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Case Report

Odontoid Fracture with Atlantoaxial Dislocation: Successful Closed Reduction A Case Report and Literature Review

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Abstract

Case: Odontoid fracture with atlantoaxial dislocation is a rare and dangerous condition that is generally regarded as difficult to reduce. This report describes a case of a 75-year-old female patient with a type II odontoid fracture and posterolateral atlantoaxial dislocation. Successful closed reduction was achieved within 4 hours using maximum 7.26 kg (16 lbs) of traction with muscle relaxants, followed by posterior C1-C2 fixation without postoperative complications or neurological deficits.

Conclusion: This case highlights the closed reduction technique and details for odontoid fracture with atlantoaxial dislocation, and summarizes the experience from previous successful closed reduction cases.

Keywords: Atlantoaxial dislocation; Odontoid fractures; Closed reduction

Introduction

Odontoid fractures with atlantoaxial dislocation represents an exceptionally rare clinical entity. A systematic PubMed search utilizing the terms "odontoid fracture with atlantoaxial dislocation" and "odontoid fracture with C1/2 dislocation" yielded 269 publications till May 2026. After applying inclusion criteria "acute traumatic presentations <4 weeks duration, adult patients, English-language publications", 32 relevant cases were identified. Among these, only 9 cases documented successful closed reduction.

Odontoid fractures with atlantoaxial dislocation represent life-threatening injuries with significant morbidity and mortality. Zitouna reported a case presenting with tetraplegia that resulted in death from respiratory complications 5 days after surgery [1]. Clarke reported a case presenting with respiratory failure [2]. Surgery for irreducible atlantoaxial dislocation becomes much more challenging due to the common occurrence of bony and vascular anomalies [3]. Therefore, closed reduction followed by open fixation represents the safer management approach. However, literature suggests that most patients fail closed reduction [4]. This article summarizes all reported successful closed reduction cases and analyzes the methods and details of closed reduction techniques.

The patient was informed that information regarding her case would be submitted for publication, and she provided consent.

Case Presentation

A 75-year-old female with a medical history of scoliosis extending to the upper thoracic and cervical spine fell from a 1-meter-high ladder at home, sustaining a forehead impact with neck hyperextension injury. The patient complained of neck pain and torticollis after the injury, along with left upper limb numbness. Physical examination revealed stable vital signs, a Glasgow Coma Scale score of 15, right forehead abrasion, and no neurologic deficits.

Upon arrival in the Accident and Emergency department, a rigid neck collar was immediately applied. Initial cervical spine radiography revealed an odontoid fracture with posterior atlantoaxial dislocation (Figure1). Subsequent computed tomography imaging confirmed a type II odontoid fracture with

C1 posterolateral dislocation to the left side of C2 (Figure 2). Computed tomography angiography showed patent bilateral vertebral arteries (Figure 3). Magnetic resonance imaging, ready availability at our centre, demonstrated cord compression mainly at the odontoid fracture level with cord oedema from C1 to C3 levels, while maintaining relatively adequate space around the cord at C1 and C2 (Figure 4).

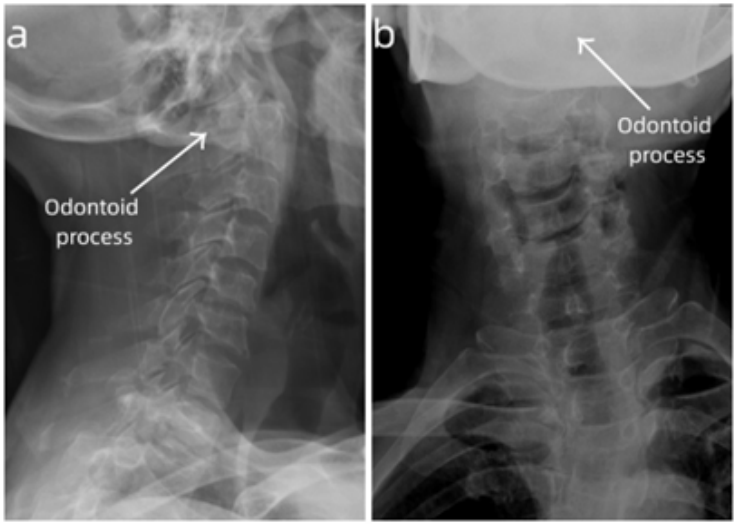

Figure 1: Preoperative radiographs.
Figure 1-A Lateral radiograph demonstrating an odontoid fracture accompanied by posterior atlantoaxial dislocation.
Figure 1-B Anteroposterior (AP) radiograph showing rightward neck tilt with leftward head translation, with the odontoid process misaligned relative to the sub axial spine.

Figure 2: Preoperative Computed Tomography.
Figures 2-A though 2-C Sagittal Views demonstrate an odontoid fracture with dislocation and overlap of the right C1–C2 facet joint. Additionally, the left C1 facet exhibits posterior translation.
Figures 2-D though 2-F Coronal Views reveal leftward translation of the C1 vertebra and odontoid process.
Figures 2-G though 2-I Axial Views show an intact C1 ring with overlap between C1 and C2 at the level of the fracture.

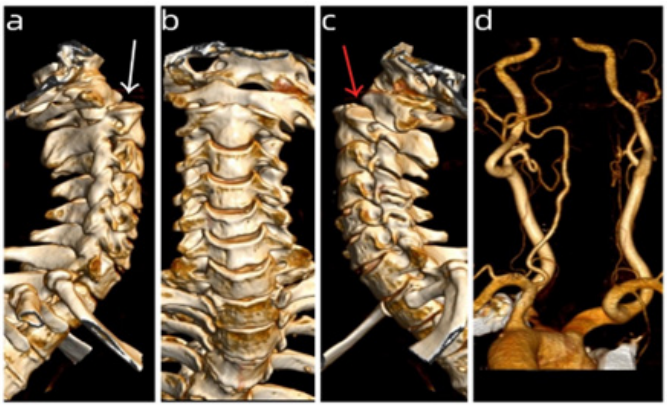

Figure 3: Preoperative 3D Computed Tomography reconstruction.
Figures 3-A through 3-C the 3D computed tomography reconstruction reveals a posterolateral dislocation of the C1 to the left relative to the C2. The right C1 facet is dislocated posteriorly and overlaps the right C2 facet (white arrow). Additionally, the anterior-inferior edge of the left C1 facet is positioned over the posterior-superior edge of the left C2 facet (red arrow).
Figure 3-D Computed tomography angiography demonstrated that bilateral vertebral arteries were intact.

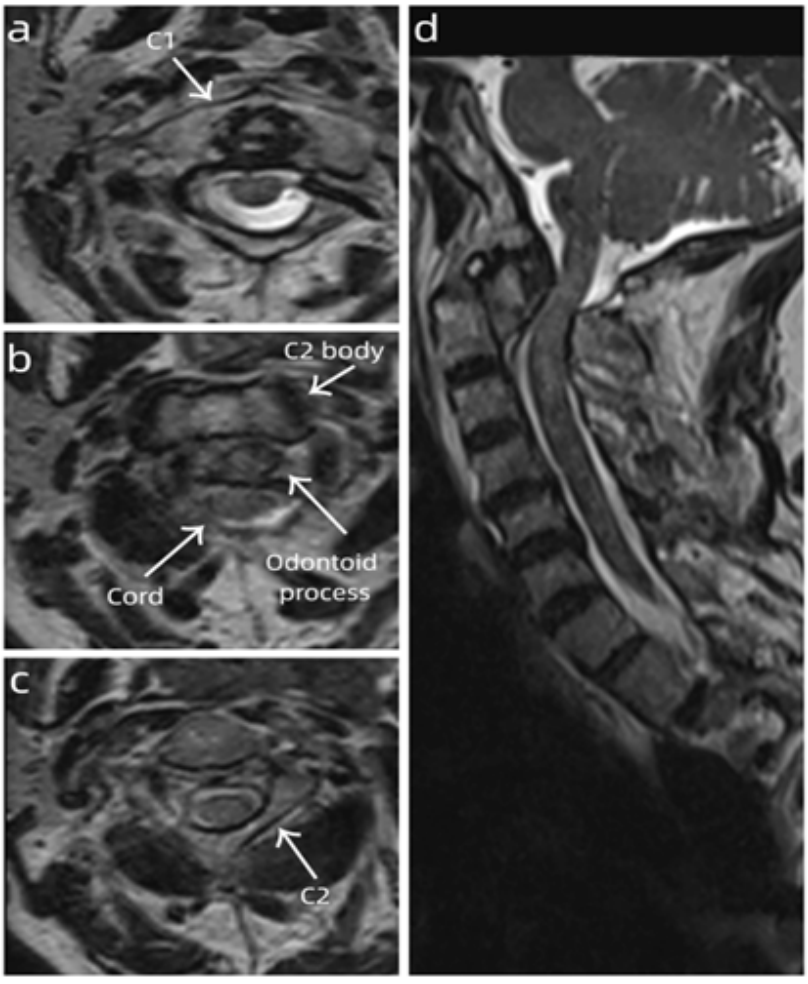

Figure 4: T2-weighted magnetic resonance imaging images.
Figures 4-A through 4-C Axial view revealed that the C1 and C2 vertebral bodies provided relatively sufficient space for the spinal cord. However, canal compromise was observed at the fracture level.
Figure 4-D Sagittal view revealed mild spinal cord edema at the C1-3 level.

The patient received continuous vital sign monitoring and appropriate analgesia. A halo crown (DePuy Bremer Halo System) was applied using four fixation pins positioned at the lateral one-third of the supraorbital region and 1 cm superior to the pinna, each tightened to 3.63 kg (8 lbs). The patient was placed in 15-20 degrees reverse Trendelenburg positioning to facilitate counter-traction. Traction was initiated at 4.54 kg (10 lbs), with neck flexion angle titrated using a portable mini-C-arm X-ray machine (Orthoscan TAU 1515) (Figure 5). Traction weight was increased by 0.90 kg (2 lbs) every 15-20 minutes, with neurological assessment 2-3 minutes following each after weight increment. Serial radiographs were performed to evaluate for over-distraction. Intravenous diazepam was administered as a muscle relaxant, starting with 2 mg bolus and monitoring for sedative effects. If the patient remained conscious after 5 minutes, an additional 1mg was given, ultimately totalling 4 mg (0.1 mg/kg). Successful reduction was achieved 4 hours after initiating traction at a final traction weight of 7.26 kg (16 lbs), with the patient reporting a clicking sensation during reduction. A halo vest was then applied to maintain reduction.

Figure 5: Clinical photographs demonstrating the cervical traction procedure.
Figure 5-A Procedure setup, showing the mini-C-arm X-ray machine position, and the surgeon standing at the head of bed to adjust the neck flexion, manage traction weight and monitor real-time fluoroscopic images.
Figure 5-B Fluoroscopic confirmation of successful atlantoaxial reduction.
Figure 5-C Demonstration of Reverse Trendelenburg position and traction pulley system.

Definitive stabilization operation was performed on post-injury day 5 via a posterior approach under general anesthesia with continuous intraoperative neuromonitoring (somatosensory evoked potentials and motor evoked potentials). C1 and C2 screws (Stryker OASYS Occipital-Cervical-Thoracic System) were inserted using navigation (Stryker NAV3i surgical navigation platform). Due to the small C1 posterior arch, C1 lateral mass screws were inserted using a notching technique [5]. The screws were connected with rods, followed by decortication of posterior C1 and C2 and application of artificial bone graft (i-Factor FLEX FR Cerapedics USA) between them.

Postoperative radiographs showed complete reduction and proper implant position (Figure 6). A Sternal Occipital Mandibular Immobilizer was prescribed for 8 weeks of additional protection. The patient's postoperative neurological status remained intact. The patient has been followed for 15 months to date; she remains asymptomatic and neurologically intact. Serial radiographs demonstrate that the implants are stable and remain in situ.

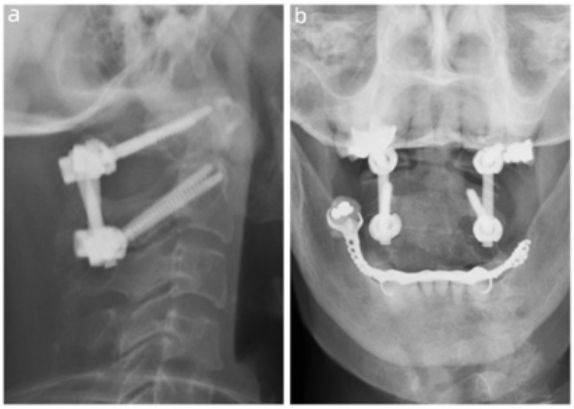

Figure 6: Postoperative radiographs.
Postoperative anteroposterior (AP) and lateral radiographs demonstrated successful fracture reduction with screws in situ.

Discussion

The literature review identified 8 reported cases of successful closed reduction (Table 1). The maximum weight for successful reduction ranged from 6 kg to 18.1 kg. One case was achieved reduction in 1 hour by the most aggressive weight in 18.1 kg, while other case required 12 hours to 7 days. None of the 9 reported cases mentioned using muscle relaxation or other medications. Only one case was treated conservatively with a halo vest as definitive management, while all others underwent operative treatment.

Table 1: Summary of Recent Literature of Successful Closed Reduction for Odontoid Fracture with Atlantoaxial Dislocation.

Author (year)	Age (yrs)/Sex	Direction of dislocation	Pre-operative status	Close reduction technique	Reduction final weight	Reduction time	Definitive operative procedure
Spoor et al. [6] (2008)	43/M	Rotatory and lateral	Right hemiparesis	Halo frame traction	Not mention	3 days	Conservative with halo vest
Clarke et al. [2] (2010)	80/M	Posterolateral	No neurologic deficit	Halo jacket	Not mention	Not mention	Posterior C1-C2 fixation
Sullivan et al. [7] (2013)	82/F	Posterolateral	Occluded left vertebral artery without neurologic deficit	Cervical traction	13.6kg	12 hours	Posterior C1-C2 fixation
Meng et al. [8] (2013)	47/F	Posterior	No neurologic deficit	Skull traction	6 kg	48 hours	Posterior C1-C2 fixation
Tian et al. [9] (2014)	50/M	Posterolateral	No neurologic deficit	Skull traction	12 kg	4 days	Posterior atlantoaxial transarticular screw fixation and interlaminar wiring with iliac crest bone graft
Park et al. [10] (2017)	20/M	Posterolateral	No neurologic deficit	Gardner–Wells tongs traction	8.2kg	2 days	Posterior C1-C2 fixation
Minyu et al. [11] (2018)	30/M	Posterolateral	No neurologic deficit	Skull traction	11 kg	7 days	Posterior C1-C2 fixation
Lachance et al. [12] (2022)	68/M	Anterior	No neurologic deficit	Gardner-Wells tongs traction	18.1 kg	1 hour	Posterior C1-C2 fixation (C2 laminar screws)
Rahimizadeh A et al. [13] (2025)	72/M	Posterior	Quadriparesis	Not mention	15kg	Not mention	C1 hook to T2 screw+- cervical Laminectomy
This case (2026)	75/F	Posterolateral	No neurologic deficit	Halo frame traction	7.3 kg	4 hours	Posterior C1-C2 fixation

Two specific conditions must be ruled out before attempting closed reduction. Przybylski et al. demonstrated a critical contraindication in a case of type III odontoid fracture with longitudinal atlantoaxial dislocation where 5 lbs of skeletal traction resulted in marked neurological deterioration from unanticipated longitudinal instability [14]. They recommended avoiding skeletal traction when recognizing wide separation among fragments, which may indicate extensive ligament disruption. Another important consideration is vertebral artery occlusion, where early open reduction may be preferable since closed reduction typically requires more time and could potentially affect reperfusion of the vertebral artery. Although one reported case noted successful reperfusion of an occluded vertebral artery after a 12-hour closed reduction [7], expert opinion on the same case suggested that direct open reduction might be quicker and safer [15]. Furthermore, the integrity of the Circle of Willis and the presence of any vertebral artery occlusive symptoms are critical factors in deciding between closed and open reduction.

Regarding closed reduction techniques, no consensus exists about the details of traction protocol, particularly at the atlantoaxial level. Each step of the process proves crucial. For traction angle, the trajectory significantly affects reduction efficacy. Crutchfield et al. suggested aligning the traction direction with the facet articulation in sub axial levels [16]. For atlantoaxial cases, we aligned traction with the C1/2 facet overlapping plane using portable fluoroscopy and rolled bedsheet support to adjust the flexion angle. Concerning the reverse Trendelenburg position for counter-traction, Crutchfield et al. recommended not exceeding 20 degrees [16].

The most critical considerations involve the weight and duration of reduction. For atlantoaxial skeletal traction, Crutchfield et al. suggested a minimum weight of 5 lbs and maximum of 10-12 lbs [16], while Fielding and Hawkins recommended not exceeding 9.1 kg in adults [17]. Various protocols exist for weight escalation during traction. Some articles recommend increasing weight based on injury level, following Crutchfield's proposal of 5 lbs minimum weight for C1 injuries up to 18 lbs minimum weight for C7 injuries [16]. Reindl et al. suggested starting with 5 kg plus 2.5 kg per level below C1, then adding 2.5 kg every 30 minutes until achieving reduction, up to a maximum of 50% estimated body weight for 1 hour [18]. Other protocols are not level-dependent; Grant et al. recommended increasing traction weight in 5-10 lbs increments every 5 minutes (up to 80% of body weight), reporting a 97.6% success rate in 82 patients [19]. Our summarized data show that most surgeons chose to use lighter weights for this procedure, even though heavier weights might work faster, as they preferred the slower but safety way.

For manual reduction assistance, we could adjust the traction direction or manual manoeuvre based on the dislocation direction. Opoku-Darko et al. described a technique for anterior dislocations involving cervical traction combined with oropharyngeal finger pressure against the dislocated lateral mass [20].

The use of muscle relaxants remains controversial. Some studies use them selectively for certain patients [19, 21], while others routinely administer diazepam [22]. While muscle relaxants may theoretically accelerate reduction time, their sedative effects could mask neurological changes. Intravenous diazepam has a rapid onset (1-3 minutes) and prolonged duration (>12 hours), with recommended skeletal muscle relaxant doses of 2-10 mg [23]. Given that most atlantoaxial traction reductions require hours or even days, the long duration of action may prove advantageous. Achieving muscle relaxation without excessive sedation is challenging due to individual variability. Starting with the lowest effective dose and carefully titrating under close medical supervision appears to be the safest approach. In our case, we began with 2 mg, adding 1 mg every 5 minutes (total 4 mg, 0.1 mg/kg) while maintaining consciousness for neurological testing. The 4 hours reduction time was shorter than most previously reported cases at this relatively low traction weight.

In addition to closed reduction, we must be fully prepared with all types of surgical approaches, various open reduction techniques, appropriate fixation construct selection, and a comprehensive postoperative rehabilitation plan.

Conclusion

Odontoid fracture with atlantoaxial dislocation is an extremely rare and critical condition requiring thorough understanding of each management step and contingency plans. Although typically difficult to reduce, successful reduction significantly decreases subsequent surgical complexity. This article summarizes the detailed reduction procedures from previous successful closed reduction cases. Most surgeons have applied relatively light weights for reduction, typically requiring longer reduction times. Muscle relaxants like diazepam may expedite reduction, but their sedative effects could mask neurological changes, suggesting that starting with low doses and careful titration is preferable. This review aims to provide a reference for clinicians encountering this challenging condition.

Acknowledgement of Author Contributions

Weng Io Ng: Conceptualization; Data curation; Formal analysis; Writing original draft; and Writing - review & editing. Hung On Cheng: Clinical supervision; Writing review & editing. Eleanor Wen: Data curation; Writing review & editing.

Conflict of Interest

The authors declare that they have no competing interests.

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