POSTERIOR CERVICAL SCREW FIXATION IN CHILDREN: THE TREATMENT EXPERIENCE

O.M. Pavlova, A.V. Burtsev, A.V. Gubin, S.O. Ryabykh
Russian Ilizarov Scientific Center for Restorative Traumatology and Orthopaedics, Kurgan, Russia

Objective. To prove the safety and technical and mechanical validity of posterior screw fixation of the cervical spine in children and to compare different types of the cervical spine fixation based on our own treatment experience and literature data.
Material and Methods. A retrospective analysis of 47 patients under the age of 18 years who underwent various types of posterior instrumental fixation of the cervical spine was performed. Level of Evidence — III.
Results. The duration of postoperative follow-up varied from 2 months to 6.6 years (mean, 2.1 ± 1.6 years). A total of 186 screws were placed, the number of screws inserted in one patient reached 10 (mean, 3.9 ± 2.4). Postoperative complications were observed in 5 (10.6 %) patients.
Conclusion. Posterior screw fixation of the cervical spine provides biomechanically reliable stabilization of the segment, helps to achieve good correction of deformity and reduction of dislocations, shortens the period of rehabilitation, and is a safe method of surgical treatment in children.
Key Words: cervical spine malformations, cervical screw fixation.

Please cite this paper as: *Pavlova OM, Burtsev AV, Gubin AV, Ryabykh SO. Posterior cervical screw fixation in children: the treatment experience. Hir. Pozvonoc. 2017;14(3):27–31. In Russian.*
DOI: http://dx.doi.org/10.14531/ss2017.3.27-31.

Given that the child's head is relatively large and the articular facets of the cervical spine are positioned horizontally, cervical spine pathologies, especially at the craniocervical and atlantoaxial areas and the upper portion of the subaxial segment, are associated with a high risk of instability and deformity.

Stabilizing operations on the CS in children are often required for the following groups of diseases:

1) mechanically and neurologically unstable congenital spinal malformations, abnormalities causing spinal imbalance, stenosing and ischemic malformations;
2) systemic diseases causing stenosis at the cervical spine and craniovertebral junction, spinal imbalance, spinal stenosis;
3) mechanically and neurologically unstable spinal injury;
4) growing tumors that cause compression of neural and vascular structures and persistent pain syndrome;
5) infections of the vertebrae;
6) neuromuscular diseases that cause spinal imbalance and spinal stenosis;
7) iatrogenic conditions causing stenosis, mechanical and neurological instability of the spine, spinal imbalance and spinal stenosis.

While in the case of the traumatic injury to the CS surgical indications are determined by the type of traumatic injury [1], stability signs [3, 16], and the presence of neurological deficit [2], neurological instability still remains the only absolute indication for surgery in patients with non-traumatic CS pathology.

Operations on the CS in children can be classified into subgroups based on the purpose of the operation: decompression, stabilization, decompression and stabilization, and correction of the spinal deformity in combination with stabilization.

However, the indications and the choice of CS fixation methods in children are still questionable. In this part of the paper, the authors present a 6-year experience in treatment of 47 patients.

The objective of the study was to prove the safety and technical and mechanical validity of the posterior screw fixation of the cervical spine in children and to compare different types of cervical spine fixation based on our own treatment experience and literature data.

Material and Methods

Study design: single-center retrospective cohort. Level of Evidence: III. Patient recruitment period: 2010–2016.

Inclusion criteria:

– age under 18 years at the time of the operation;
– the same place of the operations (clinic for spine diseases of the Ilizarov Scientific Center for Restorative Traumatology and Orthopaedics, Russia);
– the use of various options of the posterior instrumented fixation of the CS;

– etiologically verified diagnosis;
– comprehensive radiographic archive.

Preoperatively, somatic, neurological, and orthopedic status of all patients was assessed. Biplane X-ray, CT, and MRI were carried out. Functional CT, CT angiography, and functional radiography were used when indicated.

In two cases, the use of halo traction was required during preoperative preparation.

In some cases, intubation was performed using endoscopic techniques and videolaryngoscopy. Intubation was carried out by the same anesthesiologist experienced in endotracheal tube placement in these patients. Neuromonitoring was used during the operation. Motor and somatosensory evoked potentials in the upper and lower extremities were measured using standard techniques. Anesthetics that do not hinder reliable and stable monitoring were used.

Various options of the posterior instrumented fixation, either isolated or in combination with spinal deformity correction, and decompression of neural structures were used as surgical treatment methods. All patients underwent postoperative X-ray or CT.

Results

The study involved 22 (46.8 %) girls and 25 (53.2 %) boys aged 2 to 16 years at the time of the operation (mean age 9.2 ± 4.4 years). The duration of postoperative follow-up was 2 months to 6.6 years (on the average, 2.1 ± 1.6 years). The pathology was mostly represented by congenital anomalies, 27 (57.50 %) cases (Table 1). Systemic diseases were diagnosed in 13 (25.50 %) patients (Table 2). Additionally, neglected atlantoaxial rotatory fixation was observed in 3 (6.40 %) cases, primary tumors of cervical vertebrae in 2 (4.30 %) cases, post-laminectomy kyphosis in 1 (3.15 %) case, progressive scoliosis with underlying Rossolimo myotonic dystrophy involving the cervicothoracic segment in 1 (3.15 %) case.

Clinical manifestations included pain in the neck, torticollis, restriction of CS movement, progressive cervical vertebrogenic myelopathy, progressive deformity of the CS (scoliotic, kyphotic), and vertebrobasilar insufficiency symptoms.

It should be noted that the etiopathogenesis of the underlying disease in some cases predetermined clinical manifestations (Fig.). For example, local symptoms, such as pain, torticollis, and restriction of neck movement dominated in the case of congenital malformations. In the case of systemic diseases, many patients had myelopathy symptoms due to spinal stenosis or concomitant nervous system disorders (e.g., neurofibromas); progressive scoliosis was characteristic of these patients.

All patients underwent various types of the posterior fixation of the CS using screw systems, in some cases supplemented by laminar hooks or occipital plates. A total of 186 screws, 10 laminar hooks (Table 3), and 10 occipital T- or Y-shaped plates were implanted. We used conventional posterior fixation instrumentation with the screws sized 3.5 mm in diameter and having various lengths. In 30 cases, instrumented fixation was complemented by local fusion with allogeneic or autologous bone. The number of screws per patient was up to 10 (on the average, 3.9 ± 2.4). In 14 cases, we failed to insert screws at the planned level since there was a risk of injury to the neuro vascular structures due to complicated path selection or fragile bone structures.

CT control showed no screw malpositions in the early postoperative period. Postoperative complications were observed in 5 (10.6 %) patients. Four complications occurred in the late period, including pseudarthrosis with the rod fracture — 3 (60.0 %) cases and progression of cervicothoracic kyphoscoliosis — 1 (20.0 %) case. In the immediate postoperative period, 1 (20.0 %) complication was observed, myelopathy associated with corrective maneuvers in a patient with Morquio syndrome. In complicated cases, revision surgery and reinstrumentation were performed.

Table 1
The types of defects in patients with congenital malformations

Abnormality	Patients, n (%)
Klippel — Feil	12 (44.5)
Malformation	9 (33.3)
Odontoid bone	3 (11.1)
Odontoid aplasia	2 (7.4)
Dynamically unstable defect	1 (3.7)

Table 2
Systemic diseases with vertebral complications

Nosology	Patients, n (%)
Spondyloepiphyseal dysplasia	3 (23.1)
Type I neurofibromatosis	3 (23.1)
Type IV mucopolysaccharidosis	2 (15.3)
Larsen syndrome	1 (7.7)
Ollier syndrome	1 (7.7)
Down's syndrome	1 (7.7)
Diastrophic dysplasia	1 (7.7)
Undifferentiated connective tissue dysplasia	1 (7.7)

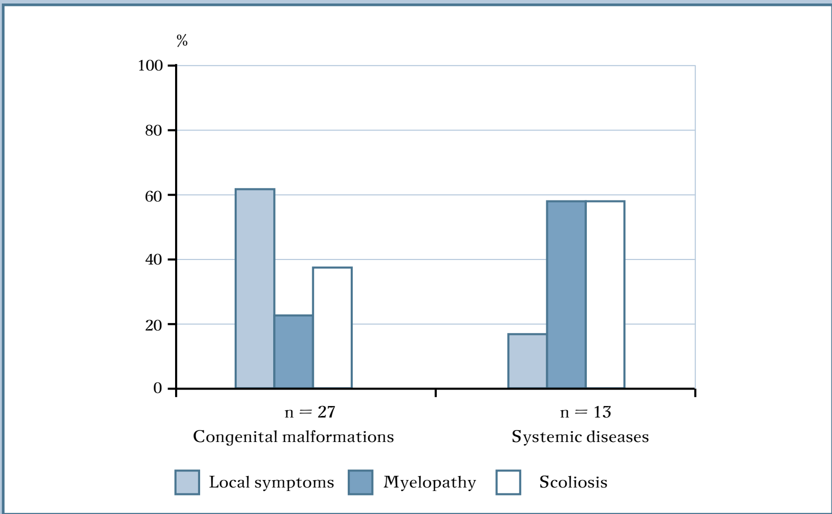

Fig.
The main symptoms in patients with congenital abnormalities and systemic diseases

Discussion

The screw instrumentation systems have several advantages in the treatment of spinal pathologies:

1) provide a reliable framework for further fusion, whereas the attempts of non-instrumented fixation at the level of cervical spine often do not result in stabilization of the segment [4, 8, 11, 15];

2) enable intraoperative segment-wise reduction of displacements due to leverage on the dislocated vertebrae along with manual positioning of the patient's head [8, 12, 14, 15];

3) enables avoiding long-term use of halo-apparatus, which is inconvenient and restricts patient's activity [4–10, 13, 15];

4) they demonstrate higher biomechanical reliability, because, according to the 3-column vertebral body load distribution system, anterior column bears about 36 % of the load, while the posterior CS structures bear 64%, which proves the effectiveness of the posterior fixation systems.

We used the data of 430 children with posterior screw fixation of the CS reported in the literature and 47 our own cases to determine the total number of complications amounting to 31 (6.5 %), of which 13 (2.7 %) were implant-related and required revision surgery. A small number of complications is indicative of safety of the posterior fixation techniques in children.

Table 3
Options of the posterior fixation in patients

Fixation place	Screws, n (%)	Hooks, n (%)
Lateral masses of C1	9 (4.8)	1 (10.0)
Transpedicularly into C2	6 (3.2)	–
Articular part of C2	21 (11.3)	–
Intralaminarly into C2	26 (13.9)	2 (20.0)
Intralaminarly into C3	3 (1.6)	–
Lateral masses of C3	29 (15.6)	–
Lateral masses of C4	31 (16.7)	2 (20.0)
Lateral masses of C5	24 (13.0)	1 (10.0)
Lateral masses of C6	24 (13.0)	2 (20.0)
Intralaminarly into C7	4 (2.1)	–
Transpedicularly into C7	6 (3.2)	–
Lateral masses of C7	3 (1.6)	2 (20.0)

Conclusion

The posterior screw fixation of the CS in children has several advantages over non-instrumented fusion, wire and cable fixation, fixation with the anterior plate and the locking hook: segment stabilization is biomechanically reliable and provides good deformity correction and reduction of displacement and shortens the rehabilitation period.

Standardized implants and instrumentation are suitable to perform the posterior screw fixation in children older than two years.

Posterior screw fixation of the CS is a safe method of surgical treatment in children.

The study was not sponsored. The authors declare no conflict of interest.

References

1. **Allen BL Jr, Ferguson RL, Lehmann TR, O'Brien RP.** A mechanistic classification of closed, indirect fractures and dislocations of the lower cervical spine. Spine. 1982;7:1–27. DOI: 10.1097/00007632-198200710-00001.
2. Association ASI. Standards for neurological and functional classification of spinal cord injury. Chicago: American Spinal Injury Association, 1992.
3. **Bernhardt M, White AA, Panjabi MM.** Biomechanical considerations of spinal stability. In: Herkowitz HN, Garfin SR, Balderston RA, eds. The Spine. Philadelphia, 1992:1071–1096.
4. **Brockmeyer D, Apfelbaum R, Tippets R, Walker M, Carey L.** Pediatric cervical spine instrumentation using screw fixation. Pediatr Neurosurg. 1995;22:147–157.
5. **Desai R, Stevenson CB, Crawford AH, Durrani AA, Mangano FT.** C-1 lateral mass screw fixation in children with atlantoaxial instability: case series and technical report. J Spinal Disord Tech. 2010;23:474–479. DOI: 10.1097/BSD.0b013e3181bf9f24.
6. **Garber ST, Brockmeyer DL.** Management of subaxial cervical instability in very young or small-for-age children using a static single-screw anterior cervical plate: indications, results, and long-term follow-up. J Neurosurg Spine. 2016;24:892–896. DOI: 10.3171/2015.10.SPINE15537.
7. **Gluf WM, Brockmeyer DL.** Atlantoaxial transarticular screw fixation: a review of surgical indications, fusion rate, complications, and lessons learned in 67 pediatric patients. J Neurosurg Spine, 2005;2:164–169. DOI: 10.3171/spi.2005.2.2.0164.
8. **Guo X, Xie N, Lu X, Guo Q, Deng Y, Ni B.** One-step reduction and fixation applying transposterior arch lateral mass screw of C1 combined with pedicle screw of C2 and rod system for pediatric acute atlantoaxial rotatory subluxation with injury of transverse ligament. Spine. 2015;40:E272–E278. DOI: 10.1097/BRS.0000000000000753.
9. **Haque A, Price AV, Sklar FH, Swift DM, Weprin BE, Sacco DJ.** Screw fixation of the upper cervical spine in the pediatric population. Clinical article. J Neurosurg Pediatr. 2009;3:529–533. DOI: 10.3171/2009.2.PEDS08149.
10. **Hedequist DJ, Emans JB.** Cervical spine instrumentation in children. J Am Acad Orthop Surg. 2016;24:370–378. DOI: 10.5435/JAAOS-D-15-00199.
11. **Hwang SW, Gressot LV, Rangel-Castilla L, Whitehead WE, Curry DJ, Bollo RJ, Luerssen TG, Jea A.** Outcomes of instrumented fusion in the pediatric cervical spine. J Neurosurg Spine. 2012;17:397–409. DOI: 10.3171/2012.8.SPINE12770.
12. **Ji XT, Li A, Wang Q, Zhao DS, Huang G, Liu WP, Qu Y, Niu L, Fei Z.** Posterior reduction and instrumentation with rod-screw construct for atlanto-axial dislocation: a single institutional study with 21 consecutive cases. Clin Neurol Neurosurg. 2013;115:1433–1439. DOI: 10.1016/j.clineuro.2013.01.009.
13. **Lowry DW, Pollack IF, Clyde B, Albright AL, Adelson PD.** Upper cervical spine fusion in the pediatric population. J Neurosurg. 1997;87:671–676. DOI: 10.3171/jns.1997.87.5.0671.
14. **Shuhui G, Jiagang L, Haifeng C, Hao ZB, Qing HS.** Surgical management of adult reducible atlantoaxial dislocation, basilar invagination and Chiari malformation with syringomyelia. Turk Neurosurg, 2016;26:615–621. DOI: 10.5137/1019-5149.JTN.13884-14.2.
15. **Sinha S, Jagetia A, Bhausaheb AR, Butte MV, Jain R.** Rigid variety occiput/C1-C2-C3 internal fixation in pediatric population. Childs Nerv Syst. 2014;30:257–269. DOI: 10.1007/s00381-013-2232-3.
16. **White AA, Panjabi MM.** Clinical Biomechanics of the Spine. Vol. 2. Philadelphia, 1990.

Address correspondence to:
Pavlova Olga Mikhailovna
Russian Ilizarov Scientific Center for Restorative Traumatology and Orthopaedics,
M. Ulyanovoy str., 6, Kurgan, 640014, Russia,
pavlova.neuro@mail.ru

Received 22.11.2016
Review completed 24.11.2016
Passed for printing 04.12.2016

Olga Mikhailovna Pavlova, neurosurgeon, orthopedist-traumatologist, junior researcher in the Laboratory of Axial Skeletal Pathology and Neurosurgery, Russian Ilizarov Scientific Center for Restorative Traumatology and Orthopaedics, Kurgan, Russia, pavlova.neuro@mail.ru;
Aleksandr Vladimirovich Burtsev, MD, PhD, orthopedist-vertebrologist, researcher, Laboratory of Axial Skeletal Pathology and Neurosurgery, Russian Ilizarov Scientific Center for Restorative Traumatology and Orthopaedics, Kurgan, Russia, bav31rus@mail.ru;
Alexandr Vadimovich Gubin, DMSc, orthopedist-traumatologist, Director, Russian Ilizarov Scientific Center for Restorative Traumatology and Orthopaedics, Kurgan, Russia, shugu19@gubin.spb.ru;
Sergey Olegovich Ryabykh, DMSc, pediatric surgeon, orthopedist-traumatologist, vertebrologist, Head of the Clinic of Spine Pathology and Rare Diseases, Russian Ilizarov Scientific Center for Restorative Traumatology and Orthopaedics, Kurgan, Russia, rso_@mail.ru.