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Treatment of the dens fractures in children

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ABSTRACT

The anatomical and biomechanical features of the immature cervical spine make the upper segments at C1–3 especially susceptible to injury.

Material and method: From 2000 to 2016, 10 patients (3 boys, 7 girls) with C2 dens fractures were treated. The average age of each child was 11 years (3–17). According to the Anderson classification, there were 6 patients with a type III fracture and 4 with a type II. 4 patients were treated conservatively using the Minerva cervical brace for 75 days (66–125) and 6 patients by means of the Halo-Vest for 79 days (64–87) and followed by the Schantz collar for 17 days (2–35).

Results: The follow up lasted 78 months (12–180). The NDI (Neck Disability Index) score was calculated for each patient, except for section 8 (driving the car). The scores ranged from 1/45 (2.22%) to 20/45 (44.44%). The mean score for 9 out of the 10 patients (one patient died) was 4.77 (10.61%).

Conclusion: The C2 dens fracture is a rare injury in children. The classification system of dens fractures developed by Anderson is useful in choosing the mode of treatment of dens fractures.

1. Background

Upper cervical spine injuries are associated with high energy and are frequently fatal. Children appear to be at increased risk of injury at this site [1–4]. The injury frequently leads to severe cord and brain-stern injury, causing respiratory arrest. Increasingly, however, there have been reports of patients surviving this injury and even patients with upper cervical fractures with intact neurological function have been documented [5]. 2–3% of all cervical spinal injuries are in children. They are more likely to occur in the upper cervical region and fractures of odontoid are the most common [6]. The same management algorithms that are used for adult injuries often do not apply to children however appropriate algorithms for evaluation and management are therefore essential in order to take proper care of these injured children [4]. Deformity, instability, post-traumatic stenosis, and neurological complications may be prevented through the early recognition and appropriate management of

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those risks. The anatomical and biomechanical features of the immature cervical spine make the upper segments at C1–3, especially C2 susceptible to injury [2,3,7]. There are several physiological differences between the cervical spine of children and adults. For instance, children have increased neck motion, which is due to the ligament laxity, relative muscle weakness, and incomplete ossification of the cartilaginous elements of the pediatric cervical spine. The treatment of C2 dens fractures in children and adolescents without neurological damage depends on the type of the fracture and displacement [2,8].

2. Material and method

From 2000 to 2016, 10 patients with C2 dens fractures were treated. It is a retrospective work consisting in the data analysis of the dens fractures treatment in children, the approval of the ethical committee was not required for this study. The parents have been informed that their child's disease will be included in scientific paper. There were 3 boys and 7 girls. The mean age was 11 years (3–17).

The fractures were caused by a traffic accident in 4 of the cases, a fall in 3 cases and sport accidents in 3 cases. In 6 patients, cervical fractures were accompanied by multiple trauma, 3 by head injuries and 1 patient required neurosurgical procedure for subdural hematoma. In 1 case, the ulnar and radial fracture was treated surgically (Figs. 1 and 2).

When a child had a known or suspected spine injury, the cervical spine was initially immobilized with a rigid cervical orthosis, specifically designed and appropriate for children. Each patient in the emergency ward was examined by a pediatric medical team (an orthopedic surgeon, a neurologist, and a pediatrician). Any limitation of motion, paraspinal muscle spasm, or torticollis suggested the need for additional investigation. The back was inspected in a log-roll fashion with gentle in line cervical traction until all screening anteroposterior and lateral radiographs of the cervical spine as well as an open mouth radiograph of the odontoid process were reviewed. The cervical spine remained immobilized until either initial radiographs were made and evaluated and injury was ruled out or definitive treatment was rendered.

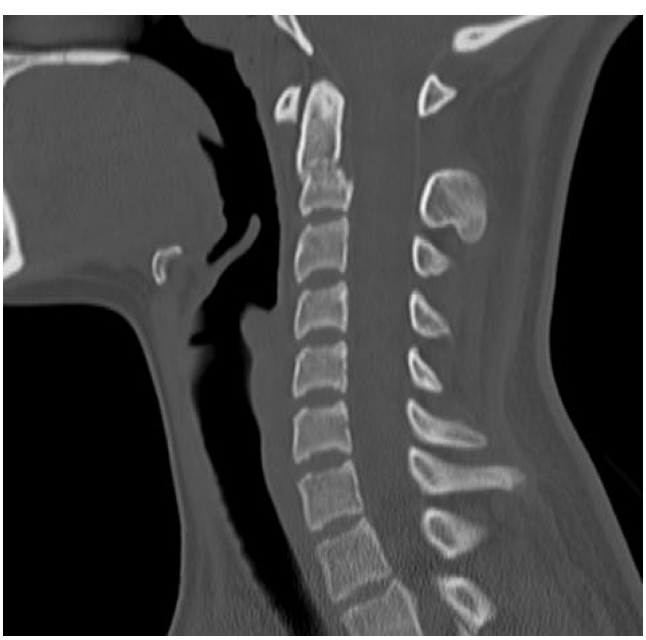

Fig. 1 – CT fracture type II.

Fig. 2 – MRI fracture type II.

After accommodation to the hospital X-ray according to Harris method in 10 patients, CT in 10 patients and MRI in 9 were used. No bony abnormalities of the upper cervical spine were found in our series. After X-ray, CT and MRI, all fractures of the C2 dens were classified according to Anderson classification. There were 6 patients with a type III fracture and 4 with a type II. The fractures were without displacement in 4 patients, with small displacement (less than 5 mm, angulation <11 degrees) in 5 patients, and with important displacement in 1 patient. The radiological examinations were carried out by an orthopedic surgeon and a radiologist and only in accordance with their assessment of the fracture stability was the orthopedic treatment started.

4 patients were treated conservatively using the Minerva cervical brace for 75 days (66–125) and 6 patients by means of the Halo-Vest for 79 days (64–87) and followed by the Schantz collar for 17 days (2–35). The Halo-Vest had been used since the day of admission in 4 cases and 2 days after hospital admission in 1 patient. The fractures with a small displacement were treated with Halo-Vest, the X-ray after reposition showed that the fracture displacement was less than 0–2 mm in the lateral view in 4 patients, in 1 patient the control X-ray showed that the displacement in the lateral view was 5 mm and in the anteroposterior view was 4 mm, 7 days after trauma the fracture was corrected to 1 mm in the lateral view and 0 mm in the anteroposterior view. The patient with an important displacement presented in the control X-ray a

2 mm translation on the anteroposterior and lateral views. The patient died which was due to the polytrauma injuries in the fourth day. In 1 case, an odontoid fracture was suggested through clinical examination but initial X-ray, CT, MRI presented suspicion of the basilar odontoid synchondrosis. The Minerva brace was used and at this time the radiological image was consulted in another radiological ward where the initial diagnosis was not confirmed and changed to the type III fracture according to Anderson classification. The Minerva brace was used (Table 1).

3. Results

The follow up was 78 months (12–180). If the child had no neck pain or cervical spine tenderness and had a full, painless range of motion of the neck and spine, then the cervical brace orthosis was removed. The patient's range of motion was evaluated only when they were conscious and cooperative. After ablation of the brace, anteroposterior and lateral radiographs with voluntary flexion and extension of the cervical

Table 1 – Clinical details of the 10 patients with upper cervical spine fractures.

number	Patient	Age	cause of injury	trauma associet e d	type of the fracture - Anderss o n classyfi ca tion	treatme nt	Neurolo gi cal status
1	GK	6	sport	thorax , abdomin al trauma	III	Minerva	
2	DA	15	traffic accident	head injury	III	Halo-Vest	
3	WZ	15	fall	ulnar and radial fracture , abdomin al trauma	III	Glisson traction , Halo-Vest	
4	BA	3	fall	thorax , abdomin al trauma	III	Minerva	
5	SD	9	sport	head injury	III	Minerva	
6	RM	16	traffic accident	head injury	II	Halo-Vest	
7	BW	13	fall	subdural hemato ma	III	Minerva	hemipar esi s
8	TP	17	traffic accident	III finger fract, abdomin al trauma	II	Halo-Vest	
9	DK	14	sport	Th6 fract, hand contusio n	II	Halo-Vest	
10	JP	10	traffic accident	multiple trauma	II	Halo-Vest	die

spine were used in 9 patients (1 patient being a non-cooperative patient). Clinical and radiological examination showed that all fractures were stable. No neurological damage was noticed except for the patient with subdural hematoma, but his neurological deficit was related to head trauma. A CT scan, 90 days (64–121) after the injury was performed all patients. Good bone consolidation was obtained in all cases. No secondary fracture displacement was noted in the group treated with the Minerva brace or the Halo-Vest.

In 1 patient, a MRI, 3 months after trauma was used due to suspicion of ligaments injury, but the MRI showed, as with the MRI after trauma, intact ligaments and no cervical instability.

The NDI (Neck Disability Index) score was calculated for each patient, except for section 8 (driving a car). The scores ranged from 1/45 (2.22%) to 20/45 (44.44%). The mean score for 9 out of 10 patients (one patient died) was 4.77 (10.61%). These results allowed us to exclude the disability in the majority of patients. We found a low degree of disability due to cervical pain in another 2 patients (we believe that in both cases this was caused largely by the additional damage). In 1 patient his neurological deficit caused by subdural hematoma was decided to be a result of his poor NDI score.

4. Discussion

Children with injuries to the cervical spine present a great challenge for medical facilities. In addition, a child presents challenges in assessment, imaging, and both operative and nonoperative management [4]. There are very few papers about pediatric C2 dens fractures, especially fractures with no neurological deficit. The goal of the C2 dens fracture is the return of maximum functional ability, minimal residual pain, decrease of any neurological deficit, minimal residual deformity and prevention of further disability [9–11]. The majority of patients were neurologically intact but their neurological status was frequently dependent upon other injuries, especially the head trauma [2]. In our patients' series, this observation is confirmed, and there is a clear dependence between the head trauma and neurological status.

Fractures of the upper cervical spine are caused by violent distractive hyperflexion or hyperextension with or without rotation or distraction [2,10]. Cervical injuries in children are usually caused by motor-vehicle accidents, falls, diving accidents, gunshot injuries and occasionally child abuse [2,3,8,10,12].

The spinal column undergoes progressive dramatic anatomic and biomechanical changes during the first fifteen years of life [4]. In order to understand the differences in injury patterns unique to the pediatric cervical spine, it was essential that the anatomic and developmental features should be unique to children [8]. The axis is derived from five ossification centers. The dentocentral synchondrosis of the axis remains open in most children until the age of three, is present in 50% by the age of four to five, and is mostly absent by the age of six. The tip of the odontoid process is not ossified at birth but appears around the age of three and fuses to the odontoid process by the age of twelve. Occasionally, it remains as a separate persistent ossiculum terminale [8,13].

The reason for both the bimodal age spread and the preponderance of atlas and axis injuries in children are related to the developmental anatomy of the upper cervical region [7]. The biomechanical features of the immature spine result in a much higher prevalence of injury above C4 in children [2,4]. There are several physiological differences between the cervical spine of children and adults. Firstly, a relatively heavy head on a small body causes high torques to be applied to the neck with acceleration stress [7]. Secondly, for instance, children have increased neck motion, which is due to the relative ligament laxity, relative muscle weakness and incomplete ossification of the cartilaginous elements of the pediatric cervical spine as well as to other factors such as the horizontal orientation of the shallow facet joints [8].

CT scans provide an excellent delineation of osseous injury patterns. Routine three- dimensional studies and sagittal and coronal reconstructions provide the physician with a detailed understanding of the osseous injury [4]. CT study becomes very important in setting of C2 fractures because it can clearly document the presence of a fracture or the synchondrosis diastasis in an immature spine [14]. CT provides the possibility of distinction between cervical bone abnormalities and fractures. In cooperative patients, flexion–extension radiographic studies can be completed as an adjunct to the magnetic resonance imaging study [3,4,15–17]. However the usefulness of the flexion and extension radiographic views is controversial, because of the lack of the rotational instability visualization, and limitation caused by pain from the cervical spine mobility [18].

The MRI is the best way to obtain a visualization of the ligaments and fracture. Abnormal magnetic resonance imaging scan can rule out major instability, but restriction of extremes of range of motion seems prudent if there is any question of a neurologic injury [4].

The radiological assessment of the stability of the C2 dens fractures is frequently based on the trauma team experience [18,19].

Initial management of children with cervical spine injuries should follow the basic principles of trauma care. The treatment of C2 dens fractures in children is generally conservative. Type I and III fractures could be treated using the cervical orthosis, but the treatment of the type II is still controversial and no consensus has been reached as far as children treatment is concerned [20]. Anderson classification and indication for treatment of stable C-2 dens fractures in children have been successfully managed with external immobilization alone, although different types of cervical immobilization have been used and cervical traction has been advocated by some authors [5,14,21]. Some authors use only a cervical collar [8]. Essentially, in type II, if a closed reduction is required, Halo-Vest is the external device of choice. The Halo-Vest provides the sufficient cervical spine stability but in the literature a high incidence of complications has been reported [18].

However, according to our patients' series, it has been found that the use of the Halo-Vest in children did not provide a high rate of complications [22]. We believe that it may have been caused by our weekly ambulatory examination and a short time when the Halo-Vest was used. The use of Minerva-type orthosis or Halo-Vest are frequently recommended for two to three months [2,8]. Although some authors take an aggressive approach and recommend an early fusion for their patients, most of them recommend surgery only for patients with penetrating wounds, deformity, non-union, or inability to achieve a closed reduction [7]. The advantages of surgical treatment are the ability to reach optimal reduction, immediate stability, eventual direct decompression of the cord, the need for only minimum external fixation, the possibility for early mobilization and clearly nursing problems [9].

The radiologic assessment of the displacement, angulation and level of the fracture are the prognostic factors for bone healing [3,4]. Many authors present the adult patients' series of the C2 dens fractures with the different amount of the pseudarthrosis but the pediatric series very seldom reveal the presence of the pseudarthrosis which was confirmed in our patients' series.

We recognize the limitation of our study owing to the small number of patients, but this type of fracture is extremely rare in children.

5. Conclusion

1 The C2 dens fracture rarely occurs in children.
2 The diagnostic method for C2 dens is CT-scan, MRI and X-ray evaluation.
3 The classification system of dens fractures developed by Anderson is useful in choosing the mode of treatment of the dens fractures.
4 The Halo-Vest is a good method for treating unstable C2 dens fractures.

Conflict of interest

None declared.

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