Clinical Case Report

ISSN: 2675-3626

When Conservative Management Fails: Pediatric Type III Odontoid Fracture With Delayed Instability

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Introduction/Background: Pediatric cervical spine trauma is rare, with most injuries involving the upper cervical region. Type III odontoid fractures are commonly managed with external immobilization when atlantoaxial stability is preserved; however, radiographic progression and occult spinal cord compromise may still occur.

Case presentation: A 7-year-old boy sustained high-energy cervical trauma after a fall from a three-story building. He reported mild, transient neck pain and had no neurological deficits. Cervical CT demonstrated a type III odontoid fracture extending to the right superior articular facet, associated with a single-line fracture of the left anterior arch of C1. Initial deformity was minimal (1 mm anterior translation and 6° anterior angulation), and he was treated with a rigid cervical collar. The patient was lost to follow-up and returned 3 months after injury; repeat CT showed marked deformity progression (42.5° anterior angulation and 4 mm translation). MRI revealed anterior spinal cord compression with intramedullary T2/STIR hyperintensity consistent with early radiological myelopathy, despite an unchanged and normal neurological examination. Given progressive instability and occult cord compromise, posterior C1–C2 stabilization with C1 decompression was performed under intraoperative neurophysiological monitoring. Postoperative recovery was uneventful. At 13 months, he remained neurologically intact, with solid fusion on CT and improvement of the intramedullary signal abnormality on MRI.

Conclusions: Pediatric type III odontoid fractures may worsen during conservative management, and clinically silent cord compression with MRI evidence of myelopathy can occur. Timely, structured follow-up imaging is essential, and prompt stabilization should be considered when progression, instability, and/or cord compression is identified.

Keywords: Odontoid Process, Spinal Fractures, Cervical Vertebrae, Spinal Cord Compression, CompressionChild

INTRODUCTION

Although cervical spine trauma is relatively uncommon in children, when it occurs it predominantly involves the upper cervical region (C1-C4), which accounts for approximately 70% of pediatric cervical injuries [1]. Odontoid fractures of the axis (C2) represent a particularly important, yet infrequent, subset of these injuries, partly due to the unique pediatric anatomy and developmental ossification patterns that can predispose to injury and complicate interpretation of imaging findings.

Odontoid fractures are traditionally categorized using the Anderson and D'Alonzo classification, originally developed for adults but commonly extrapolated to pediatric practice [2]. In this system, type I fractures involve the tip of the dens, type II fractures occur at the base of the dens, and type III fractures extend into the C2 vertebral body. Type III injuries are generally considered to have favorable healing potential because of the large cancellous bone surface area and robust regional blood supply [3] (Figure 1). Accordingly, in the absence of atlantoaxial instability, external immobilization is typically recommended as first-line management in most pediatric cases.

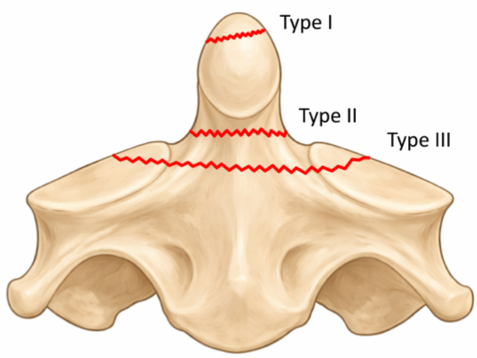

Figure 1: Anderson and D'Alonzo classification of odontoid fractures. Red lines represent the fracture areas in Type I, Type II, and Type III fractures. Source: original figure by the authors.

Submitted: 01 December 2025
Accepted: 01 January 2026
Published: 19 January 2026

However, the evidence guiding nonoperative management in children remains limited, and there is no clear consensus regarding radiographic thresholds that define instability in this population [4]. In addition, delayed displacement may be underestimated in clinical practice, particularly when follow-up is inconsistent or imaging surveillance is not standardized. A further diagnostic challenge is the possibility of confusing normal developmental synchondroses, especially in younger children, with a true fracture pattern, which can lead to diagnostic and management pitfalls [5,6].

Here, we report a rare pediatric type III odontoid fracture that evolved to delayed instability with radiological myelopathy despite an initially reassuring clinical course. We also summarize practical considerations regarding imaging surveillance, assessment of instability, and indications for operative stabilization.

CASE REPORT

A seven-year-old boy sustained high-energy cervical trauma after a fall from a three-story building. He presented with mild, transient neck pain and no neurological deficits. Cervical computed tomography (CT) on admission demonstrated a Type III odontoid fracture extending to the right superior articular facet, along with a single-line fracture of the left anterior arch of C1 (Figure 2A-2D). There were no clinical or radiological signs of instability; the odontoid fragment was reduced, with 1 mm of anterior translation and 6° of anterior angulation. He was discharged with a rigid cervical collar (Philadelphia type) and was lost to follow-up for three months.

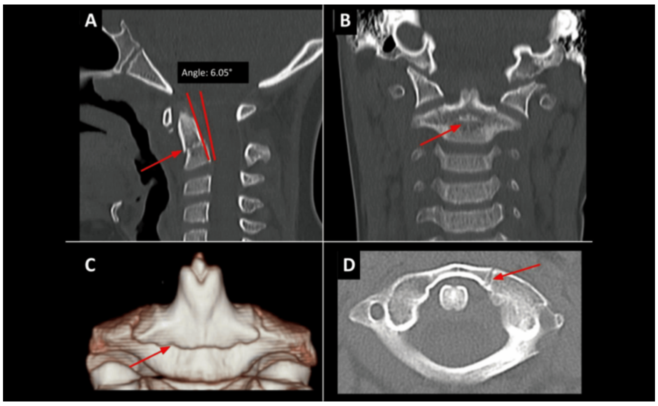

Figure 2: Cervical CT on admission. (A) Midsagittal reconstruction demonstrating a type III odontoid fracture with 1 mm anterior translation of the odontoid fragment (red arrow) and 6° anterior angulation (angle formed by the referenced red line segments). (B) Coronal reconstruction demonstrating the fracture line (red arrow). (C) Three-dimensional (volume-rendered) CT reconstruction of C2 demonstrating the fracture trajectory (red arrow). (D) Axial CT image demonstrating a single-line fracture of the left anterior arch of C1 (red arrow).
CT: computed tomography

He returned three months after the initial trauma. Repeat cervical CT and magnetic resonance imaging (MRI) demonstrated progression of deformity, with anterior angulation increasing from 6° to 42.5° and anterior translation increasing from 1 mm to 4 mm (Figure 3A). MRI also demonstrated anterior spinal cord compression and an intramedullary hyperintense signal on T2/STIR (Short Tau Inversion Recovery) sequences consistent with incipient radiological myelopathy (Figure 3B). Despite these findings, he remained neurologically intact on examination.

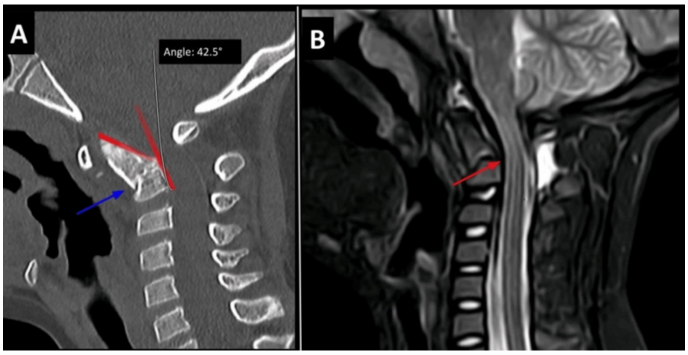

Figure 3: Preoperative imaging at three months post-injury. (A) Midline sagittal CT reconstruction demonstrating interval progression of the type III odontoid fracture with 4 mm anterior translation of the odontoid fragment (blue arrow) and 42.5° anterior angulation (angle formed by the referenced red line segments). (B) Sagittal T2/STIR MRI demonstrating anterior spinal cord compression with intramedullary T2/STIR hyperintense signal consistent with radiological myelopathy (red arrow).
CT: computed tomography; MRI: magnetic resonance imaging; STIR: short tau inversion recovery.

Given the radiological progression and evidence of cord compression, he underwent posterior stabilization and decompression under intraoperative neurophysiological monitoring. A two-level posterior arthrodesis with one-level decompression was performed. The posterior arch of C1 was resected, and C1-C2 lateral mass screws were placed using fluoroscopy and neuronavigation guidance. His postoperative course was uneventful, and he was discharged two days after surgery. A cervical collar was prescribed for five months postoperatively.

At 13 months after surgery, he remained clinically well with no neurological deficits. Follow-up CT demonstrated satisfactory bony fusion and appropriate hardware position (Figure 4A-4C). Postoperative MRI (Figure 4D) showed reduction of the previously seen spinal cord T2/STIR hyperintensity, indicating improvement of the radiological myelopathy. His functional status and quality of life returned to normal.

DOI: 10.46900/apn.v8i1.352

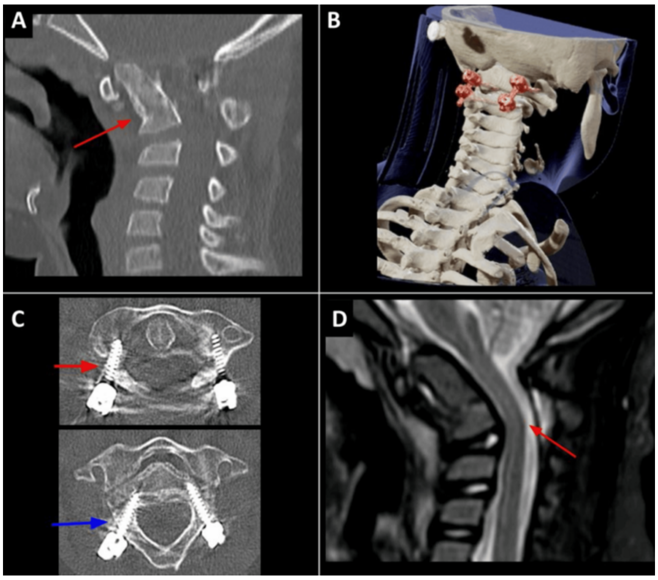

Figure 4: Three-month postoperative imaging. (A) Midline sagittal CT reconstruction demonstrating consolidation of the odontoid fracture (red arrow). (B) Three-dimensional CT reconstruction demonstrating appropriate hardware position at C1 and C2. (C) Axial CT image demonstrating satisfactory bony fusion and appropriate hardware position at C1 (red arrow) and C2 (blue arrow). (D) Sagittal MRI demonstrating improvement in spinal cord compression with reduction of the intramedullary T2/STIR hyperintense signal (red arrow).
CT: computed tomography; MRI: magnetic resonance imaging; STIR: short tau inversion recovery.

DISCUSSION

Type III odontoid fractures are frequently associated with minimal neurological findings at presentation. In a consecutive series of 212 patients (including adults), 199 (93.9%) were classified as ASIA E, and motor deficits were reported in only a small proportion; some patients could not be graded because of severe traumatic brain injury or sedation [7]. This pattern underscores an important clinical pitfall: neurological examination at presentation may underestimate the degree of radiological risk, and the absence of deficits does not exclude clinically meaningful cervical instability or impending cord compromise.

Hyperflexion of the upper cervical spine is considered a principal injury mechanism. Consequently, type III fractures may be accompanied by angulation and/or translation of the odontoid fragment, potentially resulting in anterior spinal cord compression and myelopathy. Although uncommon, severe presentations, including Brown-Séquard syndrome, cervical hematoma, neurogenic shock, apnea, and death, have been described [8]. The present case extends this spectrum by demonstrating radiological evidence of evolving myelopathy without parallel clinical deterioration, highlighting the potential for occult spinal cord compromise during conservative management.

Developmental anatomy is central to the evaluation of pediatric odontoid injuries. After approximately seven years of age, fusion of the synchondrosis between the odontoid process and the C2 body makes fractures at the C2 body-odontoid junction more typical [5,9]. Cervical CT remains a key diagnostic tool to define fracture morphology, displacement, and alignment [5,9]. Midsagittal CT reconstructions may also facilitate measurement of the atlantodental interval (ADI), which can support assessment of C1-C2 stability when instability is suspected [10].

MRI is essential for assessing the spinal cord and the ligamentous stabilizers of the craniovertebral junction. The transverse ligament stabilizes the odontoid by anchoring its posterior aspect to the internal surfaces of both C1 lateral masses, and distension or tearing may manifest as hyperintense signal on STIR-weighted sequences [11]. In this patient, MRI was pivotal in demonstrating both cord compression and intramedullary signal change consistent with early myelopathy, thereby informing escalation of management despite preserved neurological function.

Conservative management is generally regarded as first-line therapy for most type III odontoid fractures. Nonoperative treatment typically consists of rigid external immobilization for at least 10 weeks and is commonly used in adult and pediatric patients who are asymptomatic and lack radiological evidence of instability [4,12,13]. High fusion rates after prolonged immobilization have been reported in selected series, supporting conservative care when alignment and stability are maintained [14,15]. However, as illustrated here, radiological progression may occur, particularly when follow-up is delayed or adherence to immobilization is uncertain, reinforcing the need for structured surveillance rather than reliance on symptoms alone.

Clinical decision-making often incorporates radiographic markers of instability. Suggested thresholds include anterior translation of the odontoid fragment >5 mm, posterior translation ≥3 mm, angulation ≥11° in either direction, and/or sagittal fracture diastasis ≥3 mm. Additional predictors of inadequate healing after initial conservative management include a lateral mass gap >2 mm and increased coronal tilt [2,10,13,16]. Although many of these criteria derive largely from adult cohorts, interval progression toward instability parameters in a child, especially when accompanied by cord compression, should prompt reassessment and consideration of operative stabilization.

Once instability is established, surgical treatment is generally required. Posterior instrumentation with C1-C2 fixation is the most common strategy and may be combined with C1 decompression when spinal cord compression is present [4,13]. In selected cases, when the fragment is reducible, the transverse ligament is intact, and fracture orientation is favorable, anterior odontoid screw fixation may be considered [4,17]; however, feasibility may be limited by pediatric anatomy and by evolving deformity or displacement over time.

DOI: 10.46900/apn.v8i1.352

In 2024, Prabhat et al. [4] proposed a stepwise diagnostic and management algorithm for pediatric odontoid fractures based on a systematic review. Although not yet prospectively validated, operative stabilization was recommended when any of the following are present: fracture comminution, displacement >2 mm, ADI >5 mm, progressive neurological deficits, or delayed union/persistent nonunion despite external immobilization [4]. In our case, displacement progressed to 4 mm with radiological evidence of delayed instability on follow-up imaging, supporting the indication for surgical fixation.

Overall, type III odontoid fractures tend to have a favorable prognosis when appropriately treated. Notably, the largest available series reported successful management with external immobilization in most patients, with only a minority requiring delayed surgery after conservative failure; among those who underwent follow-up CT, fusion rates were high [18].

This case adds to the clinical spectrum by demonstrating marked radiological progression and early myelopathy in the absence of neurological deficits, reinforcing the importance of careful follow-up and individualized management in pediatric patients undergoing conservative treatment.

CONCLUSION

Pediatric type III odontoid fractures may demonstrate radiological progression during conservative treatment, and spinal cord compression with MRI evidence of myelopathy can occur despite a normal neurological examination. Close follow-up with scheduled repeat imaging is therefore essential, particularly after high-energy mechanisms and when compliance with external immobilization is uncertain. If interval instability and/or cord compression is identified, posterior C1-C2 stabilization with decompression is a safe and effective option that may prevent neurological deterioration.

ACKNOWLEDGMENTS

We would like to acknowledge the medical residents Dr. Fernando Cesar de Sousa Filho and Dr. Luiz Miguel Vicente Barreiros for patient care and for their assistance with data collection for the present manuscript.

DISCLOSURES

Ethical approval

Human Research Ethics Committee of the Hospital das Clínicas of Ribeirão Preto and the Ribeirão Preto Medical School issued approval 7.459.204.

Consent to participate

The patients gave consent to use their information and images for research purposes.

Conflict of interest

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Funding

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors

Artificial intelligence

The authors affirm that no artificial intelligence tools were used in the writing, editing, or content generation of this manuscript. All work was conducted manually, based on thorough research and academic expertise.

CONTRIBUTIONS

-**João Paulo Sant Ana Santos de Souza**: Conceptualization, Data curation, Formal Analysis, Methodology, Resources, Visualization, Writing – original draft, Writing – review & editing
-**Otávio da Cunha Ferreira Neto**: Data curation, Writing – review & editing
-**Vinícius Marques Carneiro**: Data curation
-**Marcelo Volpon Santos:** Data curation, Writing – review & editing
-**Ricardo Santos de Oliveira**: Data curation, Investigation, Supervision,
-**Matheus Ballestero**: Conceptualization, Data curation, Formal Analysis, Methodology, Project administration, Resources, Supervision, Visualization, Writing – original draft, Writing – review & editing

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DOI: 10.46900/apn.v8i1.352