

Odontoid Fracture with Locked Posterolateral Atlantoaxial Dislocation

A Case Report and Review of Literature

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Abstract

Case: Odontoid fractures with atlantoaxial dislocations are rare injuries. We report a case of a 41-year-old man with a Type 2 odontoid fracture with locked facet and posterolateral dislocation. He underwent single-stage C1-C4 posterior fixation and fusion, and at 2-year follow-up, he is symptom-free without any residual pain. Follow-up radiograph and CT scan show healed odontoid fracture with posterior fusion.

Conclusion: This case highlights successful management of a complex odontoid fracture by a single-stage posterior surgery. Closed reduction is usually unsuccessful, and open reduction using posterior approach is preferable.

Odontoid fractures constitute about 15% of cervical spine injuries and are frequently associated with C1 arch fractures, subaxial cervical spine fractures, and vertebral artery injuries (VAIs) (7%)¹⁻³. Odontoid fractures can be associated with atlantoaxial dislocations, which can be anterior, rotatory, or posterolateral dislocations^{4,5}. Posterolateral dislocations are relatively rare and caused by hyperextension injury patterns with less than 10 cases reported in the literature. The management approach for these cases varies based on the degree of fracture displacement, presence of locked facet, reducibility of the atlantoaxial dislocation, postreduction stability, associated ligamentous injury, and neurologic status of the patient.

We report a case of a 41-year-old man who had an odontoid fracture with locked C1-C2 facet joint and posterolateral atlantoaxial dislocation, which was managed successfully with single-stage posterior instrumented fusion.

The patient was informed that data concerning the case would be submitted for publication, and he provided consent.

Case Report

A 41-year-old man presented to our emergency department with head and neck injuries sustained during a high-speed car collision. Initial management was performed as per Advanced Trauma Life Support protocol. He had upper cervical tenderness without neurologic deficits. Radiographs showed odontoid fracture with atlantoaxial dislocation (Figs. 1-A and 1-B). Further imaging with Computed Tomography (CT) scans revealed a Type

2B odontoid fracture (Grauer subclassification of Anderson and D'Alonzo classification)⁶ with a posterolateral dislocation of the atlas over the axis, and a locked facet on the right side (Figs. 1-C, 1-E, and 2). Magnetic resonance imaging (MRI) showed extensive posterior ligamentous complex (PLC) injury with intact transverse atlantal ligament (Fig. 3).

After initial stabilization, he was planned for surgery. Prone positioning was performed using Mayfield skull clamp. Standard posterior approach for the upper cervical spine was used for exposure.

Intraoperatively, there was extensive damage to the posterior ligamentous structures at C2-C3 levels. The C3 lateral mass screw had to be skipped on the left side because of breakage of lateral mass while attempting instrumentation. Considering the extensive PLC injury and highly unstable upper cervical injury and activity level of the patient, it was decided to extend the fixation and fusion up to C4.

Posterior C1-C2 fixation by C1 lateral mass-C2 pedicle screw (Goel-Harms technique) was performed. Reduction was achieved by applying traction followed by gentle push of C1 over C2 using the thumb. Macdonald retractor was used to manipulate the facet joint to aid in reduction. Reduction was felt with a click and was confirmed with fluoroscopy. The extensive damage to posterior ligamentous structures aided in the reduction, which was easier than anticipated. Posterior fusion bed was prepared, and bone graft (autograft from posterior iliac crest mixed with allograft) was packed posteriorly from C1 to C4 for posterior fusion. Contoured rods were applied bilaterally.

Disclosure: The Disclosure of Potential Conflicts of Interest forms are provided with the online version of the article (<http://links.lww.com/JBJS/CC/C422>).

Keywords Atlantoaxial dislocation; Odontoid fractures; Locked facet; Posterior cervical fusion



Fig. 1
Preoperative imaging. **Figs. 1-A and 1-B** Antero-posterior and lateral radiographs of the cervical spine after the injury. **Figs. 1-C through 1-F** Sagittal CT sections from right to left. **Figs. 1-G and 1-H** Coronal CT sections. **Fig. 1-I** Axial CT section.

Postoperative radiographs and CT scans demonstrated restoration of atlantoaxial articulation and reduction of the fracture (Fig. 4). The patient had an uneventful recovery and was discharged after 5 days of hospital stay, followed by 2 months of mobilization with cervical collar. At 2-year follow-up, the patient was pain-free, was able to do his routine work without discomfort or pain, and had a Neck Disability Index score⁷ of 3/50 (Fig. 5). Dynamic radiographs

revealed no atlantoaxial instability, and CT scan confirmed that the odontoid fracture was healed with posterior fusion extending up to C4 (Fig. 6).

Discussion

This case demonstrates a successful single-stage surgical approach for an uncommon traumatic unilaterally locked posterolateral atlantoaxial dislocation associated with Type 2B

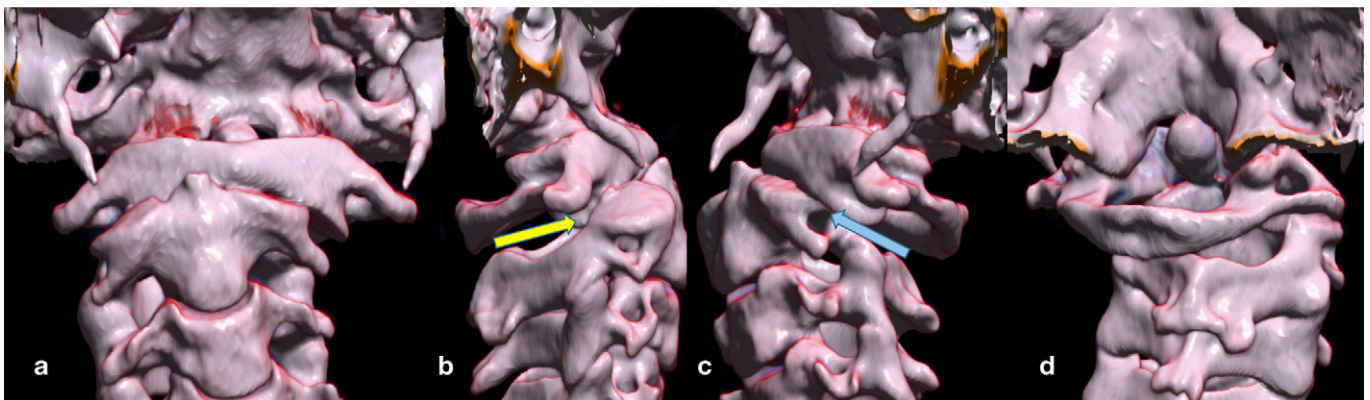


Fig. 2
Figs. 2-A through 2-D 3D-reconstructed images showing the locked facet on the right side (yellow arrow) and subluxated facet on the left side (blue arrow).

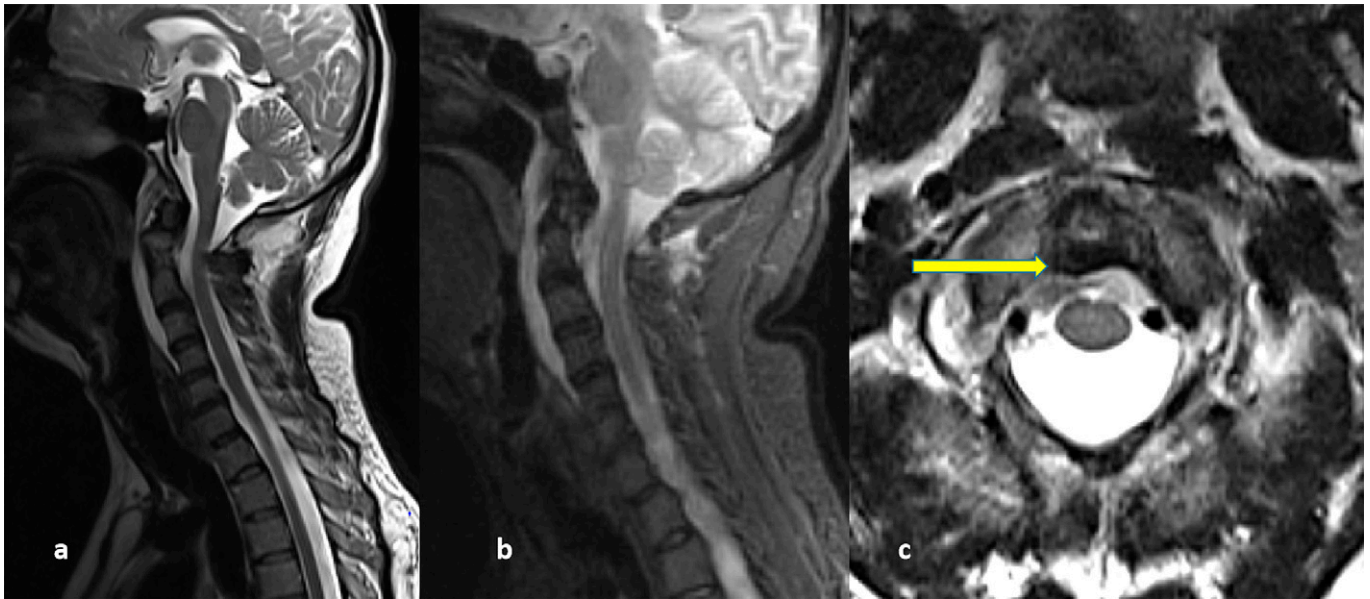


Fig. 3

Fig. 3-A Sagittal T2 weighted image showing significant prevertebral hematoma under the anterior longitudinal ligament. **Fig. 3-B** Sagittal Short Tau Inversion Ratio image showing edema of the posterior structures indicating extensive PLC injury **Fig. 3-C** Axial section showing intact transverse atlantal ligament (yellow arrow). PLC = posterior ligamentous complex.

odontoid fracture, resulting in stability, fusion, and good clinical outcome (Figs. 2-A and 2-B). Because of the rarity of such complex injuries, there are no clearly established treatment guidelines pertaining to its management. First report of C1-C2 dislocation with odontoid fracture was described by Lenehan et al. who reported a lateral dislocation managed with Goel-Harms technique supplemented with sublaminar wires⁸. Closed reduction in such complex injuries is mostly unsuccessful and eventually needs open reduction⁹⁻¹¹. A brief review of the literature on odontoid fractures with atlantoaxial dislocations is

summarized in Table I. In the current case, as there was a locked facet, trial of closed reduction was not given as our set-up allows us to do emergency definitive surgery within 24 hours of the trauma once the patient is optimized for surgery.

VAIs are commonly associated with upper cervical fracture-dislocations. However, most injuries are unnoticed and do not develop cerebrovascular accident as it may involve the nondominant vertebral artery (VA)¹². A systematic review by Temperley et al. reported a 5.2% incidence of VAI in cervical injuries¹³. Sullivan et al.¹⁴ reported a case of Type 2 odontoid

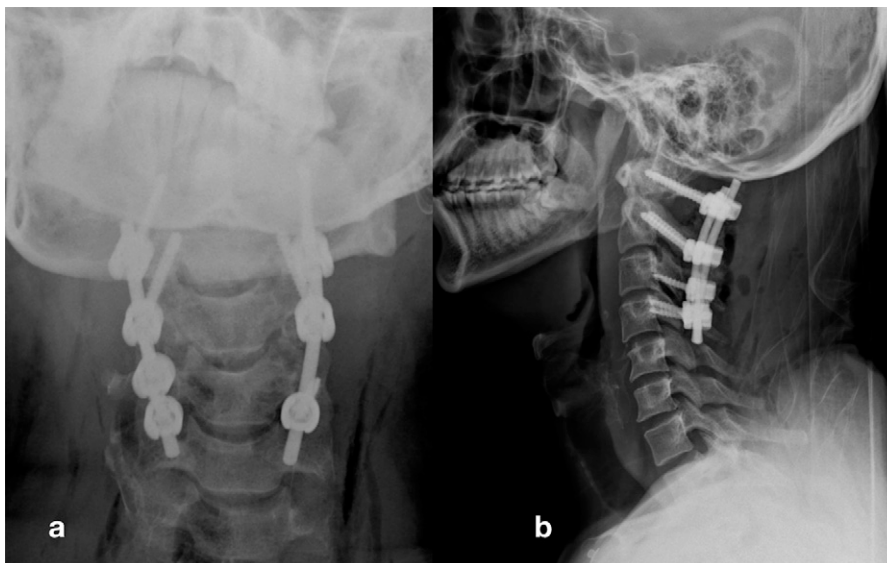


Fig. 4

Figs. 4-A and 4-B Postoperative antero-posterior and lateral radiographs.



Fig. 5
Follow-up clinical photographs showing painless neck range of motion. The patient had restriction in neck rotations, which were expected after the procedure but able to perform his daily activities without pain.

fracture with atlantoaxial instability that had complete block of left vertebral artery flow. They observed complete reperfusion of the vertebral artery without intimal tear after early cervical traction followed by posterior fixation. Preoperative assessment of the VA status is imperative to plan for surgery. If there is occlusion or thrombus of one of the VA, posterior instrumentation is avoided to preserve the other VA that might be injured during exposure or screw fixation. Studies have evaluated the role of routine MRI performed for cervical trauma as a modality for detecting VAIs¹⁵. CT angiography is performed at our institution if there is suspected VAI on MRI. In our case, despite the dislocation, the VA was patent on both sides as seen on T2-weighted MRI sections (Fig. 7), and the patient did not have any features of vertebral insufficiency; hence, CT angiography was not performed separately for this patient.

Surgical options described in the literature include anterior screw fixation¹⁶, transoral plate fixation¹⁷, transarticular screws (both anterior and posterior), and posterior C1-C2 fusion⁹⁻¹¹. However, anterior approach has its own challenges—need for reduction before fixation, lack of anchor points for intraoperative reduction, and risk of erroneous screw placement. Moreover, these high-velocity injuries are frequently associated with extensive posterior column and PLC injuries that can be addressed

better using posterior fusion. The Goel-Harms technique has proven to be a time-tested method with minimal risk of vertebral artery or cord injury^{18,19}. Other methods of fixation such as lamina screws have also been used depending on the integrity of anchor points²⁰. Posterior approach is preferred because of the ease of reduction, less morbidity, and predictable outcomes. In this case, as the dislocation was irreducible with a locked facet, it was decided to operate using a posterior approach.

There are different techniques of intraoperative reduction for atlantoaxial dislocation combined with odontoid fracture and locked atlas lateral mass. Liawrungrueang et al. proposed a leverage technique using a periosteal elevator under the C1-C2 joint to achieve reduction¹¹. On the other hand, He et al. recommended to compress the screw of atlas and axis to reduce the lateral mass interlocking anteriorly⁹. Shetty et al. divided atlantoaxial subluxations into 3 types based on the Atlanto-dens interval and direction of odontoid dislocations²¹. They described reduction maneuvers based on these subtypes. According to their classification, Type B dislocations were cases where C1 arch moved along with the fractured odontoid (transverse atlantal ligament intact), and hence, Atlanto-dens interval was maintained, but power ratio was decreased. Preparation of the C1-C2 joint and its release has to be performed before

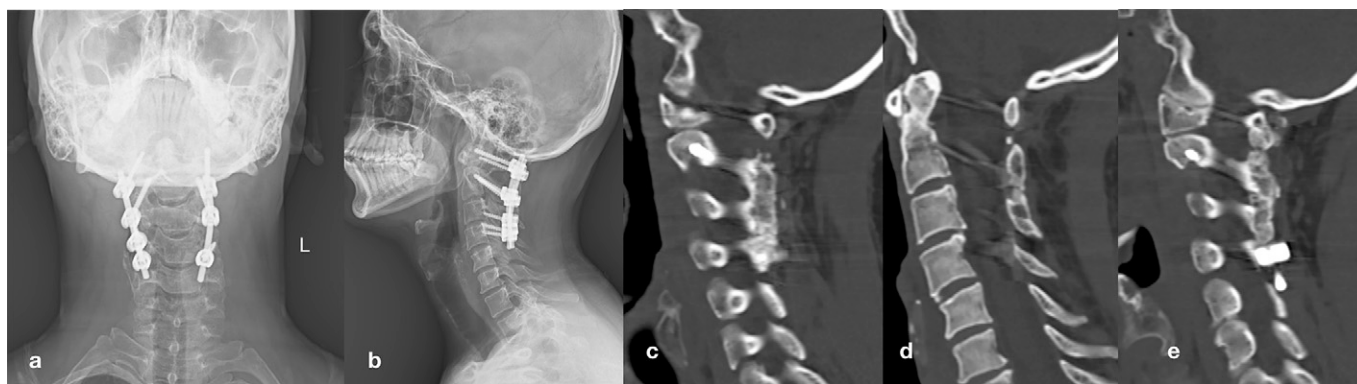


Fig. 6
Radiographic images at 2-year follow-up. **Figs. 6-A and 6-B** Antero-posterior and lateral radiographs at follow-up. **Figs. 6-C through 6-E** Follow-up CT showing solid posterior fusion and healed odontoid fracture.

TABLE I Summary of Recent Literature on Odontoid Fracture with Atlantoaxial Dislocations

Sr No.	Authors	Case Detail	Management
1	Lenahan et al. ⁸ , 2009	63-yr-old woman, Type 2 odontoid fracture with lateral dislocation	Unsuccessful closed reduction attempt followed by C1-C2 fixation with sublaminar wiring
2	Clarke et al. ²³ , 2010	80-yr-old man, respiratory difficulty after injury Type 2 odontoid fracture with posterior dislocation	Posterior C1-C2 fixation
3	Zhang et al. ¹⁷ , 2012	38-yr-old man, Type 2 odontoid fracture with posterior atlantoaxial dislocation	Transoral atlantoaxial reduction and plate fixation
4	Riouallon et al. ¹⁰ , 2014	25-yr-old man, Type 2 odontoid fracture with right posterolateral dislocation	Anterior transarticular screw fixation
5	He et al. ⁹ , 2016	72-yr-old man, Type 2 odontoid fracture with posterolateral dislocation	Failed closed reduction with skull traction. C1-C3 posterior fixation
6	Minyu et al. ²⁴ , 2018	30-yr-old man, Type 2 odontoid fracture with posterolateral dislocation	Two staged—1-wk skull traction followed by C1-C2 posterior fixation (Goel-Harms construct)
7	Ono et al. ²⁰ , 2019	24-yr-old woman, C1-C2 anterior dislocation with Type 3 odontoid fracture	Unilateral C1 lateral mass and C2 laminar screw fixation (high riding VA on the other side)
8	Liawrungrueang et al. ¹¹ , 2022	38-yr-old woman, left lateral atlantoaxial dislocation	Failed closed reduction followed by posterior C1-C2 fixation (modified Goel-Harms construct)
9	Current case (2024)	41-yr-old man, Type 2B odontoid fracture with posterolateral dislocation	Single-stage posterior C1-C4 fusion

attempting reduction. For such injuries, they described reduction by using a sublaminar wire under the C1 arch to exert a posterior traction along with an anterior-directed force at the C2 spinous process followed by fixation and fusion. Kumar et al.²² reported a case of an 11-year-old boy with a 4-month-old displaced odontoid fracture with anterior atlantoaxial subluxation. As it was a 4-month-old injury, they could not reduce it directly by traction and joint manipulation alone. The inferior part of C1 facet was osteotomized and then reduced over the C2 facet and reported it as “joint remodeling technique.”

We found that reduction was achieved easily after inserting the C1 lateral mass and C2 pedicle screw bilaterally, with axial traction coupled with anteriorly directed force on C1 over C2 using thumb. The presence of extensive posterior soft-tissue injury probably made the reduction easier!

The level of fusion depends on the associated injury either to the upper cervical spine, which leads to extension of

the fusion into the occiput or subaxial cervical spine extension into C3-C5 level based on the degree of posterior structure integrity. He et al. recommended fixation up to C3 to get strong anchor points for reduction maneuvers⁹. In our case, it was decided to extend the instrumentation up to C4 along with posterior fusion because of the damaged posterior ligamentous structures at C2-C3 levels. At 2-year follow-up, the patient is pain-free with restricted neck rotation, which is anticipated after C1-C2 fusion. CT scan performed at follow-up shows healed odontoid fracture with fusion of the posterior elements.

Conclusion

This case highlights successful management of a rare unilaterally locked posterolateral atlantoaxial dislocation with an odontoid fracture by a single-stage posterior surgery. Closed reduction is usually unsuccessful, and open reduction using posterior approach should be preferred. Extension of instrumentation

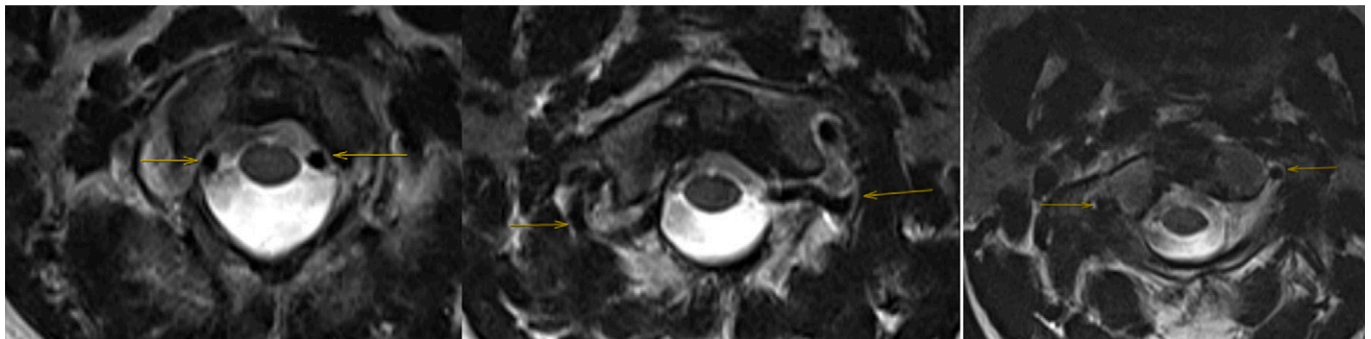


Fig. 7

Axial T2 weighted image showing normal flow voids in V3 and V4 segments of bilateral vertebral arteries (arrows).

to the subaxial region should be considered if posterior complex is damaged to avoid implant failure before fusion. ■

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