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An Odontoid Screw/Standalone Anterior Cervical Interbody Cage Hybrid Can Stabilize a Combined C2 Fracture: A Technical Case Report

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Abstract

Objective: This operative case report describes the hybridization of an odontoid screw and standalone anterior cervical cage to stabilize concomitant odontoid and posterior element fractures of C2 in a single stage surgery.

Background: There are a myriad of fracture patterns of the C2 vertebral body, which can occur in isolation or combination, and may complicate otherwise straightforward fixation strategies. So-called "type 3" displaced odontoid fractures with a coexisting posterior element fracture is one such scenario. The surgical treatment of these complex injuries may be optimized with innovative constructs.

Case Presentation: A 30s-year-old male presented to our institution after a traumatic fall down stairs. They denied any preexisting or new neurologic deficit at the time of initial consultation. Imaging revealed a broad-based transverse fracture of the odontoid process of C2 with 6mm of anterior displacement and extension of the fracture line through the left pars interarticularis. The combination of these injuries was judged to warrant operative stabilization to prevent neurologic decline. Given the complex and likely unstable fracture pattern, patient's age, and concern for neurologic function, a previously undescribed hybrid construct was conceived of and performed. A single odontoid screw was placed through the vertically oriented hole of a single level anterior cervical cage after C2/3 discectomy, thereby achieving fixation of the odontoid and vertebral motion segment simultaneously.

Results: The operation was performed without complication. The patient had an uneventful recovery from surgery in a rigid cervical collar, and postoperative imaging demonstrated satisfactory hardware placement and early fusion of both fractures at two months.

Conclusion: A previously undescribed technique of hybridizing a standalone anterior cervical cage with an odontoid screw was used to achieve simultaneous fixation of a combined odontoid and posterior element fracture pattern. This hybrid construct represents a novel surgical fixation strategy for these rare fractures.

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Introduction

Upper cervical spine fractures are among the most common cervical pathology and account for anywhere from 25-40% of all cervical traumas across all age groups [1]. Likewise, about 3% of all trauma patients have concomitant cervical spine fractures [2]. The axis (C2) is the most commonly fractured, with the odontoid, most commonly implicated in about 50% of C2 fractures [1]. Mechanisms of injury are generally high energy involving motor vehicles with cervical hyperextension [3].

The unique anatomy of the C2 vertebra that lends it specialized functionality (i.e. the odontoid process, short pedicles, broad pars interarticularis) also predispose it to unique fracture patterns [4-8]. The Anderson and D'Alonzo classification focus on isolated odontoid fractures (Table 1), with type II odontoid fractures (involving the base of the odontoid process) being the most common and largely considered unstable necessitating surgical fixation [9]. Need for surgical fixation depends on a host of factors including fracture morphology, baseline health status of the patient, bone mineral density, and neurological symptoms [3,10]. Single or dual odontoid screws are a well-established means of stabilization in select patients with intact transverse ligament [11]. Odontoid fractures may be further subdivided via the Grauer classification which may be useful in determining anterior versus posterior fixation depending on the orientation of the fracture line (Table 1).

Table 1: Anderson, D'Alonzo, and Grauer Classification of Odontoid Fractures

Classification	Description	Management
Type I	Upper portion of the odontoid peg above the transverse portion of the cruciform ligament	Mostly considered stable, non-surgical for majority of patients; may require further imaging if avulsion of alar ligament is suspected
Type II	Most common; base of the odontoid below the transverse portion of the cruciform ligament; high risk of non-union	Mostly considered unstable and often undergo surgical treatment, management depends on subtype
Type IIA	Non-displaced or minimally displaced without comminution	External fixation
Type IIB	Displaced fracture with fracture line extending from anterosuperior to posteroinferior	Anterior internal stabilization (if adequate bone density)
Type IIC	Fracture from anteroinferior to posterosuperior, or with significant comminution	Posterior internal stabilization
Type III	Through the odontoid into the body of C2	Mostly considered stable, non-surgical for majority of patients

Fractures involving the pars interarticularis of C2 are classified via Levine and Edwards (Table 2) and colloquially referred to as "Hangman's fractures". These are less common compared to isolated odontoid fractures and typical mechanisms of injury include hyperextension and axial loading [12]. Levine and Edwards class focuses on subluxation and degree of angular deformity [13,14]. These fractures are generally amenable to a rigid cervical collar, but with more subluxation and angulation are considered more unstable often necessitating surgical fixation. Common approaches include C2/3 anterior cervical discectomy and fusion or posterior instrumentation and fusion of C1-C2, or C2-C3, or C1-C3 lateral masses depending on fracture morphology, need for reduction, and the status of the posterior tension band [15].

In combination, odontoid and pars fractures may be considered unstable depending on fracture patterns; though this is rare at less than 30% of odontoid fractures [16]. These scenarios mandate careful consideration of how to achieve durable fracture stability while minimizing surgical morbidity [17,18]. Herein we present a viable alternative to multimodal stabilization of these fractures via hybridization of an odontoid screw and standalone anterior cervical interbody cage.

Table 2: Levine and Edwards Classifications of Hangman's Fractures

Classification	Description	Management
Type I	< than 3 mm subluxation of C2 on C3	Rigid cervical collar
Type II	> 4 mm subluxation of C2 on C3 or > than 11 degrees angulation	< 5mm subluxation: Reduction in axial traction and halo fixation for 6-12 weeks > 5mm subluxation: May be surgical candidates
Type IIA	Less subluxation more angular deformity vs Type II	Not suitable for axial traction, halo fixation May be surgical candidates
Type III	C2-3 facet capsule disruption, anterior longitudinal ligament disruption	Often surgical candidates

Methods

Case Presentation

A 30s-year-old male with a past medical history of hypertension presented to the emergency department two-days after a fall down multiple stairs. The patient denied loss of consciousness, but endorsed persistent head and neck pain for the days following the fall. The pain was worse with flexing, extending, and rotating his neck. He denied any pre-existing or new neurologic or myelopathic symptoms.

Computed Tomography (CT) scan revealed a fracture of the odontoid with 6mm of anterior displacement, and extension of the fracture line through the left pars interarticularis of C2 (Figure 1). A type III odontoid fracture via Anderson and D'Alonzo classification, and a type II pars fracture via Levine and Edwards classification. Magnetic Resonance Imaging (MRI) was obtained to further characterize neurologic and ligamentous integrity. There was no cord compression and imaging demonstrated an intact transverse band of the cruciate ligament. Asymmetric widening of the left atlantoaxial joint, partial C2/3disc disruption, and an associated prevertebral hematoma were also visualized on MRI (Figure 2).

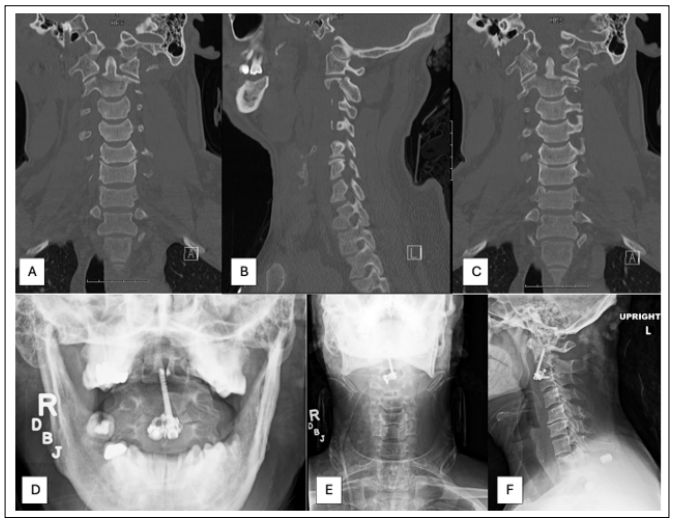

Figure 1: (A, B, & C) Preoperative Imaging Revealed a Displaced Type III Odontoid Fracture of C2 with 6mm of Anterior Displacement and Extension of the Fracture Line through the Left Pars Interarticularis, Classified as a Type II Hangman's Fracture. (D, E, & F) Two-Month Postoperative AP, Lateral, and Odontoid Views of the Cervical Spine X-Rays were Obtained Demonstrating a Stable Construct, with Early Fusion Noted of Both the Odontoid and Pars Fractures

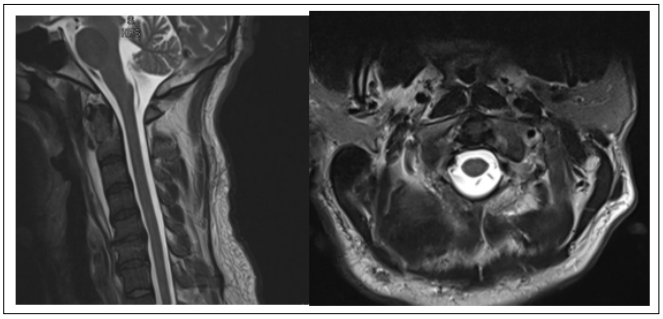

Figure 2: MRI showed Intact Transverse Band of the Cruciate Ligament, but also Asymmetric Widening of the Left Atlantoaxial Joint, Partial C2/3-disc Disruption, and an Associated Prevertebral Hematoma

The combination of these fractures amounted to a complex and likely unstable fracture pattern that could risk neurologic compromise if treated nonoperatively, and would be most prudently addressed by early surgical stabilization in this young patient. The rationale, risks, and benefits of surgical stabilization versus expectant management of these injuries was thoroughly discussed with the patient, who elected for surgery. Special consideration was given to the patient's age and baseline functional status and the desire to preserve as much cervical motion as permissible.

Operative Procedure

General nasotracheal intubation was performed to allow optimal working space. Gardner-Wells tongs were placed in the neutral position. Satisfactory reduction of the displaced fracture was noted under C-arm fluoroscopy with 10 lbs of traction. A transverse incision was made over the C3–4-disc space, and standard approach through the anterior triangle of the neck was performed.

A prevertebral hematoma with disruption of the paraspinal musculature was noted. The hematoma was evacuated. Self-retaining retractors were used after fluoroscopic confirmation of the pathological level. A rupture of the C2/3 intervertebral disc was noted; the discectomy was completed in the usual fashion. The posterior longitudinal ligament was removed with Kerrison rongeurs. After canalicular and foraminal decompression, a 7 mm standalone cervical interbody cage ("Coalition", Globus Medical, Audubon, PA, USA) was sized to fit, packed with local autograft and allograft, and tapped into the disc space.

Attention was then turned to open reduction and fixation of the odontoid fracture. Through the upper screw hole of the interbody spacer, a pilot hole the width of the outer diameter of a lag screw was drilled only to the fracture line under lateral and odontoid view fluoroscopy. A smaller pilot hole the width of the minor diameter of a lag screw was drilled to the tip of the odontoid. A 30 mm odontoid lag screw ("Corridor", Globus Medical, Audubon, PA, USA) was then placed through the upper screw hole of the interbody cage to the tip of the dens, and reduction and compression of the odontoid fracture to the C2 body was achieved as the screw was tightened. A self-drilling variable angle screw was then placed into C3 through the interbody cage. Some prominence of the final construct was noted on fluoroscopy, but this was felt to be within acceptable limits after robust fixation was confirmed on dynamic flexion and extension of the neck. Intraoperative neuromonitoring remained stable throughout the case.

Outcome

The patient tolerated the procedure well and had an uncomplicated postoperative course with preservation of neurologic function. The patient was discharged with a rigid cervical collar worn for 8 weeks post operatively. AP, lateral, and odontoid views of the cervical spine x-rays demonstrated early fusion.

At three year follow up he denies any dysphagia, and is able to complete premorbid activities at baseline functionality. Follow up XRs demonstrated stable appearance of this unique hybrid construct.

Discussion

This technical case report details the successful surgical fixation of combined odontoid and unilateral pars fractures using an odontoid lag screw through a standalone cervical interbody cage to create a hybrid construct. The described procedure achieved simultaneous rigid fixation of a displaced type III odontoid fracture and unilateral type II pars fracture, as well as successful early union on postoperative imaging, while preserving rotation about the atlantoaxial joint.

A number of alternative treatment strategies were considered and may have been reasonably employed (Table 3). Conservative non-operative management with external rigid cervical orthosis was deemed somewhat risky in this fracture pattern, albeit not unreasonable given both the odontoid fracture and the pars fractures in isolation would be considered stable patterns. Although, the incidence of failure using c-collars and halos as definitive management for complex odontoid fractures can reach rates of 40% [19]. This patient's fracture was considered complex and likely unstable warranting surgical intervention.

Table 3: Alternative Treatment Paradigms Considered

Treatment	Classification	Pros	Cons
External bracing with rigid cervical collar or halo-vest	Non-operative	• Non-invasive • No loss of motion • Avoids risk of iatrogenic adjacent segment disease	• Poor stabilization of upper cervical segments19 • Risk of non-union • Risk of delayed neurological deficit • Brace morbidity28 • Relies on strict patient compliance
Odontoid screw (single or dual) only with postoperative rigid cervical collar or halo-vest	Operative	• Preservation of C1/2 motion • Single surgery • Anterior approach • Reduction of odontoid displacement • Addresses dens • Lower but not eliminated risk of delayed neurological deficit	• Does not address pars • May contribute to instability via C2/3 disc violation • Risk of dysphagia/dysphonia from screw • Brace morbidity[28] • Relies on strict patient compliance
C2/3 anterior cervical discectomy and fusion only with postoperative rigid cervical collar or halo-vest	Operative	• Preservation of C1/2 motion • Single surgery • Anterior approach • Addresses pars • Lower but not eliminated risk of delayed neurological deficit • No risk of dysphagia/ dysphonia from screw	• Does not address dens • Loss of C2/3 motion • Possible adjacent segment disease • Brace morbidity28 • Relies on strict patient compliance
C1-2 posterior cervical fusion via a hook-rod construct, lateral mass and pars or pedicle (i.e. "Judet") screws (Goel-Harms technique), transarticular screws (Magerl technique), and/or sublaminar wiring (Sonntag, Gallie, Brooks, etc. techniques)[20-22]	Operative	• Single surgery • Addresses both odontoid and pars • No risk of dysphagia/ dysphonia from screw • Effectively eliminates risk of delayed neurological deficits • Does not require postoperative halo-vest	• Posterior surgery • Loss of C1/2 and C2/3 motion • Possible adjacent segment disease • Potential construct instability with pars fracture • Vertebral artery injury with blind pass of transarticular screws
C1-3 posterior cervical instrumentation and fusion via a hook-rod construct, lateral mass and pedicle (i.e. "Judet") screws (Goel-Harms technique), or a transarticular (Magerl technique) and Goel-Harms combined construct, and/or sublaminar wiring (Sonntag, Gallie, Brooks, etc. techniques)[20-22]	Operative	• Single surgery • Addresses both odontoid and pars • No risk of dysphagia/ dysphonia from screw • Effectively eliminates risk of delayed neurological deficit • Does not require postoperative halo-vest	• Posterior surgery • Loss of C1/2 and C2/3 motion • Possible adjacent segment disease • Vertebral artery injury with blind pass of transarticular screws
Odontoid screw (single or dual) AND C2/3 posterior cervical instrumentation and fusion via a hook/rod construct, lateral mass and pars or pedicle (i.e. "Judet") screws (Goel-Harms technique), and/or sublaminar wiring (Sonntag, Gallie, Brooks, etc. techniques)[20-22]	Operative	• Preservation of C1/2 motion • Addresses both odontoid and pars • Reduction of odontoid displacement • Effectively eliminates risk of delayed neurological deficits • Does not require postoperative halo-vest	• Two surgeries • Risk of dysphagia/dysphonia from screw • Loss of C2/3 motion • Possible adjacent segment disease • Potential construct instability with pars fracture

All operative options were carefully considered. We may have proceeded with a number of combinations including: an isolated odontoid screw with postoperative rigid cervical collar, single level discectomy and fusion to address the pars fracture with postoperative rigid cervical collar for the odontoid fracture, or addressing both fractures in one or two stages of odontoid screw and single level discectomy and fusion. Postoperative rigid cervical collar was determined prudent regardless of chosen technique until fusion was achieved [23].

Our group favors anterior cervical approaches when possible given the published improved tolerability by patients [24]. The patient's young age and intact cruciate ligament made an odontoid screw feasible [25]. Furthermore, the preservation of atlantoaxial rotation at C1/2 afforded by an odontoid screw is a major advantage of this technique. However, the placement of these screws often requires creating a trough in the C2/3 intervertebral disc to gain the necessary angulation and trajectory, which might introduce iatrogenic

instability at this level given the already compromised posterior elements. In our case significant C2-3 disc disruption was appreciated intraoperatively further owing to the decision for C2-3 discectomy and fusion. A prior report detailed a transdiscal odontoid fixation, but this was through a congenitally fused C2/3 disc; our case by comparison aimed to achieve de novo C2-3 fusion. Lastly, while the posterior fixation options would secure both motion segments in a single stage surgery, they would also all sacrifice the up to 70% of cervical rotation provided by the atlantoaxial joint [26,27]. After full consideration of the available surgical options, the single stage hybrid construct was selected.

Conclusion

A novel odontoid screw/standalone anterior cervical interbody cage hybrid was used to fix a combined odontoid and pars fracture of C2 in a single stage. The resulting construct stabilized the fractures and preserved both atlantoaxial mobility and neurologic function without dysphagia or postoperative complications. Long term follow up demonstrated this construct to be a durable option for fixation. This case emphasizes the importance of seeking innovative surgical solutions for complex fracture patterns in well-selected patients [28].

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The authors have no personal, financial, or institutional interests in any of the drugs, materials, or devices described in this manuscript.

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