

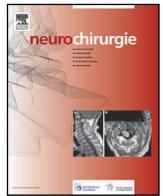


Disponible en ligne sur

ScienceDirect  
www.sciencedirect.com

Elsevier Masson France

EM|consulte  
www.em-consulte.com



Short clinical case

## C1–C2 type Harms internal fixation for unstable C2 fracture in a 6-year-old boy: Case report



N. Serratrice<sup>a,\*</sup>, L. Fievet<sup>b</sup>, A. Aulanier<sup>a</sup>, G. Pech Gourg<sup>c</sup>, D. Scavarda<sup>c</sup>, S. Fuentes<sup>a</sup>

<sup>a</sup> Department of Neurosurgery, La Timone Hospital, Assistance Publique - Hôpitaux de Marseille, 264, rue Saint-Pierre, 13005 Marseille Cedex 5, France

<sup>b</sup> Department of Pediatric Surgery, Centre Hospitalier Régional Henri Duffaut, 305, rue Raoul Follereau, 84000 Avignon Cedex 9, France

<sup>c</sup> Department of Pediatric Neurosurgery, La Timone Hospital, Assistance Publique - Hôpitaux de Marseille, 264, rue Saint-Pierre, 13005 Marseille Cedex 5, France

### ARTICLE INFO

#### Article history:

Available online 11 July 2019

#### Keywords:

Cervical fracture  
Odontoid  
Child, C1–C2 internal fixation  
Pediatric neurosurgery

### ABSTRACT

**Background.** – Decision-making is often difficult in odontoid fracture in children.

**Case report.** – We present the case of a 6-year-old boy who sustained cervical trauma on falling out of a tree. Initial cervical X-ray and CT-scan did not find any traumatic lesion. Three-week check-up revealed an unstable C2 fracture in the synchondrosis at the base of the odontoid bone, with anterior displacement (type IC on the classification of Hosalkar et al.), without neurological symptoms except for cervical pain and limitation of head rotation. MRI confirmed the absence of medullary lesion. The Harms technique was used to fix C1 and C2, using adult instrumentation without bone graft. Bone fusion was obtained at 8 months. Hardware was removed at 10 months. No complications were reported.

**Conclusions.** – Posterior internal fixation for unstable C2 fractures in children can be effective and relatively safe.

© 2019 Published by Elsevier Masson SAS.

### 1. Introduction

Cervical spine injuries are rare in children (2–5% of trauma cases); odontoid fracture represents 10% of all fractures and dislocations of the cervical spine in children [1]. The trauma involves the synchondrosis at the base of the odontoid process; displacement is anterior. It is currently described as an epiphysiolysis of the odontoid process. Treatment is usually non-operative, with initial stabilization in a cervical collar in extension or halo body-jacket in case of bone or cartilaginous lesion without associated ligamentous lesion [2]. Surgical treatment has certain indications: unstable fracture, severe displacement or neurological involvement (on the classification of Hosalkar et al. [3]); particular attention must be paid to avoid growth disorder secondary to the procedure [4].

We present the case of a 6-year-old boy with displaced C1–C2 fracture reduced using the Harms technique with adult instrumentation and without bone graft, and the main decision-making

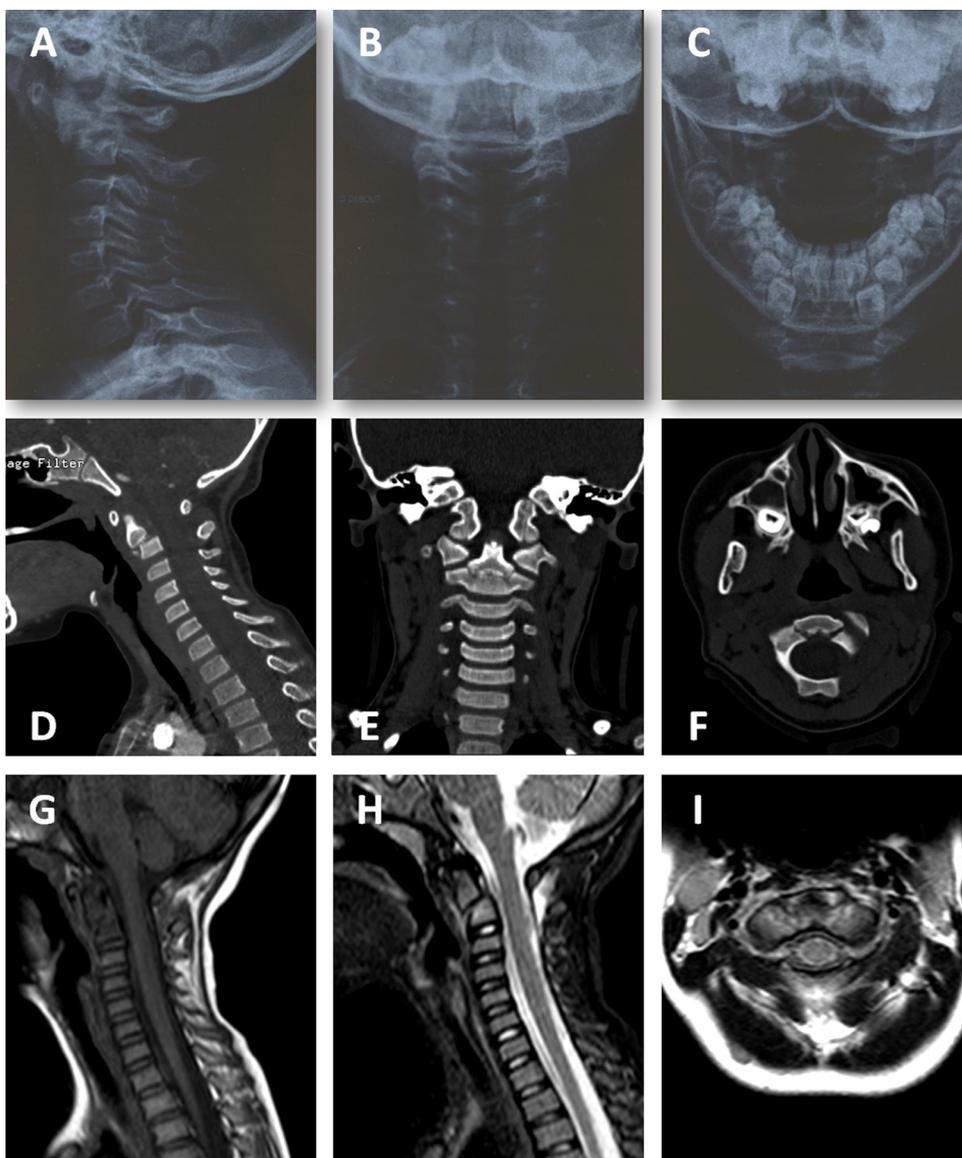
factors in the surgical management of odontoid fractures, which are always challenging in children.

#### 1.1. Case report

A 6-year-old boy fell out of a tree, sustaining cervical trauma. Initial cervical X-ray, completed by craniocervical CT-scan, did not find any traumatic lesion at either cranial or cervical level. The patient was immobilized with a cervical collar. Control X-ray at 3 weeks suggested C2 fracture due to discontinuity at the base of the odontoid, with anterior displacement of C1 on C2 and reduced anteroposterior diameter (Fig. 1A, B & C). CT revealed fracture of the odontoid process in the synchondrosis, with 3 mm pathological anterior tilt, classified as type IC according to Hosalkar et al. (Fig. 1D, E & F). No abnormalities were observed in supra-aortic arteries. MRI showed anterior tilt of the odontoid process associated with T1 hypointense signal and T2 hyperintense signal of the C2 vertebra, confirming the possibility of initial fracture of the base of the odontoid process, with secondary displacement, without medullary anomaly or other visible lesion (Fig. 1G, H, I). Neurologically, the child presented cervicgia without irradiation, with difficulties in head rotation. These radio-clinical arguments suggested unstable fracture. Harms C1–C2 fixation was performed under general anesthesia, in prone position, head fixed in a Mayfield brace, using adult instrumentation. A median cervico-occipital

\* Corresponding author.

E-mail addresses: nicolas.serratrice@ap-hm.fr, nico.serratrice@orange.fr (N. Serratrice), fievet.lucile@ch-avignon.fr (L. Fievet), arthur.aulanier@ap-hm.fr (A. Aulanier), gregoire.pechgourg@ap-hm.fr (G. Pech Gourg), didier.scavarda@ap-hm.fr (D. Scavarda), stephane.fuentes@ap-hm.fr (S. Fuentes).



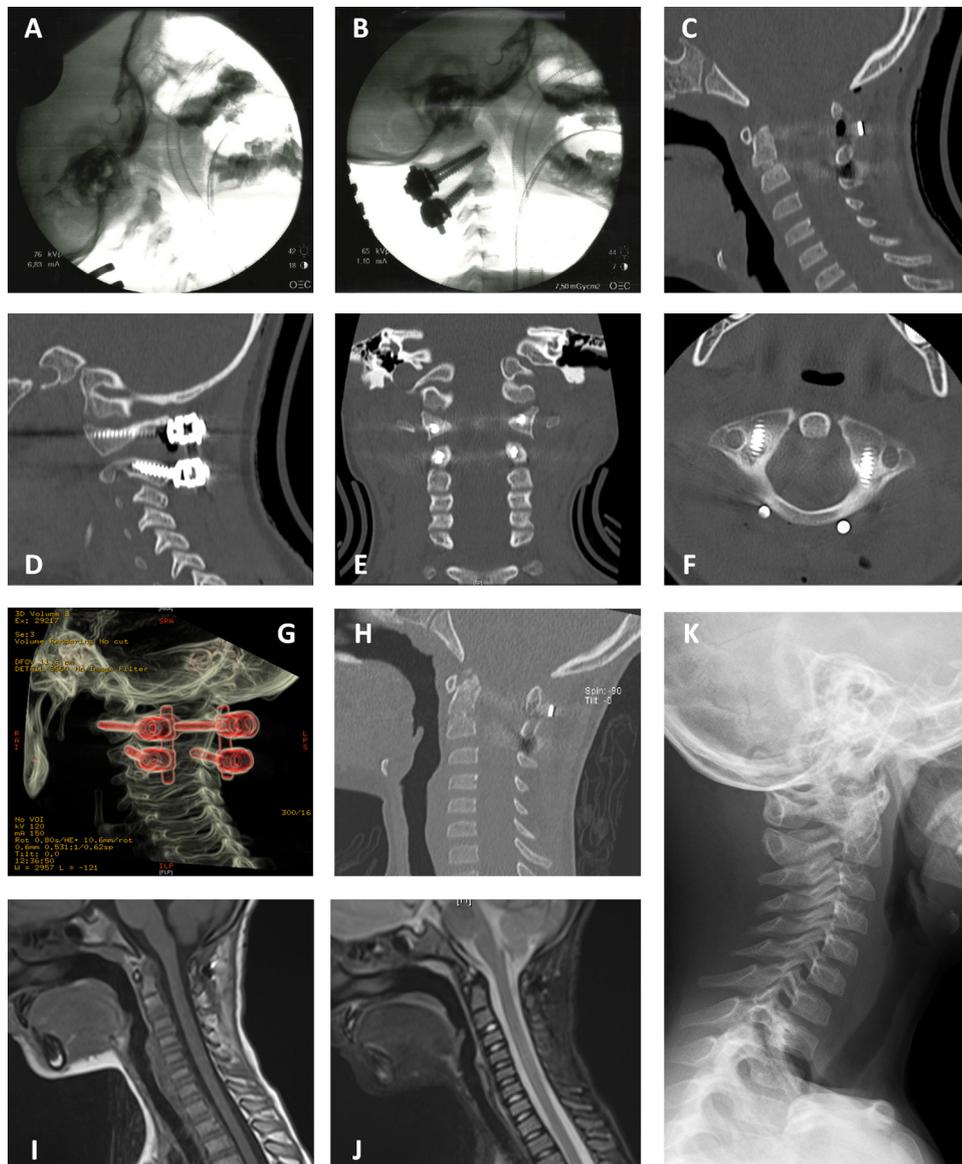
**Fig. 1.** Initial cervical X-rays: profile (A), front (B) and open mouth (C). Cervical CT-scan: sagittal (D), coronal (E) and axial (F) bone sequences. Fracture of the base of the process of the odontoid bone with anterior displacement (type IC according the classification of Hosalkar et al.). No medullary anomaly on cervical MRI: sagittal view T1 sequence (G), sagittal view T2 sequence (H) and axial view T2 sequence (I).

incision with bilateral muscle release exposed the occipital cleft of the C1 posterior arch and the C2 blade. The C2 joint masses were exposed laterally, and the lateral masses of C1 were progressively dissected, pushing back the perivertebral venous structures to the C1 and C2 milling entry points. Harms fixation with ascending convergent pedicle screwing in C2 ( $15 \times 3.5$  mm) and screwing in the lateral masses of C1 ( $25 \times 3.5$  mm) used the Pass OCT® material (Médicrea International, Rillieux La Pape, France) currently used in adults, under lateral fluoroscopic control (Fig. 2 A & B). Screw locking achieved reduction of the fracture and attachment of a transverse device (Médicrea International). No bone graft was performed. After rinsing and hemostasis, plane-by-plane closure and skin closure were performed. No relevant complications were observed postoperatively. Postoperative pain was controlled by adapted analgesia. This modern screw construct did not require postoperative halo immobilization or cervical collar. Postoperative cervical CT showed good reduction (Fig. 2C, D, E & F). The patient was discharged at 5 days. At 8 months, controls showed complete bone fusion (Fig. 2G & H). Hardware was removed at 10 months, without complications. The final radiological result was excellent

on X-ray and MRI (Fig. 2I, J & K). The functional result was also excellent, with good recovery of range of motion.

## 2. Discussion

Odontoid synchondrosis fractures are rare in children, even if they are the most common cervical fracture in children under 7 years of age [1,4]. The mechanism is high-energy: fall from a large height or road accident. Neurological lesions are infrequent because the vertebral canal is wide [1]. It is important to know the specific radiological semiology in children: in particular, there is a growth plate at the base of the odontoid process that can suggest fracture; it closes between 3 and 7 years of age. Complementary examinations such as computed tomography (CT) or magnetic resonance imaging (MRI) are generally indicated when any abnormality is found or suspected on standard X-ray, because open synchondrosis is likely to be missed on plain radiographs. CT and MRI the most effective examinations for accurate diagnosis of bone/cartilage, ligament and medulla spine lesion [1]. Because open basilar synchondrosis differs between younger children and older children or adults, and often



**Fig. 2.** Lateral cervical fluoroscopic control before (A) and post-surgery (B). Post-operative CT-scan control: sagittal (C & D), coronal (E), and axial (F) bone sequences. Complete reduction (G), 3D reconstruction. Complete reduction and fusion on CT-scan (H) at 8 months without any myelopathy signs on MRI (I & J, respectively T1 and T2 sequences). (K) X-ray showing perfect alignment on a sagittal view after removal of osteosynthesis material at 10 months post-operation.

makes decision-making difficult, Hosalkar et al. described a new classification distinguishing four patterns (types IA, IB, IC and type II) based on fracture site (relation of the fracture line to the basilar synchondrosis), degree of displacement and presence or absence of atlantoaxial dislocation [3]; children with closed synchondrosis are classified on the Anderson-D'Alonzo classification [5]. Staged treatment with external brace immobilization is mandatory for stable non-displaced or minimally displaced fracture. In unstable fracture, when reduction cannot be correctly achieved or maintained, surgical fixation is recommended to obtain early fusion [3,6–10].

Post-traumatic deformities most often occur when the severity of the initial lesion has been overlooked (as in the present case report) or when operative or non-operative treatment has been inadequate. It is very important to perform early complementary CT or MRI in case of violent cervical trauma: clinical and X-ray control are not enough to detect cervical injuries. Prevention of these deformities therefore requires knowledge of the anatomical elements responsible for stability and spinal growth. Long-term monitoring is essential, given the risk of long-term growth problems.

Here we described the case of a 6-year-old boy with an unstable fracture of the odontoid synchondrosis (type IC on the classification of Hosalkar et al.) reduced surgically by harms C1–C2 fixation with adult instrumentation without bone graft. This cervical fixation provided the stability necessary for the synchondrosis to heal without postoperative halo jacket or cervical collar. This case report illustrates that surgical stabilization by cervical fixation in young children with unstable odontoid synchondrosis fracture can be effective and relatively safe.

The major complication of cervical spine surgery in the long term is the risk of deformity. The consequences of short upper cervical assembly have been little studied in children. In 2016, Martinez Del-Campo et al. demonstrated that, after occipitocervical fixation, the craniocervical junction and upper cervical spine continued to present normal growth, curvature, and alignment parameters in children with constructs spanning up to four levels [11]. Another interesting advantage of short assembly, as in the present case, is that it is removable. Nevertheless, long-term monitoring of such surgery is essential, given the risk of long-term cervical deformity.

Importantly, there are often problems of bone size when adult instrumentation is applied in children. In the present case, bone size was enough, but clearly there are many children who cannot accept adult-size screws, which highlights the importance of preoperative imaging such as fine-slice CT in bone window, to plan hardware positioning and size. Although vertebral size and the screw corridor may make screw positioning challenging, the technique provides high fusion rates in a complicated patient population [3]. That is the reason why this kind of technique must be performed in a specialized center, with adequate technical platform and teams trained in this type of intervention. The technique is well described [3], but still requires good knowledge of the anatomical elements involved in stability and spinal growth. Imaging assessment of the main cervical vessels should be systematic ahead of this type of surgery [12]. Screw introduction must obligatorily be under fluoroscopic guidance, or better still under neuronavigation. Dedicated fixation materials for pediatric populations of different ages could be worth developing.

Lee et al. compared C1–C2 transarticular screw fixation and C1 lateral mass–C2 pedicle screw fixation: both produced excellent results for reduction and stabilization of the atlantoaxial complex, but the radiological outcome tended to be better in C1 lateral mass–C2 pedicle screw fixation [13]. In children, the Harms technique appears to be the safest, being outside the medullary canal and avoiding injury to the vertebral arteries. Here, we used adult hardware that was easily adaptable to the child. Anterior retropharyngeal reduction and sequential posterior fusion could be an effective therapeutic strategy for atlantoaxial rotatory fixation with locked C1–C2 lateral facet [14]. Other surgical strategies are possible, such as hooks, or the recent less invasive posterior C1–C2 interlaminar fixation using an absorbable monofilament suture, which was strong enough to provide sufficient stability for synchondrosis healing; late absorption of the suture was followed by complete restoration of motion between C1 and C2 [6].

In comparison to staged management, cervical surgery prevents halo jacket complications in children [2]. Children are significantly less affected in their daily live activities. Moreover, in children with cervical skeletal dysplasia it has been shown that rigid fixation with screws and rods improves fusion rates. But the risk of non-union in children with C1–C2 instability is higher with classical non-operative treatment, even using a halo body-jacket, than with cervical fixation. Yang et al. showed that a short-segment fixation technique to revise C1–C2 pedicle screw fixation provided effective biomechanical stability and mobility, as well as relieving the pain and symptoms of myelopathy [15].

### 3. Conclusion

In children, treatment of the cervical region is made difficult and threatening by its anatomical complexity and the potential gravity of injury. Clinical and radiological examination should be systematic in any trauma of the cervical spine in children. Treatment requires specific knowledge and should whenever possible be conducted in a specialized center. Here, we reported a case of a 6 year-old child who presented an instable odontoid synchondrosis fracture after a fall (type IC on the classification of Hosalkar et al.). Non-operative treatment is generally the attitude of choice, but in this case of unstable cervical fracture it was decided to fix

C1 and C2 using the Harms technique, with adult instrumentation and without bone graft. This achieved good results in terms of static and dynamic cervical development. Long-term monitoring of these lesions is essential. Surgical treatment in children requires good knowledge of the anatomical elements responsible for stability and spinal growth, and should be provided in specialized centers.

### Funding

None.

### Disclosure of interest

The authors declare that they have no competing interest.

### References

- [1] Easter JS, Barkin R, Rosen CL, Ban K. Cervical spine injuries in children, part I: mechanism of injury, clinical presentation, and imaging. *J Emerg Med* 2011;41(2):142–50, <http://dx.doi.org/10.1016/j.jemermed.2009.11.034>.
- [2] Mandabach M, Ruge JR, Hahn YS, McLone DG. Pediatric axis fractures: early halo immobilization, management and outcome. *Pediatr Neurosurg* 1993;19(5):225–32.
- [3] Hosalkar HS, Greenbaum JN, Flynn JM, Cameron DB, Dormans JP, Drummond DS. Fractures of the odontoid in children with an open basilar synchondrosis. *J Bone Joint Surg Br* 2009;91(6):789–96, <http://dx.doi.org/10.1302/0301-620X.91B6.22173>.
- [4] Easter JS, Barkin R, Rosen CL, Ban K. Cervical spine injuries in children, part II: management and special considerations. *J Emerg Med* 2011;41(3):252–6, <http://dx.doi.org/10.1016/j.jemermed.2010.03.018>.
- [5] Anderson LD, D'Alonzo RT. Fractures of the odontoid process of the axis. *J Bone Joint Surg Am* 1974;56(8):1663–74.
- [6] Labbe JL, Peres O, Leclair O, Goulon R, Scemama P, Jourdel F, et al. Posterior C1–C2 fixation using absorbable suture for type II odontoid fracture in 2-year-old child: description of a new technique and literature review. *J Pediatr Orthop* 2016;36(8):e96–100, <http://dx.doi.org/10.1097/BPO.0000000000000637> [Review].
- [7] Shammassian B, Wright CH, Wright J, Onwuzulike, Tomei KL. Successful delayed non-operative management of C2 neurosynchondrosis fractures in a pediatric patient: a case report and review of management strategies and considerations for treatment. *Childs Nerv Syst* 2016;32(1):163–8, <http://dx.doi.org/10.1007/s00381-015-2821-4>.
- [8] Ni B, Guo X, Xie N, Lu X, Yuan W, Li S, et al. Bilateral atlantoaxial transarticular screws and atlas laminar hooks fixation for pediatric atlantoaxial instability. *Spine (Phila Pa 1976)* 2010;35(24):E1367–72, <http://dx.doi.org/10.1097/BRS.0b013e3181e8ee87>.
- [9] Reilly CW, Choit RL. Transarticular screws in the management of C1–C2 instability in children. *J Pediatr Orthop* 2006;26(5):582–8, <http://dx.doi.org/10.1097/01.bpo.0000230337.26652.55>.
- [10] Ringel F, Reinke A, Stüer C, Meyer B, Stoffel M. Posterior C1–2 fusion with C1 lateral mass and C2 isthmic screws: accuracy of screw position, alignment and patient outcome. *Acta Neurochir (Wien)* 2012;154(2):305–12, <http://dx.doi.org/10.1007/s00701-011-1224-x>.
- [11] Martinez-Del-Campo E, Turner JD, Soriano-Baron H, Newcomb AG, Kalb S, Theodore N. Pediatric occipitocervical fusion: long-term radiographic changes in curvature, growth, and alignment. *J Neurosurg Pediatr* 2016;18(5):644–52, <http://dx.doi.org/10.3171/2016.4.PEDS15567>.
- [12] Vachhrajani S, Sen AN, Satyan K, Kulkarni AV, Birchansky SB, Jea A. Estimation of normal computed tomography measurements for the upper cervical spine in the pediatric age group. *J Neurosurg Pediatr* 2014;14(4):425–33.
- [13] Lee SH, Kim ES, Sung JK, Park YM, Eoh W. Clinical and radiological comparison of treatment of atlantoaxial instability by posterior C1–C2 transarticular screw fixation or C1 lateral mass–C2 pedicle screw fixation. *J Clin Neurosci* 2010;17(7):886–92, <http://dx.doi.org/10.1016/j.jocn.2009.10.008>.
- [14] Lavelle WF, Palomino K, Badve SA, Albanese SA. Chronic C1–C2 Rotatory Subluxation Reduced by C1 Lateral Mass Screws and C2 Translaminar Screws: A Case Report. *J Pediatr Orthop* 2017;37(3):e174–7, <http://dx.doi.org/10.1097/BPO.0000000000000787>.
- [15] Yang F, Dong L, Tan M, Ma H, Yi P, Tang X. In vivo analysis of cervical range of motion after revised C1–C2 pedicle screw technique for pediatric atlantoaxial instability. *Pediatr Neurosurg* 2013;49(5):282–6, <http://dx.doi.org/10.1159/000366165>.