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Conclusion:

Odontoid fractures present frequent and challenging problems to treating spinal surgeons. Requisites to successful outcomes are a thorough understanding of the regional complexity, anatomical variation, and patient factors. Surgeons must also possess an understanding of the myriad treatment options for these injuries along with the technical acumen to employ them effectively.

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Challenges in Odontoid Fracture Treatment: Axis or Ally?

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Introduction:

Odontoid fractures are among the most common yet challenging spinal injuries treated. Fractures of this vulnerable craniocervical region can occur in all age groups and may be induced by a variety of traumatic mechanisms. Low-energy trauma in the elderly can induce fragility fractures of the weakened odontoid waist. The poor blood supply to this water-shed area can produce significant challenges to healing for this population. Nonunion risks include posterior fracture displacement and angulation, increasing fracture comminution, bone density, delayed treatment, and advanced-age.

High-energy trauma is typically to blame for odontoid fractures in younger patients involved in acceleration-deceleration accidents. Anatomical variation in this area can further complicate identification of these injuries. Entities such as odontoid hypoplasia, atlantoaxial pseduosubluxation, and os odontoideum can lead to significant confusion for treating specialists when attempting to identify and classify injuries to the axis bone. Pediatric patients have skeletal attributes placing them at inherent risk of injury to the craniocervical junction. These include increased head-torso ratio, ligamentous laxity, poorly developed muscular support, and horizontal facet joints. Challenges specific to children further include the multiplicity of physes in this region which prove to be weak points of bony spinal development. Variations in arterial anatomy across age-groups can also pose significant challenges to treatment and are typically attributable to differences in trajectory of the vertebral artery. Injury identification requires computed tomography (CT) scanning and often employs magnetic resonance imaging (MRI). Concerning odontoid fracture findings include posterior angulation and posterior displacement placing the spinal cord at risk. However, the large space-available-for-the-cord (SAC) at C1-2 portends a minimal risk of spinal cord injury (SCI) at this level.

Once injuries are identified, the modified classification system of Anderson and D'Alonzo can help guide treatment. Fractures of the odontoid tip are classified as Type 1 and require rigid cervical collar immobilization only unless the injury is associated with craniocervical dissociation (aka: occipitoatlantal dissociation "OAD"; aka: occipitocervical dissociation "OCD"). When this occurs, obligatory occipitocervical fixation is employed.

Type 3 injuries are fractures of the odontoid base with extension into the vertebral body of the axis. Given the large cancellous bony surface area, these fractures readily heal with rigid cervical collar immobilization.

Type 2 fractures are the most common and are associated with fractures of the odontoid base (or "waist"). Treatment for this fracture type remains controversial and without consensus opinion. However, further sub-classification of Type 2 fractures can potentially help guide treatment (see below). Aside from fracture type, angulation, and displacement, treatment considerations include age, bone quality, associated injuries, patient comorbidities, associated neurological injury, anatomical considerations, and surgeon preference/experience.

Treatment Options:

Many treatment options exist for Type 2 odontoid fractures which speaks to the lack of consensus and ongoing controversy related to this topic in the field of traumatic spinal injury treatment. Rigid external cervical immobilizers can be employed when Type 2 odontoid fractures remain reasonably well aligned and with minimal displacement (<10degrees angulation and <4mm fracture translation, respectively). Halo-fixators can be employed with reasonable treatment success and union rates. However, this treatment should be avoided in elderly and polymorbid patients given the treatment course fraught with complications. These complications can include poor reduction maintenance, dysphagia, delirium, pneumonia, pin-site infection, spinal-fluid leak, and even death.

Anterior odontoid lag-screw fixation is a valid treatment modality in patients with Type 2B fracture patterns (anterosuperior to posteroinferior fracture obliquity) and good bone stock with minimal comminution *(see Case Study 1 example)*. Single or double screw techniques can be used.

Type 2A (horizontal fracture-line with minimal comminution) and Type 2C (posterosuperior to anteroinferior obliquity +/- comminution) are not treated as well with anterior screw fixation. Posterior surgical treatment methods are also valid modalities. These include many options from antiquated wiring-constructs to trans-articular position screws (Magerl Technique) to C1 lateral-mass screws coupled with C2 pars/pedicle screws (Harms Technique) – Case 2 employs the latter option. Prior to choosing a treatment modality, spinal surgeons make a thorough analysis the fracture "personality," but also take into account any and all patient factors that can affect treatment. Once a gestalt is formulated, the treating spinal surgeon strategically implements the surgical plan that is laden with potential complications.

CASE STUDY 1

A healthy, athletic 68-year-old retired male fell while skiing. He sustained an extension injury to the craniocervical junction. Collar immobilization was employed by the ski-patrol and he was transferred neurologically-intact to the Rocky Mountain Regional Trauma Center by ground ambulance. An isolated Type 2B odontoid fracture was diagnosed *(Image 1)*.

He was taken urgently to surgery where closed reduction was achieved in Mayfield tongs with cranial manipulation under fluoroscopy. Single anterior lag-screw fixation was utilized. Findings included good purchase in solid bone along with anatomical alignment on postoperative CT scanning *(Image 2)*. The patient was discharged in good condition with a cervical collar for added support and plans to return to skiing once healing occurs and rehabilitation training is completed.

Whereas anterior odontoid screw fixation may not be utilized in other patients >65 years, the organized opinion of this patient revealed a younger physiological age with minimal to no comorbidities and good bone quality. This allowed successful implementation of this treatment modality. Further preoperative analysis also demonstrated high-riding vertebral artery anatomy which precluded Harms and Magerl posterior techniques.

Image 1 – Mid-sagittal injury CT-Scan image demonstrating a modified-Anderson/D'Alonzo Type 2B odontoid fracture with severe posterior displacement threatening the spinal cord.

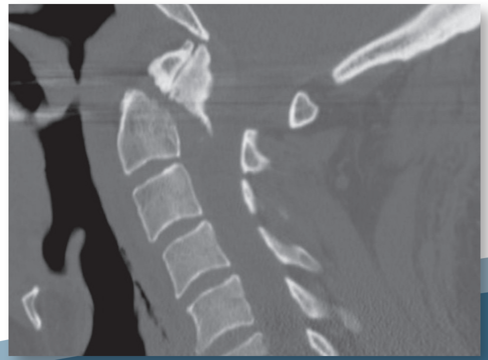

Image 2 – Mid-sagittal postoperative CT-Scan image showing anatomical reduction and anterior lag-screw fixation with reconstitution of the native spinal canal diameter.

CASE STUDY 2

A healthy, athletic 64-year-old ski racer fell during a giant-slalom competition sustaining a Type 2B odontoid fracture *(Image 3)*. He also sustained an ASIA-D incomplete spinal cord injury *(Image 4)*. Ski patrol immobilized him in a field-collar and he was air transported to Denver Health.

He was urgently taken for reduction and open fixation utilizing a posterior approach along with indirect decompression of the spinal canal *(Images 5 and 6)*. Prior to exposure, reduction utilizing Mayfield tongs under fluoroscopy assistance was successful. Harms instrumented fusion technique was then executed. Postoperatively, the patient made an excellent neurological recovery on the inpatient rehabilitation unit, demonstrated maintained reduction at the six-week follow-up appointment *(Image 7)*, and returned home to Steamboat, Colorado where he hopes to return to skiing next winter.

Reasons for posterior approach in this patient included favorable vertebral arterial anatomy, surgeon preference, and potential need for posterior laminectomy for direct decompression if indirect techniques were to have failed.

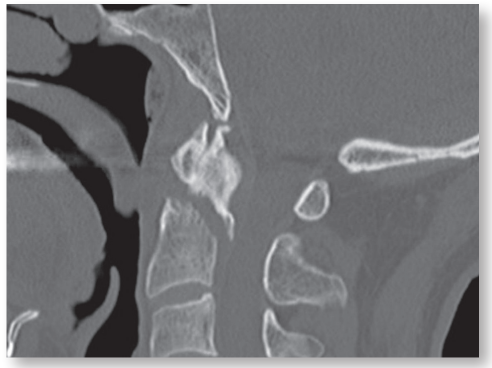

Image 3 – Mid-sagittal injury CT-Scan image demonstrating a modified-Anderson/D'Alonzo Type 2B odontoid fracture with moderate posterior displacement and spinal canal encroachment.

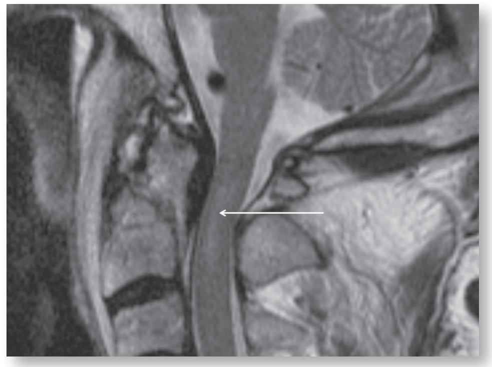

Image 4 – Mid-sagittal T2-weighted MRI-Scan image showing posteriorly displaced odontoid fracture, spinal canal encroachment, and spinal cord edema (arrow) consistent with incomplete spinal cord injury.

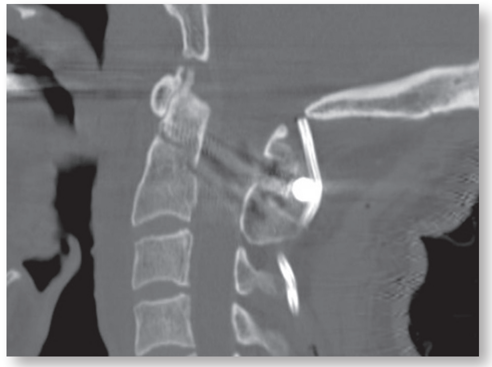

Image 5 – Mid-sagittal postoperative CT-Scan image depicting anatomical fracture reduction, reconstitution of the spinal canal, and stable posterior internal-fixation.

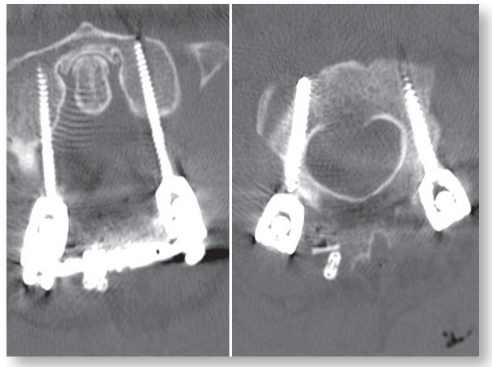

Image 6 – Postoperative axial CT-Scan images showing excellent placement of bilateral C1 lateral-mass screws (left) coupled with bilateral C2 pedicle screws (right).

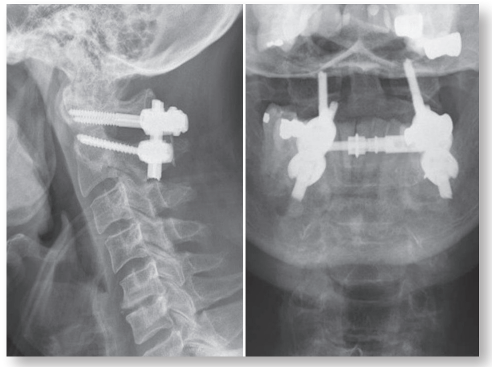

Image 7 – Upright, anteroposterior and lateral X-ray images demonstrating a well-aligned odontoid fracture six-weeks following open-reduction and posterior internal-fixation utilizing instrumented C1-2 Harms technique along with tri-cortical iliac crest allograft fusion.