Case Report

Computer-assisted navigation of anterior odontoid screw fixation for type II odontoid fracture: case report and practical positioning technique

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Background: Odontoid process fractures, particularly type 2 fractures, pose significant treatment challenges due to their high rates of nonunion. Anterior odontoid screw fixation (AOSF) is traditionally performed using percutaneous methods with biplanar fluoroscopy. Computer-assisted navigation has emerged as a promising tool to enhance surgical precision, but its application in AOSF is rarely utilized. Cervical spine stability during AOSF is crucial for optimal outcomes and navigational accuracy.

Case Description: A 64-year-old male presents with a displaced type 2 odontoid fracture following a fall. The fracture was treated with AOSF with the assistance of computed tomography (CT) navigation. A practical positioning technique employing a pressure infusion bag was introduced to stabilize cervical motion during surgery. This technique allows for precise instrumentation while minimizing the risk of navigational inaccuracy. Intraoperative imaging confirmed excellent fracture reduction and screw placement, facilitating a favorable surgical outcome.

Conclusions: CT navigation for AOSF is not yet widely adopted for the treatment of type 2 odontoid fractures due to inherent risks of fracture displacement, navigational inaccuracy, and iatrogenic injury. The off-label use of a pressure infusion bag for cervical stabilization offers a practical and cost-effective solution to enhance surgical precision. While further research is needed to compare the efficacy and radiation exposure of navigation-guided versus fluoroscopy-assisted AOSF, our report demonstrates that a safe and optimal outcome can be achieved using navigation-guided techniques.

Keywords: Anterior odontoid screw fixation (AOSF); computed tomography (CT); navigation; cervical stabilization; case report

Submitted Apr 21, 2024. Accepted for publication Jul 26, 2024. Published online Sep 12, 2024.
doi: 10.21037/jss-24-46
View this article at: https://dx.doi.org/10.21037/jss-24-46

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Introduction

Background

Odontoid fractures are the most common fractures of the cervical spine in patients over 65 and make up 10–20% of all cervical spinal fractures (1,2). Type 2 fractures, classified by Anderson and D'Alonzo, consist of fractures along the base of the odontoid process where there is a vascular watershed (3). Due to high rates of nonunion, treatment of type 2 odontoid fractures has proven to be challenging.

The two main surgical options for type 2 odontoid fractures are anterior odontoid screw fixation (AOSF) and C1–C2 posterior spinal fusion (PSF). In contrast to cervical PSF, in which the motion of the atlantoaxial segment is sacrificed, AOSF maintains atlantoaxial motion (4). AOSF is the preferred method of treatment for patients with odontoid process fractures oriented in an anterosuperior to posteroinferior direction and are not comminuted. In patients with osteoporosis, severe cervicothoracic kyphosis, or injury to the transverse ligament, AOSF is not recommended (4-6).

Rationale and knowledge gap

AOSF is traditionally performed with the assistance of biplanar fluoroscopy. One C-arm can be placed in a position obtaining anteroposterior images of C2 while a second C-arm is placed orthogonally obtaining lateral images. A Kirschner wire (K-wire) is placed orthogonally across the fracture for provisional reduction. A cannulated screw can then be inserted after predrilling and tapping over the K-wire.

In recent decades, the use of intraoperative computed tomography (CT), in combination with computer-assisted navigation, has gained popularity. However, significantly unstable fractures such as odontoid fractures can lead to navigational inaccuracy (7). Navigational inaccuracy during AOSF may risk injury to the spinal cord due to screw or drill cutout. For these reasons, navigation is rarely used in AOSF.

Objective

In this case report, we discuss the use of computer-assisted navigation to safely perform AOSF and describe the authors' preferred technique with a unique positioning pearl. We present this case in accordance with the CARE reporting checklist (available at https://jss.amegroups.com/article/view/10.21037/jss-24-46/rc).

Highlight box

Key findings

- Our patient experienced an excellent outcome after being treated with anterior odontoid screw fixation (AOSF) using computed tomography (CT)-assisted navigation for acute type 2 odontoid fracture.

What is known and what is new?

- AOSF with CT-assisted navigation is not widely adopted due to the risks of fracture displacement, loss of navigation accuracy, and iatrogenic injury.
- Positioning techniques are especially crucial in CT-assisted AOSF, as enhanced cervical spine stability can maintain instrumentation precision.

What is the implication, and what should change now?

- Intravenous pressure infusion bags are widely available in U.S. hospitals. Spine surgeons may consider using these bags to support the cervical spine during AOSF.

Case presentation

A 64-year-old male presented to the emergency department complaining of neck pain after falling and hitting his head during a night of heavy alcohol use. Imaging of the cervical spine revealed a type 2 odontoid fracture with 4 mm of posterior displacement of the fractured fragment (*Figure 1*). The consensus decision was made within the spine team to proceed with AOSF the next day.

All procedures performed in this study were in accordance with the ethical standards of the University of Michigan institutional review board (IRB) HUM00250029 and with the Helsinki Declaration (as revised in 2013). Written informed consent was obtained from the patient for the publication of this case report and accompanying images. A copy of the written consent is available for review by the editorial office of this journal.

Technique

Positioning

The patient was placed supine on a flat Jackson table with the arms tucked. A Mayfield clamp was secured onto the patient's skull. Fracture reduction was performed with gentle traction of the Mayfield in line with the long axis of the cervical spine with the neck at neutral. The Mayfield clamp was then attached to the bed frame with the neck in a slightly extended position. We initially supported the

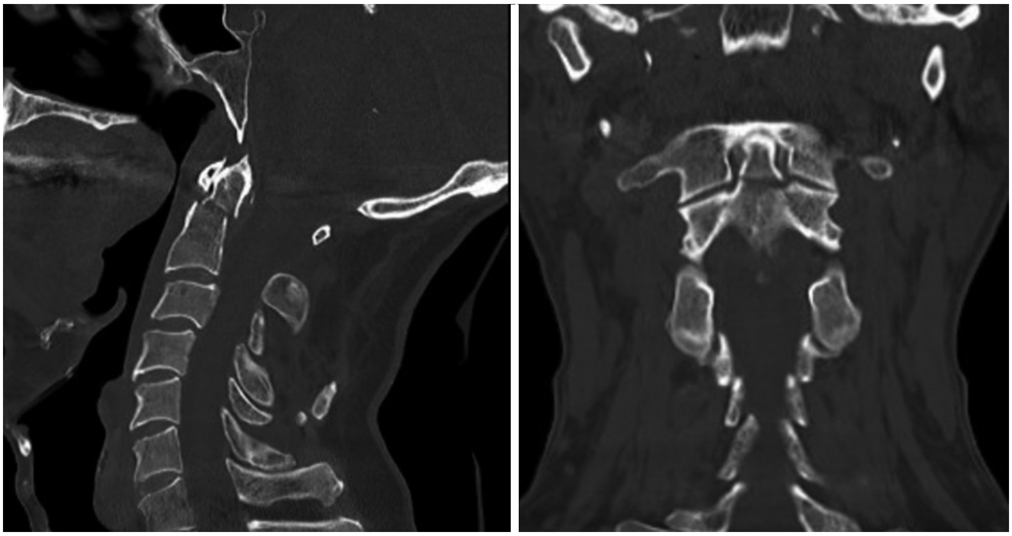

Figure 1 Injury computed tomography scan demonstrated an odontoid process fracture with slight posterior displacement of the tip.

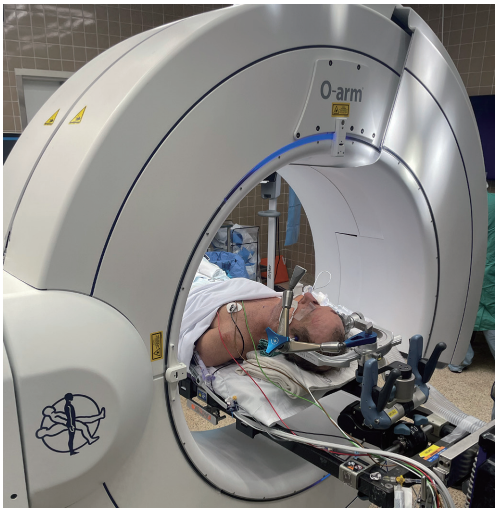

Figure 2 The patient is positioned supine with the arms tucked with the Mayfield head attachment mounted to the bed frame. The patient's head and neck were initially supported by a stack of blankets, but neck stability was inadequate. This image is published with the patient's consent.

neck with folded blankets placed under the head (*Figure 2*) as described by other authors (8); however, we found that this was not sufficient to control flexion and extension. In place of blankets, we placed a standard 500-milliliter pressure infusion bag under the neck and partially inflated it to the desired neck position (*Figure 3*). Pressure infusion bags are used to provide bolus doses of intravenous fluids. The firm contour of the pressure bag matches the curve of the posterior neck, counteracting flexion and extension while also providing cushion to prevent pressure ulceration. Intraoperative CT was obtained to confirm acceptable fracture reduction.

Setup

A 3-centimeter right-sided incision was made at approximately the level of the C5–C6 disc space using a standard Smith-Robinson approach. The incision must be significantly caudal to C2 because of the steep the trajectory to fix the fracture. Once down to the prevertebral space, the prevertebral fascia was retracted cranially to expose the C2–C3 disc space, which was confirmed using fluoroscopy.

Operative technique

After exposure, we attached a stealth array to the Mayfield and intraoperative CT was obtained to confirm maintenance of fracture reduction. A navigated drill was used starting at the center of the superior body of C3, through the C2–C3 disc space, the body of C2, then finally into the odontoid process and across the fracture. A navigated probe was used to confirm that there was no cortical breach. Finally, a 4.0-mm fully threaded self-tapping cannulated screw was inserted with a navigated screwdriver and bicortical purchase was achieved. Final CT was obtained showing excellent screw placement (*Figure 4*).

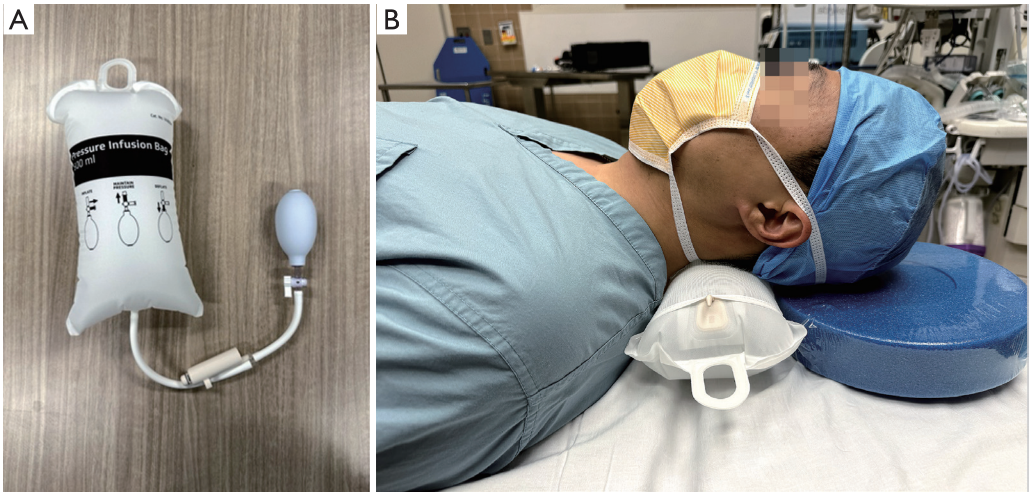

Figure 3 The authors' positioning technique for anterior odontoid screw fixation involves using an intravenous pressure bag, a widely available device in hospitals and operating rooms, to support the patient's neck while supine. (A) Intravenous pressure bags are inflatable devices used to bolus intravenous fluids. (B) The contour of the intravenous pressure bag not only supports, but also matches the contour of the neck. Absolute neck stability is crucial during anterior odontoid screw fixation to minimize iatrogenic injury and navigational inaccuracy. This image is published with the participant's consent.

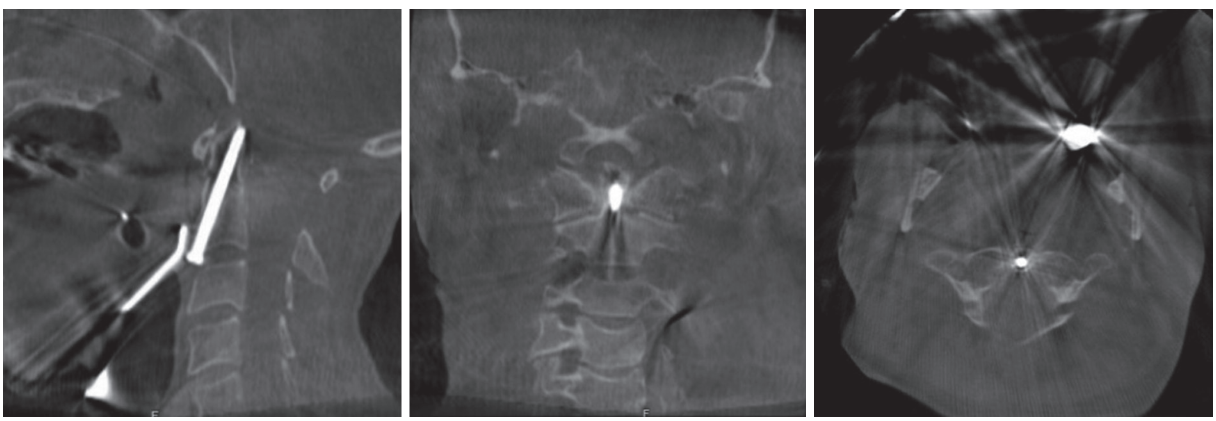

Figure 4 Intraoperative computed tomography scan demonstrated excellent fracture reduction and anterior odontoid screw placement.

Follow-up

Following meticulous hemostasis, a Hemovac drain was placed to prevent post-operative hematoma and the incision was closed in layers using 3-0 vicryl and skin glue. A Miami-J cervical collar was placed postoperatively, and the patient was instructed to maintain cervical precautions for 12 weeks. Postoperative radiographs demonstrated maintenance of fracture reduction and healing at 6 months (*Figure 5*) and the patient reported no residual pain or motion deficits.

Discussion

Key findings, strengths and limitations

Computer-assisted navigation is not yet widely adopted for anterior fixation of type 2 odontoid fractures. Here, we describe a case of successful AOSF for type 2 odontoid fracture using computer-assisted navigation. Our method introduces an inexpensive and practical positioning tip for stabilizing cervical motion, leveraging the pressure infusion bag—a readily available and standard piece of equipment in

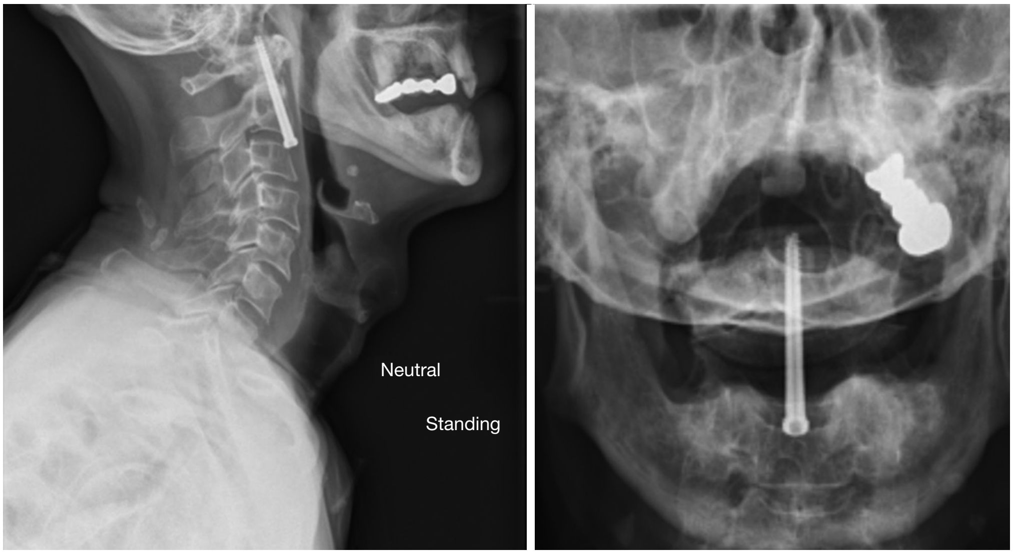

Figure 5 Radiographs at 6 months exhibited maintained screw alignment and fracture healing.

U.S. hospitals. Our aim is to reduce barriers to access for surgeons in both academic and community-based settings. In addition, because navigation can be prone to inaccuracy, we recommend the liberal use of intraoperative CT to verify precise instrumentation.

Fluoroscopy-guided navigation for AOSF requires the use of one, and sometimes two, C-arm machines positioned orthogonally near the head and approaching from opposite sides of the table. This setup can pose challenges and inconvenience for the surgeon and their assistant when maneuvering instruments due to limited space. Operating a second C-arm machine often necessitates the presence of an additional radiology technician. Unlike fluoroscopy, navigation does not require significant neck hyperextension, which is typically necessary for adequate trans-oral X-rays. Due to parallax and the superimposition of structures such as teeth or the skull, achieving optimal fluoroscopic imaging of the odontoid process can be reliably challenging without experienced surgeons and radiology technicians. The advantages of fluoroscopy include rapid image acquisition and real-time identification of fracture displacement or screw malposition.

Comparison with similar research

No literature has compared the accuracy of between fluoroscopy freehand and navigation-guided AOSF in the treatment of type 2 odontoid fractures. With respect to the thoracolumbar spine, one meta-analysis showed safer profile and higher accuracy with navigated pedicle screws compared to fluoroscopic freehand pedicle screws (9). Another article showed the opposite in C2 pars or pedicle screw placement: freehand fluoroscopy resulted in more acceptable screw placement than in navigated screws (10). Further research is needed to illuminate whether AOSF is safer and more accurate with freehand fluoroscopy or CT navigation.

Minimally invasive techniques, including endoscopic or percutaneous placement of odontoid screws, have also been described. One study discusses a series that used a tubular dilator retractor system for screw placement, achieving good results with no complications in 28 out of 29 patients (11). Another study utilized a beveled bone marrow biopsy needle (Jamshidi needle) as a sleeve for guide wire insertion, showing excellent clinical and radiological outcomes without soft tissue or esophageal complications (12). We believe these minimally invasive techniques can be employed alongside our positioning technique using navigation-guided instrumentation to enhance safety.

Explanation of findings

The average radiation emitted from CT navigation compared to freehand fluoroscopic insertion of anterior odontoid screws is unknown. At our institution, operating room staff stand outside of the operating room or behind a leaded shield during intraoperative CT spins. Conversely, staff and surgeons wear individual lead aprons during fluoroscopy assisted procedures with C-arm. Therefore, we hypothesize the overall radiation dose to staff is lower with the use of intraoperative CT than with the use of fluoroscopy during AOSF. Multiple intraoperative CT scans may be required with navigation techniques to ensure safe screw placement and maintain fracture reduction. This can result in higher radiation doses to the patient. Fluoroscopy-guided techniques expose both the patient and the operating room staff to radiation. As discussed earlier, less experienced surgeons and radiation technicians may require longer fluoroscopy time and deliver higher radiation doses to achieve optimal imaging. One study showed that for one-level minimally invasive transforaminal lumbar interbody fusion (TLIF), navigated pedicle screws resulted in almost no radiation to operating room staff, but resulted in higher radiation doses to patients compared to free fluoroscopic pedicle screws. However, the radiation doses to patients between intraoperative CT and fluoroscopy guided pedicle screws was the same at 2 or more TLIF levels (13). Further study comparing aggregate fluoroscopy time and lead apron dosimetry data should be collected between fluoroscopic and CT-guided techniques.

Implications and actions needed

Additional research is necessary to evaluate radiation time, patient-reported outcomes, radiographical fusion rates, optimal screw positioning, and complication rates in the treatment of type 2 odontoid fractures with AOSF using intraoperative CT navigation versus fluoroscopy-guided techniques. We plan to continue using this novel technique in the future to eventually compare our series with a historical fluoroscopy-guided cohort.

Conclusions

We report a case of successful treatment of type 2 odontoid fracture with AOSF using computer-assisted navigation. Accuracy with navigation is vital. We discuss an innovative, practical, and inexpensive positioning technique to stabilize cervical spine motion prior to screw fixation.

Acknowledgments

Funding: None.

Footnote

Reporting Checklist: The authors have completed the CARE reporting checklist. Available at https://jss.amegroups.com/article/view/10.21037/jss-24-46/rc

Peer Review File: Available at https://jss.amegroups.com/article/view/10.21037/jss-24-46/prf

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://jss.amegroups.com/article/view/10.21037/jss-24-46/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All procedures performed in this study were in accordance with the ethical standards of the University of Michigan institutional review board (IRB) HUM00250029 and with the Helsinki Declaration (as revised in 2013). Written informed consent was obtained from the patient for the publication of this case report and accompanying images. A copy of the written consent is available for review by the editorial office of this journal. Because the project involves only one case and is intended as an illustrative example for educational purposes, including the off-label use of a healthcare device, no additional IRB approval is required.

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Cite this article as: Gong DC, Yassin M, Patel RD, Kashlan ON, Aleem I. Computer-assisted navigation of anterior odontoid screw fixation for type II odontoid fracture: case report and practical positioning technique. J Spine Surg 2024;10(3):590-596. doi: 10.21037/jss-24-46

