD, D'Alonzo RT: Fractures of the odontoid process of the axis . J Bone Joint Surg Am. 1974, 56:1663-74.
2. Hadley MN, Dickman CA, Browner CM, Sonntag VK: Acute axis fractures: A review of 229 cases. J Neurosurg. 1989, 71:642-7.
3. Aebi M, Etter C, Coscia M: Fractures of the odontoid process. Treatment with anterior screw fixation. Spine (Phila Pa 1976). 1989, 14:1065-70.
4. Borne GM, Bedou GL, Pinaudeau M, Cristino G, Hussein A: Odontoid process fracture osteosynthesis with a direct screw fixation technique in nine consecutive cases. J Neurosurg. 1988, 68:223-6.
5. Geisler FH, Cheng C, Poka A, Brumback RJ: Anterior screw fixation of posteriorly displaced type II odontoid fractures. Neurosurg. 1989, 25:30-7.
6. Moossy JJ, Hanley EN: Anterior screw fixation of odontoid fractures . Neurosurg. 1989, 25:847.
7. Apfelbaum RI, Lonser RR, Veres R, Casey A: Direct anterior screw fixation for recent and remote odontoid fractures. J Neurosurg. 2000, 93:227-36.
8. Dailey AT, Hart D, Finn MA, Schmidt MH, Apfelbaum RI: Anterior fixation of odontoid fractures in an elderly population. J Neurosurg Spine. 2010, 12:1-8. 10.3171/2009.7.SPINE08589
9. Rao G, Apfelbaum RI: Odontoid screw fixation for fresh and remote fractures . Neurol India. 2005, 53:416-23.
10. Jenkins JD, Coric D, Branch CL Jr: A clinical comparison of one- and two-screw odontoid fixation. J Neurosurg. 1998, 89:366-70.
11. ElSaghir H, Böhm H: Anderson type II fracture of the odontoid process: Results of anterior screw fixation. J Spinal Disord. 2000, 13:527-30.

12. Andersson S, Rodrigues M, Olerud C: Odontoid fractures: High complication rate associated with anterior screw fixation in the elderly. Eur Spine J. 2000, 9:56-9.
13. Daentzer D, Deinsberger W, Böker DK: Vertebral artery complications in anterior approaches to the cervical spine: Report of two cases and review of literature. Surg Neurol. 2003, 59:300-9.
14. Wilson DA, Fusco DJ, Theodore N: Delayed subarachnoid hemorrhage following failed odontoid screw fixation. J Neurosurg Spine. 2011, 14:715-8. 10.3171/2011.1.SPINE10561
15. Section on Disorders of the Spine and Peripheral Nerves of the American Association of Neurological Surgeons and the Congress of Neurological Surgeons: Isolated fractures of the axis in adults. Neurosurg. 2002, 50:S125-39.
16. Kim S, Chung J, Yi BJ, Kim YS: An assistive image-guided surgical robot system using O-arm fluoroscopy for pedicle screw insertion: preliminary and cadaveric study. Neurosurg. 2010, 67:1757-67. 10.1227/NEU.0b013e3181fa7e42
17. Oertel MF, Hobart J, Stein M, Schreiber V, Scharbrodt W: Clinical and methodological precision of spinal navigation assisted by 3D intraoperative O-arm radiographic imaging. J Neurosurg Spine. 2011, 14:532-6. 10.3171/2010.10.SPINE091032
18. Schils F: O-arm-guided balloon kyphoplasty: Prospective single-center case series of 54 consecutive patients. Neurosurg. 2011, 68:250-6. 10.1227/NEU.0b013e31821421b9