PEER REVIEWED LETTER

Spondylolisthesis of C2 in an Eight-Week-Old Infant: Long Term Followup

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Injury to the pediatric cervical spine (C-spine) comprises approximately ten percent of all spinal trauma.[1] Pertaining to pediatric C-spine injuries, 50% of cases are centred around the occiput to C2.[2] The axis is the most commonly injured vertebra in children with an increased frequency of odontoid synchondrosis fractures in patients younger than seven years of age.[3] Past that age, the incidence of subaxial injuries increases, approaching an adult distribution. Treatment of pediatric of C-spine fractures is challenging given the anatomical constraints to surgical stabilization, and fitting difficulties with rigid external orthoses in this age group. Reported is a case of a severely anteriorly displaced spondylolisthesis of C2 in an eight-week-old infant managed non-operatively with two-year follow-up. A review of the current literature is included.

Methods

A prospective study over a 2.5 year period from July 2004 to February 2007, of the management of an eight-week-old male infant, who presented to our emergency department with multiple injuries including a severe, traumatic, spondylolisthesis of C2.

Results

An eight-week-old male infant presented to emergency department with multiple injuries including a large subgaleal hematoma, a linear occipital skull fracture, and multiple rib fractures consistent with non-accidental trauma. There were no focal neurological deficits on exam. He was irritable but interactive and it was noted that he held his head in a slight degree of flexion. Lateral cervical spine x-rays showed a widely displaced spondylolisthesis of C2 (Figure A).

The patient was placed in a Philadelphia collar, which was well tolerated, and followed with serial clinic visits. A CT scan through the cervical spine at four months post-injury showed acceptable bony alignment while in the Philadelphia collar; However, upon removal of the collar at six months, there was significant anterior subluxation of C2 on C3 (Figure B). Despite the lack of neurological deficits and neck pain, the patient was placed in a custom-fit Minerva jacket with his neck held in slight extension (Figures C), for a three-month period with a goal of preventing progressive deformity. At nine months post-injury, the Minerva jacket was removed and flexion/ extension films showed satisfactory alignment of the patient's cervical spine. Follow-up films at 15 months post-injury continued to show acceptable alignment with a final set of flexion/extension films at two years showing stable range of motion of the cervical spine, and bony fusion of the posterior elements of C2 and C3 (Figures D). The patient has remained pain-free with no neurological sequelae, and has good range of motion through his neck.

Discussion

Reports of traumatic spondylolisthesis of C2 in infants have been previously documented, mainly as a result of motor vehicle accidents,[4-8] falls,[9-11] or non-accidental trauma.[12,13] Most of the reports have documented alleviation of neck pain and early radiographic fracture stability using external immobilization, with limited follow-up. Our report shows a severe traumatic C2 fracture with radiographic stability four months post-injury whilst in external immobilization; however, we document on-going instability at six months once the collar was removed (Figure B). Due to short-term follow-up, previous studies have postulated the need for surgical fusion in their patients. Non operative management was successful in treating the ongoing anterior C2 subluxation and surgical management was not necessary.

Several anatomical and biomechanical factors influence the nature of early pediatric C-spine injuries. The C-spinal in the infant is very flexible, due to the lax nature of the immature ligaments, particularly throughout the first eight years of life.[14] The facet joints are more shallow and horizontal than those of the adult spine.[15,16] Absent uncinate processes and weak nuchal muscles also cause increased flexibility.[17,18] Taken together, these features lend to increased translational and rotational mobility. The laxity of the ligaments can allow for pseudo-subluxation in the pediatric C-spine.[18,19] Currently, the diagnosis of an unstable C-spine injury in children less than eight years of age can be made if there is angulation at any level greater than 7°, and/or if there is the presence of greater than 4.5 mm of subluxation at C2-3 or C3-4. Beyond age eight, subluxation beyond 3.5 mm at any subaxial level is abnormal.[20]

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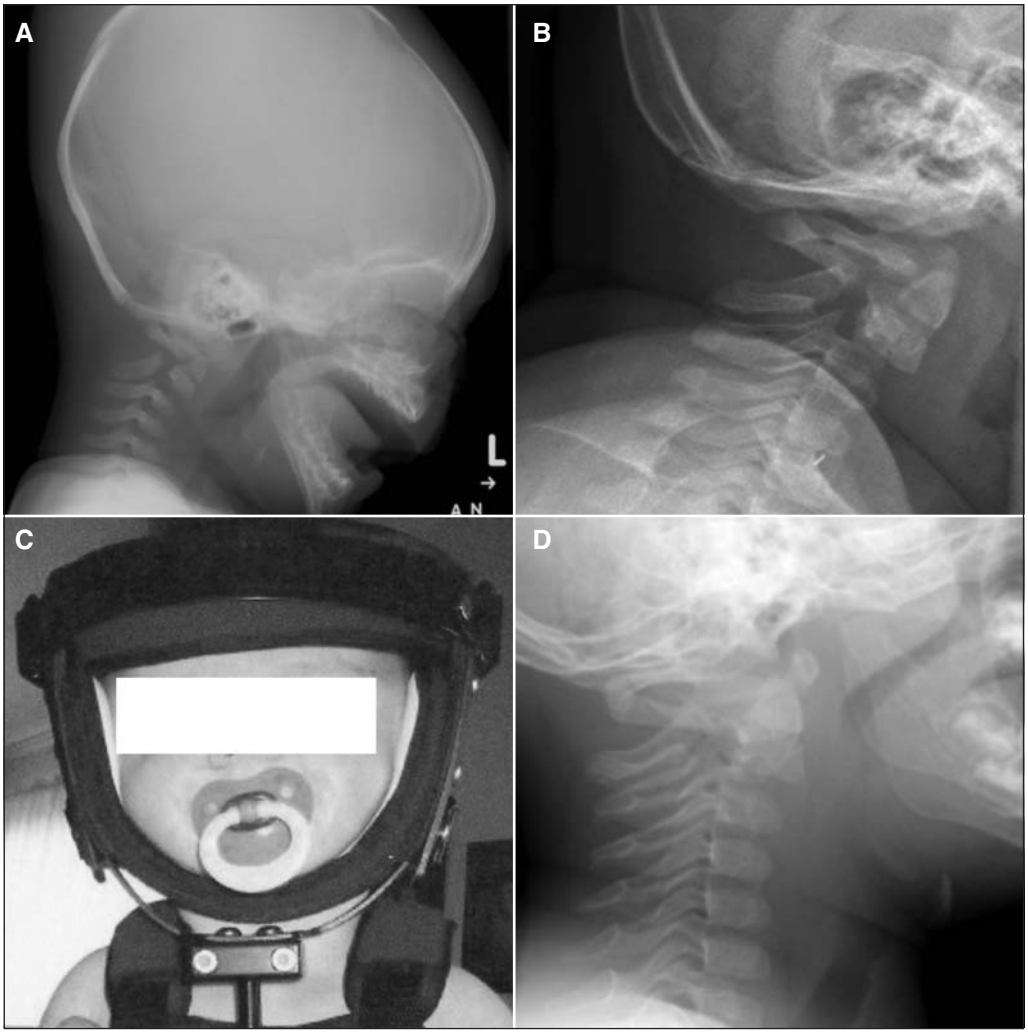

***Figure**: (A) Lateral skull and C-spine x-ray at age 8 weeks demonstrates the presence of an occipital skull fracture and spondylolisthesis of C2 on C3. (B) Imaging at 6 months post-injury following prolonged immobilization in a Philadelphia collar shows significant, ongoing anterior subluxation of C2 on C3 when the child had the collar removed. (C) A custom-fitted Minerva jacket and brace was applied for 3 months following failure of the Philadelphia collar to achieve anatomic stability. (D) Flexion/extension films at 2 years post-injury shows stable fibrous non-union of C2 with fusion of the posterior elements of C2 and C3 (figure shows the flexion film).*

With specific attention to C2 fractures, the multiple ossification centres of the developing axis make pediatric fracture detection here problematic. The immature axis contains five ossification centres: one for each of the two arches, one for the centrum or body, and two for the dens. The centres for the dens are radiographically fused at birth, leaving cartilaginous physes known as the neurocentral synchondroses, flanked on either sides of the centrum by the two arches, visible on imaging. The neurocentral synchroses close between three and six years of age and the posterior arches close between two and four years of age, and should not be mistaken for fractures.[17,21]

The biomechanics of the pediatric C-spine also contribute to the pattern of injuries seen. A relatively large head to body ratio in children less than eight years of age shifts the fulcrum of movement to the upper cervical spine, with the greatest movement at C2-3.[16] This fulcrum shifts to C3-4 by age six and finally to C5-6 in adolescents and young adults, similar to the mature spine. Consideration of the larger head in infants should also be given during cervical immobilization on a spine board, with mean elevation of the torso by 25 mm in order to achieve neutral neck positioning and avoid exacerbating a traumatic kyphotic deformity.[22,23]

Most pediatric C-spine injuries can be managed non-operatively with external immobilization even in the setting of

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ligamentous instability.[2,16,24,25] External immobilization of the infant C-spine can be challenging given the increased inherent mobility and large head size. Infants may be noncompliant with collars and the necessity to wear the collar for long periods of time may cause difficulties with cleaning and skin breakdown. With halo ring fixation, the thin calvaria necessitates careful planning of pin placement, often with CT bony windows for reference, with pin site infection being the most common complication. The amount of torque applied to each pin changes with age, with the recommendation of 'finger tightness' for children up to two years of age.[16] Eight to ten pins are required in children less than two years of age, decreasing to the normally required four pins by age five.[26] The custom-fit Minerva jacket precludes the use of pins and has demonstrated good results with fracture reduction and healing of cervical spine injuries while being well tolerated in the pediatric population.[27]

Surgical stabilization options are often limited by the anatomy of the immature and developing pediatric spine. In addition, preservation of spinal mobility with non operative treatment may be preferred, and prevent the need for fusion in the developing spine. If surgery is undertaken, a posterior bone and cable fusion with external fixation is often preferred in children less than four years of age due to the anatomic limitations of plate and screw constructs. Anterior discectomy and fusion has good outcomes by age five, and by age ten, the cervical spine has almost reached adult height, allowing both anterior and posterior approaches to be effectively considered.[28,29] With respect to choice of fusion material, there have been reports of allograft failure in children with posterior instrumentation, advocating the use of rib or iliac crest autograft in this population.[30,31]

In summary, we report a case of a severe spondylolisthesis of C2 in an eight-week-old infant caused by non-accidental trauma that was managed successfully with prolonged use of rigid external orthosis. Two and a half year follow-up demonstrated fibrous non-union of his fracture.

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