Odontoid Fractures

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Abstract

Pediatric odontoid fractures are rare but should be suspected in any child at risk for cervical spine trauma. Injuries to the odontoid have occurred even with relatively minor injuries such as ground-level falls. The fulcrum of motion in pediatric patients is at the C2-C3 level resulting in a greater risk of upper cervical fractures. Under the age of 7 years, the most common odontoid fracture is through the cartilaginous synchondrosis between the odontoid process and the body of the axis. Adolescents who sustain an odontoid fracture after synchondrosis fusion can be classified using the Anderson and D'Alonzo criteria and treated appropriately. A thorough clinical and radiographic evaluation is critical. Treatment options include both non-operative and operative options. Synchondrosis fractures will heal reliably with external immobilization. Non-union after treatment is rare. Surgery is reserved for patients who fail conservative treatment, with loss of reduction, nonunion, or neurological symptoms. A neurological deficit is uncommon with these injuries. If an odontoid fracture is neglected, nonunion may occur with the development of an os odontoideum and subsequent atlantoaxial instability. This chapter discusses non-operative and operative treatment, imaging studies, and potential complications in the management of pediatric odontoid fractures.

1 Brief Clinical History

A 3-year-old male was involved in a rollover motor vehicle accident where the family minivan struck a tree. He was appropriately restrained in a car seat and airbags were noted to have deployed. At the scene, he was awake, alert, and moving all extremities spontaneously. He was immobilized in a cervical collar and transported to a local hospital (Fig. 1). A CT scan was obtained demonstrating a displaced odontoid fracture (Fig. 2). Spinal precautions were continued, and he was transferred by ambulance to a pediatric trauma center for definitive care.

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C. A. Iobst, S. L. Frick (eds.), *Pediatric Orthopedic Trauma Case Atlas*,
https://doi.org/10.1007/978-3-319-29980-8_68

Fig. 1 Initial immobilization should consist of an appropriately sized pediatric cervical collar. Due to the disproportionate large head of children less than age 8 years, a backboard with an occipital recess should be used to avoid excessive cervical flexion

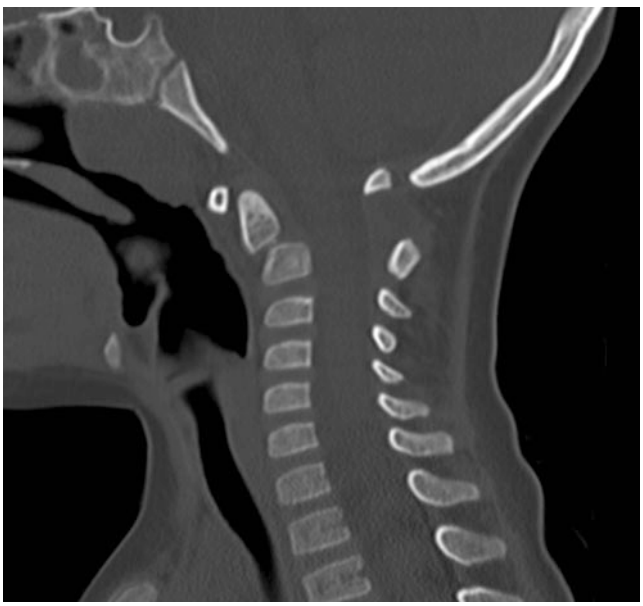

Fig. 2 Sagittal reconstruction of a CT scan demonstrating an odontoid fracture with displacement through the dentocentral synchondrosis

2 Preoperative Radiographs

Odontoid synchondrosis fractures are most commonly displaced anteriorly with some degree of angulation. A lateral radiograph may be adequate to make the diagnosis; however, this fracture can be missed on plain radiographs. The addition of cross sectional imaging, either CT or MRI, should be considered for any child who is unresponsive, intubated, has positive neurological findings on clinical exam, or in whom a high clinical suspicion of a cervical injury exists despite the presence of normal radiographs. A CT scan with coronal and sagittal reformats is effective at identifying odontoid fractures and other cervical injuries. Alternatively, an MRI is capable of both identifying fractures as well as define the extent of soft tissues injuries and avoids exposing the patient to additional radiation.

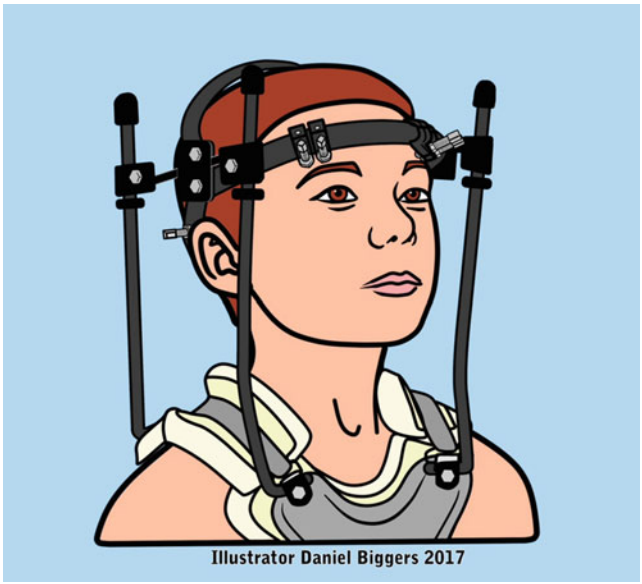

Fig. 3 Illustration of a pediatric halo with two pins placed on each side anterolaterally

3 Preoperative Problem List

- Displaced odontoid fracture without neurologic deficit

4 Treatment Strategy

The primary treatment of pediatric odontoid fractures is non-operative. Immobilization with a halo vest (Fig. 3) or Minerva cast for 6–12 weeks can be used (Figs. 4 and 5). Synchondrosis fractures will heal reliably with external immobilization. Nonunion of an adequately treated odontoid fracture is rare in a young child. Surgery is reserved for patients who fail conservative treatment, with loss of reduction, nonunion, or neurological symptoms. Surgical treatment introduces a risk of complications due in part to the patient's smaller physical size and remaining growth potential. When required, C1-C2 arthrodesis is performed with internal fixation, consisting of posterior wiring with structural bone graft,

Fig. 4 Coronal view of a 13-month-old in a Minerva cast

Fig. 5 Saggital view of a 13-month-old in a Minerva cast

atlantoaxial transarticular screws, or C1 lateral mass screws combined with C2 pars screws. Of note, the long-term effects of upper cervical fusion in a young child remain unknown.

5 Technical Pearls

An unstable C2 synchondrosis fracture is reduced under fluoroscopy with gentle cervical extension (Fig. 6). Once a successful reduction is obtained, immobilization is required. A Minerva cast is very effective, particularly for infants; however it does require skillful application. Adequate padding and avoidance of pressure on bony prominences and the ears are critical to avoid skin breakdown.

Alternatively, a halo vest is an excellent treatment option, providing excellent stability while also allowing caretakers greater access to the child. When applying a halo, it is important to remember the anterior safe zone for pin insertion, which is just superior to the lateral 2/3 of the eyebrow (Fig. 7). During insertion of the anterior pins, the eyes should be closed, and gentle caudal skin traction should be placed on the eyebrow to avoid tethering the skin cranially. Posterior pins should be placed opposite to the anterior pins, taking care to leave clearance between the halo ring and the ears.

For children older than age 6 years, a standard four-pin configuration (two anterolaterally and two posterolaterally) may be utilized, torqueing the pins at 6 to 8 in.-lbs. For younger children, the pin insertion technique must be modified to limit the risk of skull perforation. In this age group, a greater number of pins (up to four anterolaterally and up to six posterolaterally) may be placed with lower insertional torques. A general guideline is finger tight pins for infants and a torque of 1 in.-lb per year of life under the age of 6 years.

An upright radiograph in the cast or halo vest is important to confirm adequate alignment after the reduction (Fig. 8). The fracture is then followed with serial radiographs. Once adequate healing is judged by radiographs and/or CT scans, the cast or halo immobilization is discontinued, and the patient is transitioned into a cervical collar. The patient gradually weans from the use of the collar over the upcoming weeks. One month later, lateral cervical flexion-extension films are obtained to confirm that there is no motion at the fracture site or other instability (Figs. 9, 10, and 11).

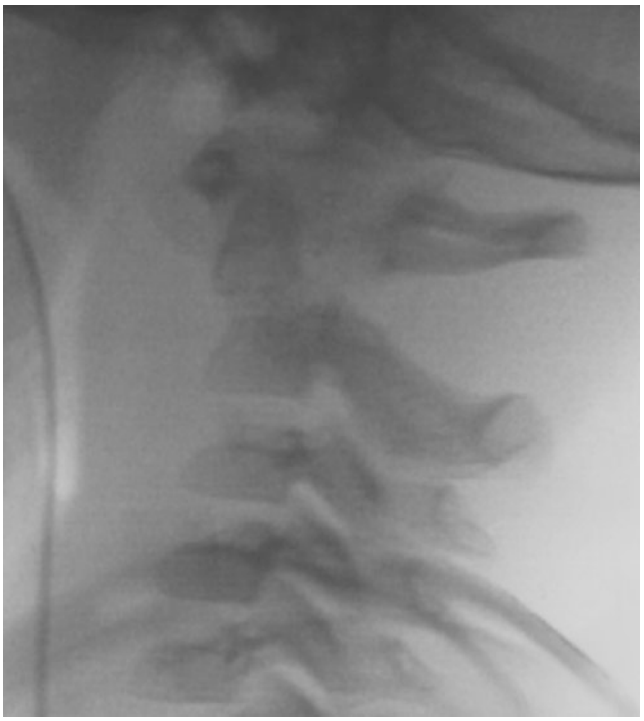

Fig. 6 An eight-pin halo ring was applied under general anesthesia with the pins torqued to 3 in.-lbs. The odontoid fracture was reduced with fluoroscopic control, and a halo vest was applied

Fig. 8 An upright radiograph in the halo vest demonstrates adequate alignment of the odontoid fracture

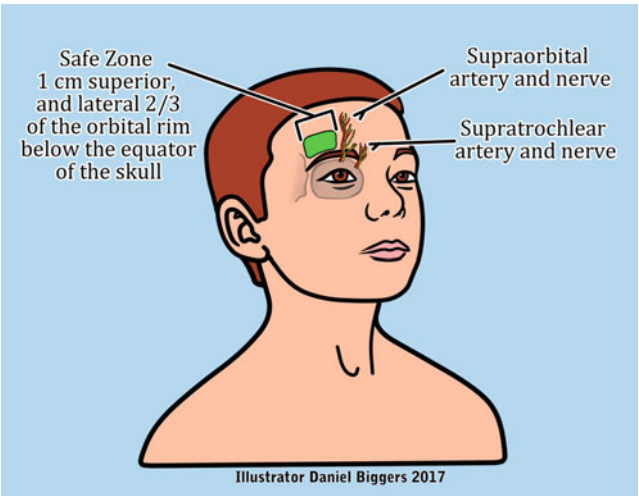

Fig. 7 The anterior safe zone for pin insertion is just superior to the lateral 2/3 of the eyebrow

Nonunion is rarely encountered in the management of pediatric odontoid fractures. However, in older adolescents, nonunion may occur despite adequate immobilization in a halo vest.

Fig. 9 Lateral radiograph demonstrating the healed odontoid fracture 6 weeks following the injury

Fig. 10 Lateral flexion radiograph demonstrating no evidence of instability 10 weeks following the injury

Fig. 11 Lateral extension radiograph demonstrating no evidence of instability 10 weeks following the injury

6 Avoiding and Managing Problems

Problems in the management of pediatric odontoid fractures are specific to the treatment technique:

6.1 Non-operative Treatment (Minerva Cast or Halo Vest Immobilization)

The preoperative imaging (CT head) should be scrutinized for a skull fracture or anatomic variants which could be problematic with halo pin placement. During application of the halo, pin placement into the medial 1/3 of the orbit is to be avoided due to the presence of the supraorbital and supratrochlear nerves and artery.

Observe carefully for evidence of skin breakdown during the treatment period. While the child is in a halo vest, activity restriction is critical as a fall in the halo may lead to a skull fracture or other complication. Pin tract infections are common and may be minimized with daily pin care. If a superficial infection is noted, a short course of oral antibiotics is usually adequate to clear the infection.

6.2 Operative Treatment (C1-C2 Arthrodesis)

Potential surgical complications include but are not limited to superficial or deep infection, vertebral or internal carotid artery injury, nerve root or spinal cord injury, nonunion, implant malposition, and hardware failure.

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