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GRAND ROUNDS

Treatment of cervical subaxial injury in the very young child

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Abstract

Introduction Infant's cervical spine has serious differences compared to other pediatric age groups and adults. Anatomical and biomechanical constitution of an infant is unique, and the pediatric spine gradually begins to resemble the structure of the adult spine after age 10. In addition, clinical presentation of the cervical spinal traumas has many distinctions from birth to the end of adolescence. In young children, cervical spine traumas are mainly localized in the upper cervical region. Traumalocalized in subaxial cervical region and fracture-dislocations are rare in infants.

Case report Here, we present a case history of a 7-month-old infant with surgically treated severe subaxial flexion-distraction injury. Neurologic examination revealed complete loss of motor function below C5. A whole-body CT was taken and we observed that C5–6 dislocated anteriorly approximately one vertebra size and also unilateral facet joint was locked. The patient was intubated and closed reduction was attempted with fluoroscopy under general anesthesia, but it was unsuccessful. Whereupon C5–6 microdiscectomy was performed with the anterior approach and fixation was provided with the craniofacial miniplate. Despite anterior stabilization, exact posterior alignment could not been achieved so, posterior approach was added to the surgery. At 12 month follow-up, the patient improved from quadriparesis to paraparesis and we achieved a satisfactory radiological outcome.

Keywords Infant · Subaxial · Anterior · Posterior · Fusion · Pediatric trauma · Cervical spine injury · Spinal cord injury · Stabilization

Case presentation

A 7-month-old female infant was admitted to emergency service due to a traffic accident. We were informed that one of the parents died in the accident and it was referred to us to think it was a high-energy trauma. In neurological examination, the eyes opened spontaneously, the patient was restless and there were no limb movements (The pediatric Glasgow Coma Scale = 9, Frankel grade = A). The patient was intubated due to low oxygen saturation and had respiratory distress in the emergency department, so we immediately hospitalized her in the pediatric intensive care unit.

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Diagnostic imaging

A whole-body CT scan was taken. There were a cephalohematoma in the right occipital region on brain CT and bilateral lung contusion on thoracic CT. C5 dislocated anteriorly approximately one vertebra size and also unilateral facet joint was locked on the left side on cervical CT (Fig. 1a, b). It was observed on cervical MRI that there were a spinal cord contusion at C4–5 level, nearly complete transection just under it, spinal cord edema below C5 level, and also intensity changes in favor of subarachnoid hemorrhage. Moreover, it was seen that intervertebral disk was avulsed from the superior endplate of C-6, and posterior ligaments and paravertebral muscles were avulsed at C5–6 level (Fig. 1c).

Review of the literature

Cervical traumas in infants show differences compared to other pediatric age group and adults due to immature neck muscles and bones, the relatively bigger head size, and ligamentous laxity of spine [1–4]. In this age group, cervical spine traumas often take place in the upper cervical region. Trauma mechanisms are usually in the form of subluxation and ligament injuries rather than bone fractures.

Dislocation, subluxation, locking of cervical facet joints, and distraction injury are rarely seen in the subaxial region in infants. According to recent data, the treatment of infantile subaxial cervical dislocation was non-surgical (external orthosis) or surgical (posterior decompressive laminectomy and bone fusion without an instrument) [4–6] (Table 1).

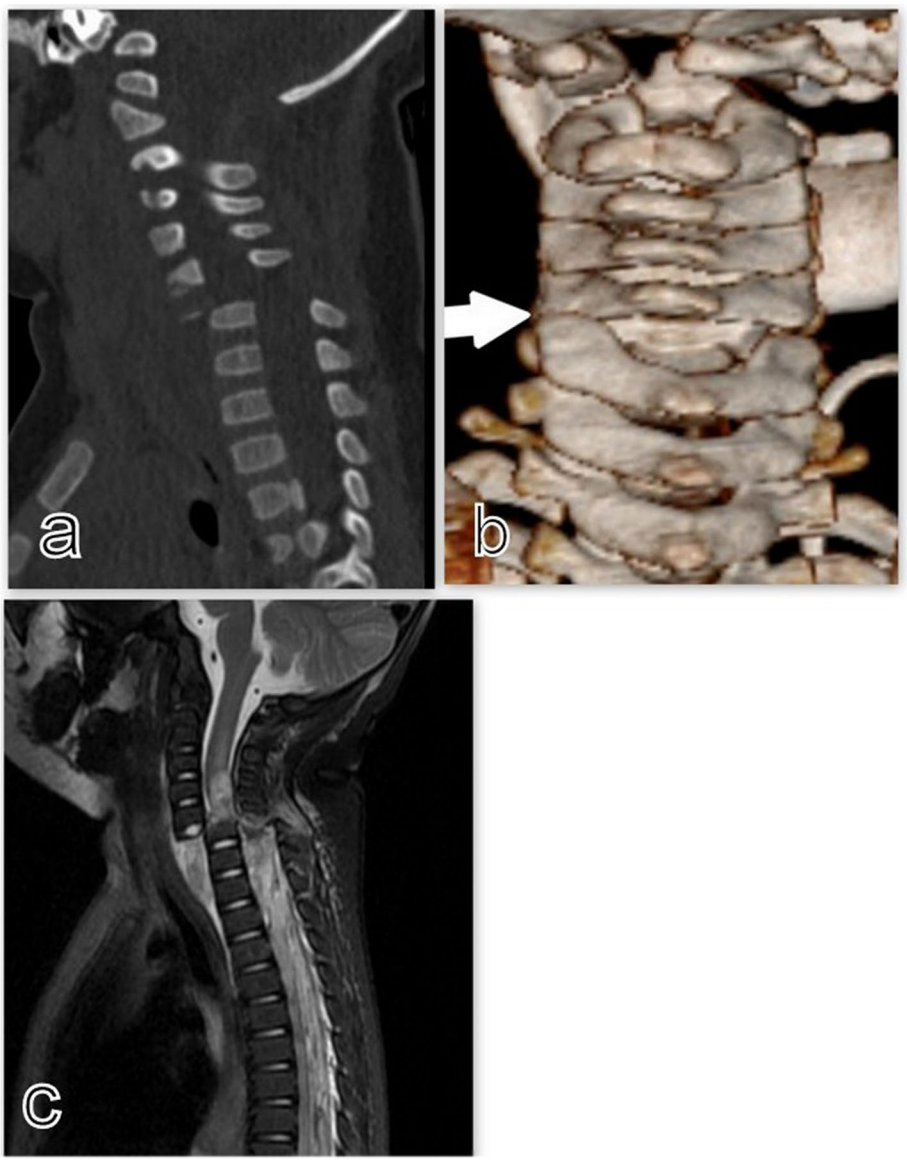

Fig. 1 C5-6 dislocation fracture (**a**), unilateral locked facet joint on cervical CT (**b**), spinal cord contusion, edema, avulsion of intervertebral disc, and posterior ligamentous injury on cervical MR

Table 1 Surgically treated subaxial cervical traumas in infantil age group

Authors	Age	Procedure	Fusion material	Instrumentation
Holland et al. [4]	3 weeks	Posterior fusion	Rib autograft + rhBMP-2	None
Rooks et al. [6]	3 months	External immobilization, posterior fusion	Not mentioned	None
	3 months	Posterior laminectomy + fusion	Not mentioned	None
Present case	7 months	Anterior–posterior combine + fusion	Allograft	Anterior-craniofacial miniplates

rhBMP-2 recombinant human bone morphogenetic protein-2

Progressive kyphosis developed in a patient treated with an external orthosis [6].

An important challenge of pediatric cervical stabilization with cervical plates and screws is that these materials are not suitable for small bone structure. For this reason, craniofacial miniplates and screws have been reported to be used in the posterior stabilization of occipitocervical region [7]. Besides, anterior stabilization has been performed using miniplates and screws in a 2-year-old child with C3–4 dislocation and in a 15-month-old child with C6–7 dislocation [8, 9]. Our case, regardingly, shows that miniplates and screws can be used in anterior stabilization in infants.

In the literature, another polemical issue is the fusion material for very young children. Autografts/allografts are widely used as the fusion material in the pediatric population [10]. In our case, one piece was removed from the iliac crest for anterior fusion, but it was felled into fragments while reshaping due to incomplete ossification and cartilaginous structure. Thus, an allograft was used as a material for anterior fusion, and iliac crest bonny parts were used for posterior fusion. It should be considered that bone morphogenetic protein or demineralized bone matrix is synthetic materials which can be used in these age for fusion [4, 10]. The most important disadvantage of artificial materials is heterotopic ossification, systemic or local toxicity, and the risk of inducing carcinogenesis by osteoblastic and osteoclastic activation [11].

Epidemiology

Pediatric spinal injuries constitute 1–10% of all cases of spinal injury and spinal cord is most frequently injured at the cervical level in all pediatric age groups [3, 12]. In children younger than 2 years, 74% of cervical spinal traumas are located in axial (C1–2), 22% in subaxial (C3–7) and 4% in SCIWORA [13]. The most common cause of cervical spinal traumas is motor vehicle accidents for children younger than 2 years. Other common mechanisms of injury are falls, pedestrian struck by moving vehicle, blunt injury to the head or neck, obstetrical complications, and child abuse [6, 9, 12, 13]. The underlying syndromic diseases such as Down syndrome, Morquio syndrome, Grisel syndrome, and rheumatoid arthritis may predispose the minor cervical trauma to a greater effect in young children [14].

Although cervical spinal trauma is rare in young children, it can lead to significant morbidity when it occurs. Neurologic outcomes of very young children with cervical spinal traumas had poor outcomes; 26% of them died during hospitalization, 37% had persistent neurologic deficits, and 37% recovered to healthy life [13].

Diagnosis

Although the radiologist is well experienced, it is difficult to evaluate in very young children cervical spine injuries due to unfused synchondroses, exaggerated atlantodental intervals, pseudosubluxation, more horizontal facets, flatter vertebral bodies, ligamentous laxity, epiphyseal variations, incomplete ossification, and absence of lordosis [14, 16, 17]. In addition, there is no standard algorithm for radiologic evaluation of very young, non-communicative patients [15, 17]. Commonly used diagnostic methods are X-rays (anterior–posterior, lateral, and open-mouth), CT, and MRI.

In pediatric trauma patients who are not alert, not able to response, or have neurological deficit, midline cervical tenderness, or painful distracting injury, are intoxicated, it is recommended that anteroposterior and lateral cervical spine X-rays should be performed [15]. Flexion–extension graphs can be added if instability suspicion continues. It should be kept in mind that false-negative rate for a single lateral radiograph ranges from 21 to 26% [17].

CT scanning is recommended to exclude occult fractures, to evaluate areas that are not sufficiently visible on the X-rays, to detect post-traumatic instability [15–18]. In this age group, trauma mechanisms are usually subluxation and ligament injuries rather than bone fractures; therefore, the role of computerized tomography in very young children's cervical traumas is limited [9, 17, 19]. In addition, exposure to radiation with tomography should not be forgotten. Risk of thyroid cancer is two times higher for patients screening with tomography in 0–4 years old [20]. However, it should not be forgotten that the sensitivity and specificity of the

Table 2 Patient's situation and interpretation according to widely used classifications

	Presented patient status	Commentary on this case
CSISS [24]	Anterior column injury: isolated (traumatic disk herniations) Lateral column injury: complex (unilateral facet dislocation) Posterior column injury: complex (posterior ligamentous injuries)	Three column injury, Instability
SLIC [25]	Morphology: Rotation/translation (facet dislocation); four point Discoligamentous complex: disrupted; two points Neurologic status: complete cord injury; two points	Eight point, surgical management required
Radiographic findings associated with cervical instability [22]	Unilateral/bilateral facet subluxation Ligamentous injury with significant facet or interspinous widening Vertebral subluxation greater than 4.5 mm (< 8 years old)	Instability

CSISS cervical spine injury severity score system, *SLIC* subaxial cervical spine injury classification

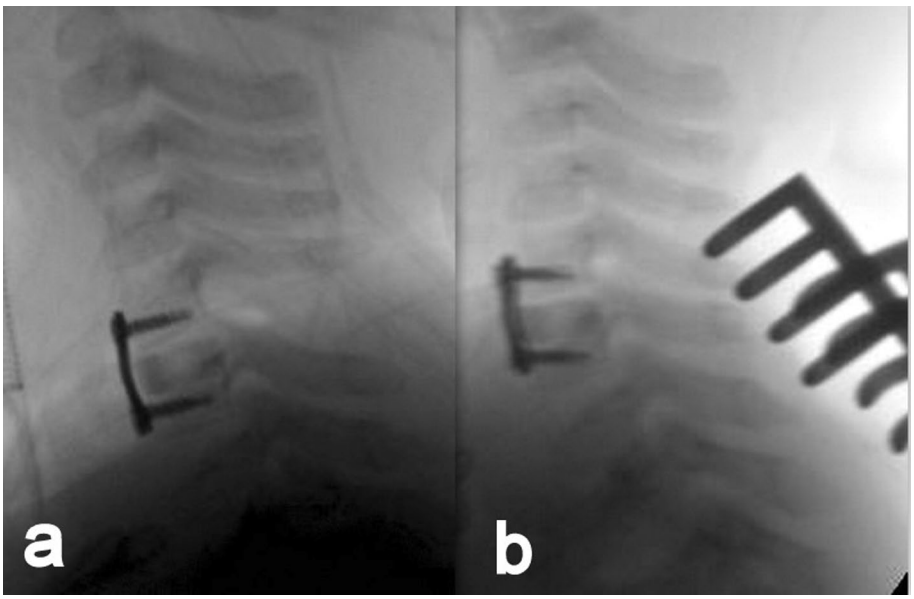

Fig. 2 Sagittal alignment: after anterior procedure (**a**) and after posterior procedure (**b**)

tomography is high in cases of high-energy critical instable injuries [18].

MRI of the cervical spine may be considered to reveal spinal cord injury, to identify ligamentous injury and traumatic disk herniation, to obtain information about the prognosis of the patient [17]. The patients who have a normal CT scan after cervical trauma in 48% of them acute traumatic findings (82% ligamentous/soft-tissue injury, 12% disk protrusion, 4% hematoma, and 3% spinal cord signal changes) are detected on MRI [21].

Pathology

This case is an example of severe cervical subaxial flexion-distraction injury in a 7-month-old infant. In this ground, pathologic findings are: complete tetraplegia representing spinal cord injury, unilaterally locked facet, anterior and posterior ligamentous injury, hemorrhagic cord contusions, intervertebral disk disruption, C5–6 anterior dislocation, and soft-tissue edema/hematoma.

Differential diagnosis

It is known that this injury has been developed after a traffic accident and it is facilitating differential diagnosis. However, it should be considered in the differential diagnosis; child abuse, pseudosubluxation, the underlying congenital neuromuscular diseases, persisting synchondroses, vertebral artery injury, whiplash-associated disorders, acute torticollis, hanging injuries, and SCIWORA.

Rationale for treatment and evidence-based literature

The difficulties in the management of serious infantil cervical traumas begin at the emergency room with neurological examination. In the absence of a certain algorithm, conservative therapy or surgery is hard to choose [15]. In view of conservative therapy, insufficiency of rigid collar and the disturbing Halo vest may be uncomfortable for infants [22]. Furthermore, one of the compelling points of surgery is the lack of surgical stuff designed for internal fixation. Another

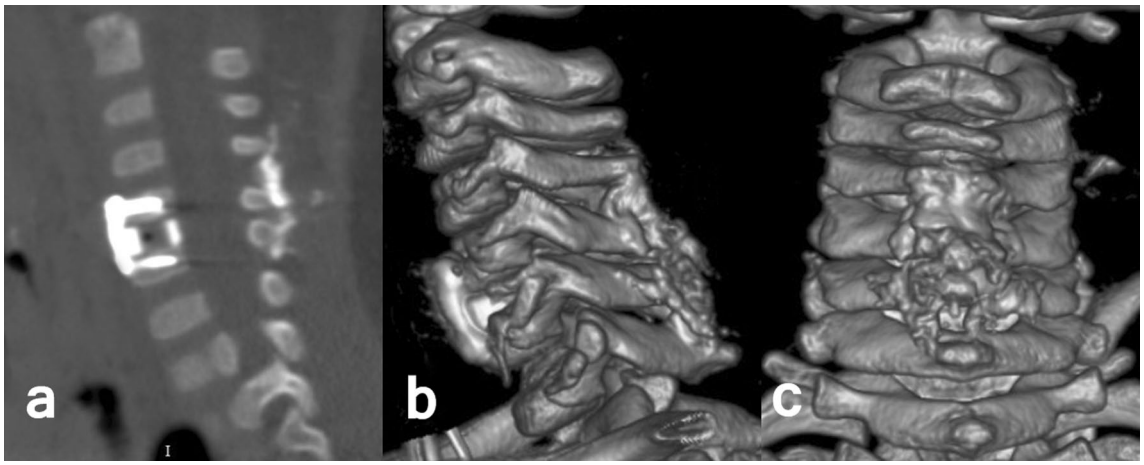

Fig. 3 Fusion: 12th postoperative month

spot is that thin and weak bone structure could be easily damaged during surgical procedure (such as decortication and wiring).

Among the adults with severe flexion–distraction injury to subaxial cervical spine resulting in a high degree of instability and neurologic deficit; decompression, cervical stabilization, and realignment are highly recommended [23]. However, based on the available literature, there is insufficient evidence to support diagnostic and treatment standards in pediatric population [15, 22]. Literature information about surgical treatment methods is limited to only case presentations in very young children.

In adults, there are many classification systems commonly used to help surgical decision while treating cervical spine traumas, but there is still no valid guideline for pediatric population [22]. In the presented case, the patient underwent surgery by means of adult cervical spine assessment rules of instability and spinal cord compression (Table 2). After surgical intervention, the patient had started to sit in bed with rigid collar immediately and physical therapy started early, while she was still in the intensive care unit. Therefore, surgery enabled prevention of pulmonary complications, respiratory distress syndrome, tracheostomy requires, and pressure ulcerations.

Procedure

Closed reduction was attempted with fluoroscopy under general anesthesia after intubation, but it was unsuccessful. Thus, the patient was operated under emergency conditions. C5–6 microdiscectomy was performed with the anterior approach and the alignment was achieved by open reduction. Traumatic dural tear and CSF leakage was not observed. The allograft (Tutoplast®, Tutogen Medical, GmbH, Germany) was placed into the evacuated disk space. Fixation was provided with the craniofacial miniplate (Medplates®, Ramed Medical, Izmir, Turkey), (1 mm in thickness, 12 mm in length) and screws (12 mm in length). Fluoroscopy showed that sagittal alignment was supplied, but there was still a separation in posterior interspinous distance (Fig. 2a). Thus, a posterior approach was added to the surgery and the patient was brought to the prone position, and then, the posterior cervical incision was made between the C3–7. It was seen that the posterior ligamentous complex was avulsed and instability continued despite anterior stabilization. Laminae were closer together with bilateral sublaminar polyester fiber suture (Mersilene®, Ethicon US, LLC) and fusion was made by an allograft taken from the iliac crest. It was seen that excellent improvement in alignment was achieved with fluoroscopy (Fig. 2b).

Outcome and follow-up

The patient was followed up in intensive care unit under sedation and with intubation in postoperative period. Closed tube drainage system was performed because of hemothorax occurrence on the third postoperative day. Tube drainage was terminated with the improvement of hemothorax on the tenth postoperative day. Sedation was discontinued on the 12th postoperative day and the patient was extubated on the 19th postoperative day. A rigid cervical collar was designed for patient and physical therapy was started. After sedation was discontinued, it was seen that the patient's neurological status was promoted to Frankel grade C. The patient was discharged on the 31st day of hospitalization and patient's treatment was continued in a rehabilitation center. After intensive rehabilitation, she was able to raise the upper limbs against gravity, but she had extreme difficulty moving her fingers.

The lower extremities were completely flaccid and are flexic. Fusion was seen to be achieved on cervical CT taken on the 12th postoperative month (Fig. 3).

Compliance with ethical standards

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Conflict of interest The authors declare that they have no conflict of interest.

Informed consent Informed consent for the publication of the case report was obtained from the parents of the baby girl.

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