



360° fixation with modern instrumentations of segment separation cervical spine injury in a 23-month-old

Viktor Zs. KOVARI, Janos VAJDA, Robert VERES

From the department of Neurosurgery, Hungarian Defense Forces Medical Centre

In this case report clinical and technical lessons including seven years follow up learned from a flexion-distraction, highly unstable cervical spine injury causing a complete separation of C6-7 cervical segment with tetraparesis in a 23-month-old boy, are presented. To our knowledge this is the only documented case in medical literature where adult size implants (cage, plate and lateral mass screw-rod system) were utilized for cervical combined anterior and posterior internal fixation in a child under the age of two years without implant-size related problems. Seven years after the injury the child attends elementary school, can operate a wheelchair manually, and can eat and write. Computed tomography control showed no failure of the hardware and fusion was later observed in the intervertebral space of the stabilized cervical segment, however adjacent segment syndrome occurred without deterioration of the patient's status. The decision on the mode of realignment and fixation to be made in such a case was difficult because there is no standard procedure for infants.

Keywords : pediatric cervical trauma ; modern cervical instrumentation ; cervical spinal injury ; circumferential fixation ; complete segment separation.

INTRODUCTION

In the pediatric population spine trauma is rare (1,11,13). The proportion of cervical trauma regarding

Viktor Zsolt Kovari, Janos Vajda, and Robert Veres declare that they have no conflict of interest. This article has not been published in any journal as of this date.

spinal trauma cases is much higher compared to lumbar and thoracic spinal injuries in children than in adults, up to 80% (8,12,13). Cervical spine injuries in the pediatric population differ from those occurring in adults. In the infant/toddler subgroup (ages 0 to 3 years) cervical spinal injuries mainly involve the upper cervical spine (C0-C2) due to less developed neck musculature, increased ligamentous laxity and head/body weight ratio which renders the fulcrum of the rotation at approximately to the C2-3 level at flexion movement, while in the older age groups (eight and older) they tend to involve the lower spinal section, like in adult cases (7,9,11-13,16). One of the non-anatomical causes of the

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- Viktor Zsolt Kovari, M.D.
Hungarian Defense Forces Medical Centre, Department of Neurosurgery
 - Janos Vajda, M.D.
National Institute of Clinical Neuroscience
 - Robert Veres, M.D., Ph.D, Consultant Neurosurgeon.
Mafraq Hospital, Department of Neurosurgery
- Correspondence : Viktor Zsolt Kovari, M.D., Hungarian Defense Forces Medical Centre, Department of Neurosurgery, 44. Robert Karoly Blv., 1134 Budapest, Hungary
E-mail : viktor.zs.kovari@gmail.com
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different injury patterns under eight years of age in motor vehicle collision can be the generally used five-point child harness which restrains the body but allows the movement of the head (1). Survival rate among young children who suffered complete lower cervical injuries resulting in complete cord trans-section is rare (8). Infants had 25% mortality rate in a study where 206 pediatric spinal trauma cases were evaluated by Jeffrey B. Knox (7). The cases resulting in absolute spinal instability require surgical treatment. The decision on the mode of realignment and fixation to be made in such a case is difficult because there is no standard procedure for infants, and the solution must always comply with the given circumstances. In this case the operative treatment and an unexpected outcome of a 23-month-old boy who survived a motor vehicle collision (MVC) that caused a severe cervical, 3 column instable injury with the complete separation of C6 vertebra and spinal cord avulsion is presented.

There are only five reports presenting the cases of very young patients (three year of age or younger) surviving MVC accident resulting in complete lower cervical spine cord trans-section, and none of those patients was stabilized by adult size implants circumferentially in one stage as it is presented in this article (5,9-11,16).

CASE REPORT

History and Examination

A 23-month-old boy was involved in a frontal motor vehicle collision. Paramedics extricated the child and transported him by ambulance to the hospital. His Glasgow Coma Scale (GCS) score was 13 at the time of arrival to the hospital. The patient underwent tracheal intubation and was ventilated because of shallow breathing. On presentation he parried with the upper extremities but gave no response with the lower extremities in response to stimulation (pain). A computed tomography (CT) scan was performed of the head, neck, thorax, abdomen and pelvis, and it revealed a mediastinal hematoma and complete separation between C6-7 vertebrae with breaking off the lower anterior edge of the C6 vertebral body (Fig. 1). The distance

between the C6 and C7 vertebrae was 9 mm, meaning the total disruption of the disco-ligamentous complex (DLC). This type of flexion-distraction injury is classified as an Arbeitsgemeinschaft für Osteosynthesefragen (AO) C type and the pattern of it suggested a highly unstable situation with a severe spinal cord injury. A head CT scan revealed no sign of cerebellar or brainstem ischemic injury not even in the areas perfused by vertebral arteries. A Magnetic Resonance Imaging (MRI) was not performed because it was not well utilized and therefore not used 24 hours per day for acute cases at the time of the accident and treatment in Hungary (2006). Additionally femoral shaft fracture was revealed by X-ray. The patient was transferred to the National Institute of Neurosurgery with his spinal injury in a hard cervical collar.

Procedure

It was assumed that the C6-7 segment separation injury was a highly unstable one, and a HALO-brace treatment alone would not have been appropriate in providing enough stability and fusion (13). It was considered that the vertebral dislocation might not have been realigned only manually in closed fashion and open repositioning might be required. Previous studies proved that anterior and posterior instrumentation provide better stability than either anterior or posterior alone (2). Consequently, the decision was made to perform a circumferential fixation (anterior cervical discectomy, fusion, plating and dorsal fixation with mass screw-rod system) and a repositioning of C6 vertebra. HALO ring was placed on the head. Closed reduction under fluoroscopic guidance was not successful and a standard right-side cervical ventral approach was performed. The torn anterior longitudinal ligament, complete disruption of the intervertebral disc, torn posterior longitudinal ligament, torn dural sac and partial spinal cord avulsion was visible at the level C6-7 with cerebrospinal fluid (CSF) leakage. Intervertebral disc removal was performed, however the C6 repositioning attempt failed from the anterior approach and the wound was closed temporarily. HALO vest was connected to the ring and the patient was turned to the prone position with the

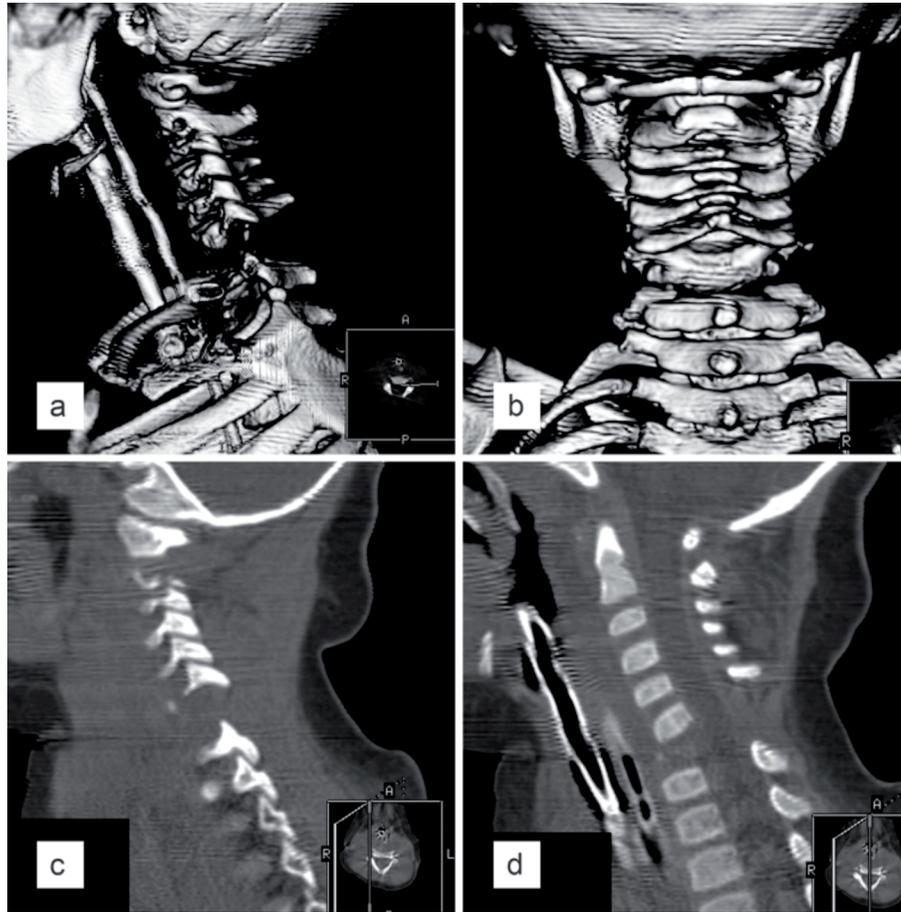


Fig. 1. —3D (a, b) and sagittal plane (c, d) reconstruction of a computed tomography scan demonstrating the distraction injury with the gap between C6-7 vertebrae

protection of HALO-brace. After the disconnection of the dorsal section of the vest from the HALO ring a standard midline posterior opening was done. The complete disruption of the posterior ligamentous complex, facet-joint capsules and the dural sac was observed between C6 and C7 vertebrae, and spinal cord pulp leaked from the dural sac. The C6 inferior articular processes were locked in a luxated position. The C7 superior articular processes were removed with high speed drill, after which the C6 vertebra could be realigned. C6 and C7 bilateral lateral mass screw-rod fixation was performed (3.5x12 mm long Axon /Synthes/ screws were applied bicortically). Following a posterior closure the patient was turned around again to the supine position again with HALO-brace protection. The

anterior wound was reopened and an intervertebral 12/4 mm Solis /Stryker/ cage was inserted. Finally, an anterior fixation was performed by placing a 22.5 mm Zephyr plate /Medtronic/ onto the C6 and C7 vertebrae and inserting two 3.5x13 mm screws in the C6 and two 3.5x13 mm other screws in the C7 vertebrae. The HALO vest was reinstalled and was left on the patient. All screws seemed to be fully contained in the patient's bone and there was no implant-size related problem in the operating room, either with the intervertebral cage or with the ventral plate and lateral mass screws as far it could be assessed by C-arm fluoroscopic imaging. Intraoperative neurophysiological monitoring was not used because it was not normally available in Hungary in 2006.

Postoperative Course

After the surgery the patient needed to be transported back to the intensive care unit (ICU) of the children's hospital for further treatment. The day following the spinal procedure a control CT scan (Fig. 2) showed an acceptable realignment of the spine, with good positioning of the mass screws and an acceptable, but not perfect, position of the ventral plate, which had reached the level of the intervertebral disc at the upper adjacent segment. The plate stabilizing screws proved to be bicortically purchasing. The patient was sedated, intubated, and the HALO was removed.

The patient was lost to follow-up for seven years, hence further medical evaluation could not be performed. The patient is quadriparetic but is able to attend an elementary school, and can write and operate a manual wheelchair. Unexpectedly he still has some C8 and Th1 radicular function considering the ab- and adduction strength of the fingers of the hands (2/5) bilaterally, and the grip strength of the hands bilaterally. Auto-urinary catheterization is applied regularly and he has automatic defecation. Control CT (Fig. 3) and X-rays were done and showed the implants in unchanged position without loosening. It appears, based on the resolution of the given CT examination, there is fusion between the surgically-fused C6-7 vertebrae and between also the C5-6 vertebrae. The ventral part of the C5 vertebral body slightly overlaps the C6-7 segment stabilizing ventral plate. Ventral tilting of C5 vertebra with concomitant bilateral facet subluxation causing a mild kyphotic deformity is visible.

In spite of the appropriate realignment and acceptable positions of the implants a large osteophyte causing severe stenosis in the spinal canal at the site of the injury was observed during the examination conducted when the child was brought in seven years later. The intra-canal osteophyte, which looks like an upturned teardrop, originates from the right pedicle, lateral mass and lamina of C7 vertebra. The osteophyte caused the spinal canal to narrow into a crescent moon shape which is three millimeters in diameter.

An X-ray revealed a mild paralytic thoracic and lumbar scoliosis secondary to the spinal cord injury.

DISCUSSION

This is the case of a neurologically compromised very young child who suffered a flexion-distraction type injury of the lower cervical spine and survived. The injury involves the complete disruption of all the ligaments, the intervertebral disc, the dural sac and facet joint capsules between the C6 and C7 vertebrae. It caused a complete segment separation with a nine millimeters gap between C6 and C7 vertebrae along the contusion and a partial tear of the spinal cord rendering the child a quadriparetic.

Instrumentation of the cervical spine of a young child is challenging due to small anatomical structures and less ossified bones.

In the past pediatric spine constructs have focused on contoured occipital rods, with loop wires in craniocervical fusions or wiring techniques in the lower cervical spine (4,14,15). Because the wiring constructs are not as biomechanically sound as rigid segmental instrumentation, wired patients often require a HALO vest placement as a supplement to obtain stability and fusion (4,6,12). In adult cases modern segmental cervical instrumentations have been shown to be biomechanically superior to traditional wiring methods, and provide increased stability and union rate (4,6). The constructs may also decrease the need for postoperative HALO immobilization, and that may reduce the rate of complications which occur from wearing HALO fixateur (2,4,8). Hedequist et al presented a retrospective case series examining patients older than six years of age with different types of pathologies treated by modern rigid internal fixation systems effectively used in adults (4). However, in the aforementioned case series, the youngest patient who had an anterior plate fixation was 12 years old.

In four of the five traceable articles written about surgical solutions to similar highly unstable cervical spine injuries, anterior and posterior stabilization was performed based on the theory that a biomechanical analysis had shown the superiority of combined anterior and posterior fixation compared to either anterior or posterior instrumentation alone (2,3,12,13,16). Matsumoto provided only posterior stabilization (9).

In none of these reports were modern anterior plates and lateral mass screw-rod system used with

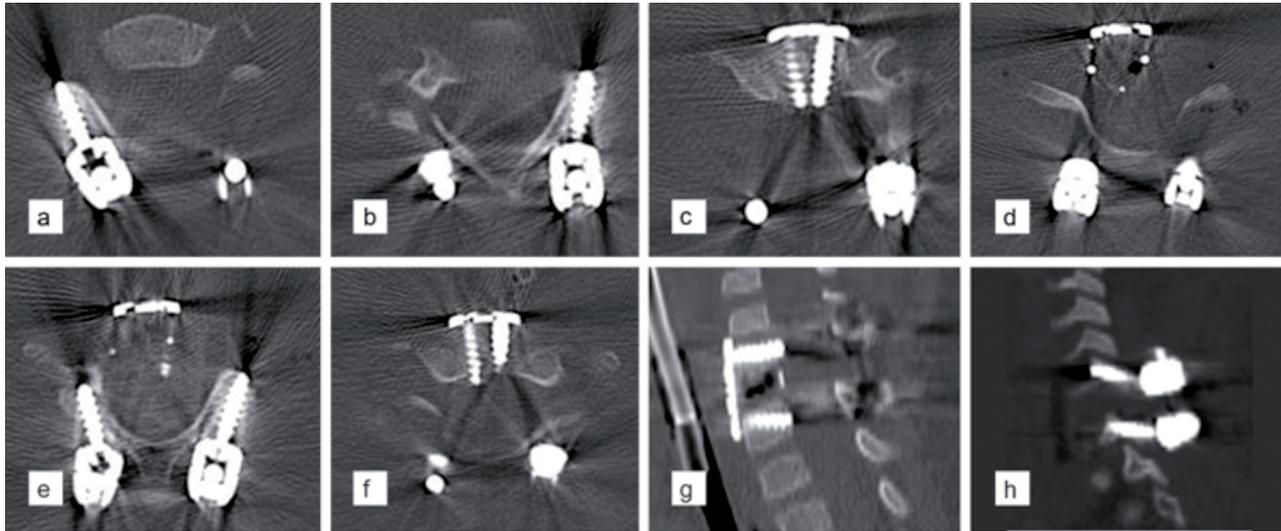


Fig. 2. —Axial plane CT scan slices present lateral mass screws in C6 vertebra (a, b), in C7 vertebra (e) on the day following the spinal procedure. Ventral plate fixing screws are shown in C6 body (c), and C7 body (f) with bicortical purchase. Intervertebral cage is demonstrated between C6-7 vertebrae (d). Sagittal plane reconstruction presents the anterior cervical implants with realignment (g) and the left sided lateral mass screws (h)

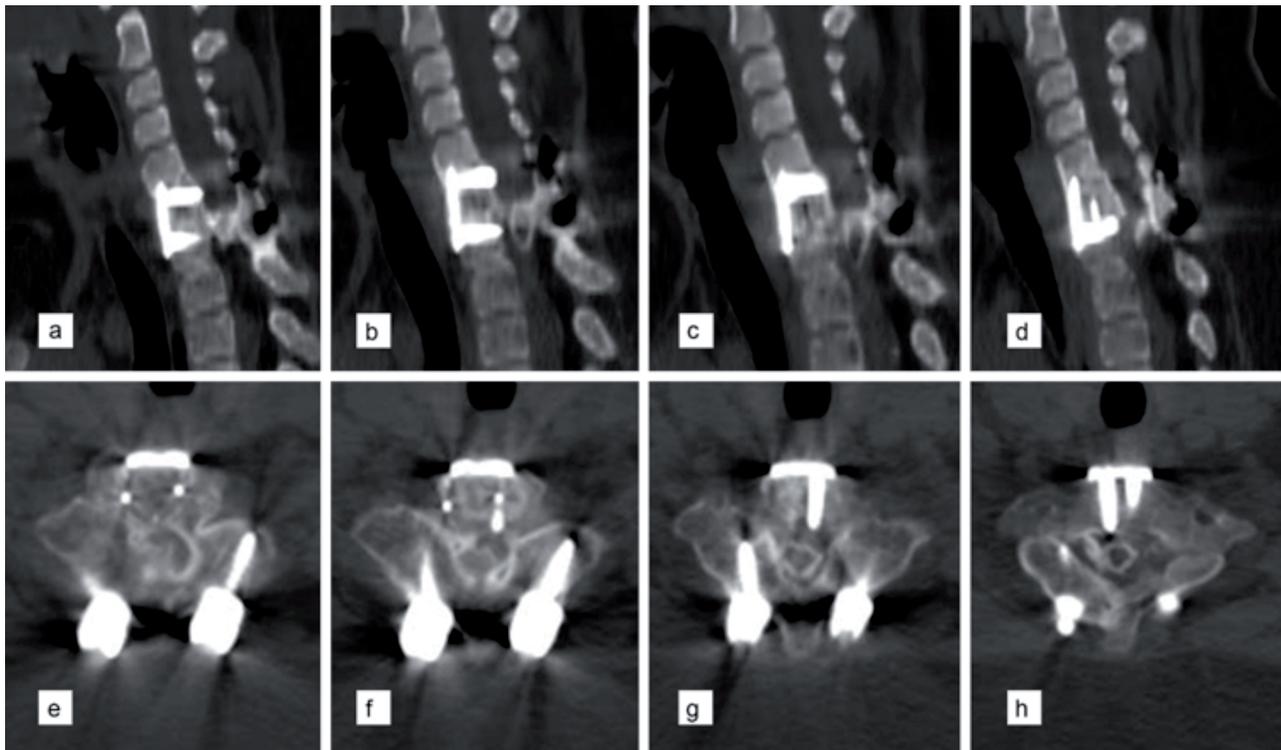


Fig. 3. —Fusion is visible between the surgically-fused C6-7 vertebrae and also between C5-6 vertebrae with the ventral tilting of C5 vertebra and concomitant bilateral facet subluxation causing a mild kyphotic deformity on sagittal plane reconstruction of a control CT scan 7 years postoperatively. Ventral part of the C5 vertebral body slightly overlaps the ventral plate which is stabilizing the C6-7 segment (a-d). A large osteophyte causing severe stenosis in the spinal canal at the site of the injury is observed, which originates from the right pedicle, lateral mass and lamina of C7 vertebra (e-h)

an intervertebral cage to establish a 360° fixation to fuse the spine, normally done in adults, as was applied in this case. This is the first reported case where combined segmental, anterior and posterior cervical spine fixation was used in an almost two-year-old child in a one stage procedure with modern, segmental, adult size implants. However his neurological status did not improve. There were no instances of implant size-related constraints intraoperatively. The control CT taken of the patient seven years following the event revealed solid intervertebral fusion between C6 and C7 vertebrae and no loosening of the implants. Though during the procedure the positioning of the ventral plate appeared to be adequate, already on the initial control CT scan images it was observed that the upper margin of the ventral plate was placed above the upper endplate of C6 vertebra, meaning it reached the adjacent intervertebral disc. The suboptimal plate position could lead to the forward tilting of the C5 vertebra with concomitant bilateral facet subluxation, revealed seven years later, which was interpreted as an adjacent segment syndrome. Conversely, the upper adjacent segment syndrome caused no neurological deterioration. McGrory and Klassen reported significant radiographic adjacent segment syndrome in 29% out of 42 pediatric patients who underwent posterior arthrodesis for cervical fractures and dislocation (10). In addition to the risk of adjacent segment syndrome the fusion in young patients has the risk of extension beyond the levels surgically treated (5).

Despite of the level of the injury (C6-C7 segment) the preserved ab- and adduction ability of the hand fingers with 2/5 strength and the good grip strength and flexion force of the hand fingers (4/5) bilaterally are very interesting because the muscles generating these movements are innervated inherently by Th1 and C8 nerve roots. The importance of it is further pronounced because, as an additional unique and unexpected outcome, a spinal canal-occupying osteophyte appeared at the level of the C7 vertebra, however it did not cause further neurological deterioration, meaning that outcome was not relevant to the clinical results. Preserved Th1 and C8 radicular function is hardly imaginable with the osteophyte, which almost completely obstructs

the spinal canal. Therefore the remaining finger ab-, adduction ability and good finger flexion and grip strength must originate from upper roots. The cause of the evolution of the osteophyte could be the C6-7 fusion because, although the exact cause of the osteophyte is unclear, it appears to originate adjacent to the surgically-fused intervertebral space.

Flexion-distraction injuries of the lower cervical spine are very rare in young children, especially with complete segment separation, and limited literature makes treatment decisions difficult (3,7-9,12). The choice of the adequate implant also necessitates a thorough evaluation (2,7,9,12). The long term effects of the fusion of the cervical motion segment are still uncertain. The clinical significance of adjacent segment syndrome and the large osteophyte visible on CT scan in the spinal canal are uncertain because they did not cause further neurological deterioration or pain. Modern segmental fixation implants in children need further investigation.

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