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Three-dimensional correction for idiopathic scoliosis with posterior spinal fusion and the risk of neurological complications

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ABSTRACT

Introduction: The correction of adolescent idiopathic scoliosis (AIS) using the posterior approach is the most common and well-documented technique in medical literature. As with any invasive procedure, it carries the risk of potential neurological complications (NCs).
Aim: Evaluation of NCs after surgical treatment of AIS and patient satisfaction after surgery.
Material and methods: A retrospective evaluation of 195 patients operated in 2007–2013 with posterior approach and direct vertebral derotation. We evaluated the age of the patients during the surgery, the angle of the main curvature, the thoracic kyphosis, sex, BMI, the average length of stay in the hospital after surgery, the average percent curve correction, postoperative NCs, and SRS-22 at the final follow-up (FFU).
Results: The operated patients were 71% female. The average age was 16.5 years. The mean duration of surgery was 330 min. The average amount of blood loss was 820 mL. The average length of stay was 5.5 days. NCs were recorded as follows: numbness of the lateral femoral cutaneous nerve (6), muscle weakness of the lower limbs (5), paraesthesia of the foot (5), lower limb paraesthesia (5), radiculopathy (4), paraparesis (2), and neurogenic bladder (2). All NCs were eliminated in the postoperative period and at FFU, and there were no neurological deficits. SRS-22 scores at FFU were good.
Conclusions: (1) The rate of NCs is insignificant and left no lasting musculoskeletal dysfunction. (2) Number of complications was higher when we did not use neuromonitoring. (3) Total satisfaction after surgery at FFU was good.

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1. Introduction

Spinal deformities are a group of diseases of varying etiology and pathogenesis whose essential common feature is a significant, visible, and noticeable deviation of construction, which together involve varying conditions in the biomechanics of the spine.[1–3] Adolescent idiopathic scoliosis (AIS) is a three-dimensional deformation that appears during development, applies to patients with no apparent cause for its formation, and measures at least 10° (Cobb angle) in the AP-standing X-ray.[4–6] AIS is found in 0.3%–15.3% of spinal deformities, and is found in 13.8% of the total population.[7] During most of the twentieth century, the main goal of the treatment of AIS was to stop the progressive curvature, which, in its advanced form, could affect the functioning of internal organs, which in turn is associated with the functioning of the whole body, leading to irreversible dysfunction, and even death.[5,6] Today, due to the rapid advancement of medical knowledge, a new generation of implants and operating techniques as well as devices to improve the safety of operations have been established. The goals of treatment have evolved regarding the correction of deformity, such as providing cosmetic effects.[3,8–12] The primary goal of treatment remains the welfare and safety of the patient, which should always be remembered.

The correction of AIS using the posterior approach is the most common and well-documented technique in medical literature. As with any invasive procedure, it carries the risk of potential complications. In spinal surgery, where the use of various implants and instruments for correction of deformation is the norm, complications may be related to the procedure itself, or the equipment and implants.[5,6,9–11,13–18] Though complications in spinal surgery among adults are well known, and have been repeatedly described in medical literature, reports of complications among children and adolescents are scarce.

2. Aim

In our work, we have decided to evaluate the neurological complications (NCs) that can occur after the surgical treatment of AIS performed by the posterior approach technique, using transpedicular screws, driven by a 'free-hand' technique, as well as assess the satisfaction of patients after the surgical treatment using the rating scale SRS-22.

3. Material and methods

We carried out a retrospective evaluation of 195 patients operated on due to AIS in our department during 2007–2013. The following inclusion criteria were adopted: (1) bone maturity above stage 2 using Risser's classification; (2) scoliosis classified as Lenke 1, 2, 3, 4, 5, 6; (3) angle of the main curvature greater than 45°; (4) correction technique (posterior approach technique) and correction system based on Cotrel–Dubousset; and, (5) period of postoperative final follow-up (FFU) of a minimum of 2 years.

In all patients included in the study, the surgical technique used the posterior approach, transpedicular screws, and the system based on Cotrel–Dubousset. Correction techniques used were direct vertebral rotation or bilateral apical vertebral derotation. Patients were examined preoperatively and the study included only those without neurological deficits and without prior surgical procedures in their medical history. Summary demographics of our study group are presented in Table 1. A complication was defined as an unexpected event that required medical or surgical intervention to improve the resulting outcome. In addition, NCs were divided as follows: perioperative (intraoperative, and those in the first 7 days postsurgery), early postoperative (8–30 days after the surgery) and late postoperative (more than 30 days postoperatively). All complications were included in the study. We did not divide them into minor or major. All adverse events were counted. A single patient could manifest several complications, and in such cases, each complication was noted individually.

Statistical analysis used 10.0 Statistica (StatSoft, Inc., 2011). The study used the Shapiro–Wilk test, Student's *t*-test, and nonparametric methods. The significance level was assumed at level $\alpha = 0.05$. The results were considered statistically significant when the calculated probability P met the test inequality $P < 0.05$. We have analyzed the collected material and confronted it with the available literature.

4. Results

The patient outcomes are included in Table 2. Most patients were female (71%). Regarding the distribution of Lenke curve types, we recorded most as type I ($n = 75$), and fewest as types IV ($n = 9$) and VI ($n = 6$). The average age was 16.5 years. The mean duration of surgery was 330 min. The average amount of blood loss was 820 mL. The average length of stay in the hospital after surgery was 5.5 days.

Out of 195 operative patients, there were 380 perioperative complications. NCs accounted for 7% of all adverse events. The remaining 93% were not neurological and were not analyzed here. All NCs were recorded and summarized in Table 3, and all were classified as perioperative.

Table 1 – Summary demographics of patients with AIS.

Demographics	Number and percentage
Male	56 (29%)
Female	139 (71%)
Lenke classification	
I	75
II	56
III	18
IV	9
V	31
VI	6
Age, years	16.5 ± 1.5
BMI	21.5 ± 3.5
Risser's classification	3.5 ± 1.0
Preoperative major Cobb angle,°	65 ± 9
Preoperative thoracic kyphosis T5–T12,°	42 ± 8

Table 2 – Outcomes after surgery.

Variable	Number
Postoperative major Cobb angle,°	26 ± 9
Postoperative thoracic kyphosis T5–T12,°	38 ± 8
Percent curve correction	69 ± 9
Duration of surgery, min	330 ± 92
Blood loss, mL	820 ± 212
Length of hospital stay, days	5.5 ± 2.3

Table 3 – Neurological complications (*n* = 29; 7%).

Variable	Number
Numbness of the lateral femoral cutaneous nerve	6
Muscle weakness of the lower limbs	5
Foot paraesthesia	5
Lower limb paraesthesia	5
Radiculopathy	4
Paraparesis	2
Neurogenic bladder	2

Total rating of patient satisfaction after surgery at FFU was good, as shown in Table 4. There were no statistically significant relationships in the analyzed group of patients.

5. Discussion

Most data available in medical literature regarding complications associated with surgical correction of idiopathic scoliosis are retrospective or come from case studies.[5,6,8–11,13–24] The most reliable tests, which were performed using SRS, and a database of 3 years, reported morbidity 5.7% in the cohort of 6 334 patients.[10,19] The incidence of complications postsurgery performed using the posterior approach was 5.1%. The incidence of NCs was 15.4%, most of which occurred in the perioperative period (6.13%). Other retrospective multicenter studies of pediatric patients showed 27% intraoperative NCs.[25] Some authors draw attention to late postoperative complications detected within 2 years after surgery.[24] In contrast, the use of advanced surgical procedures for the treatment of spinal deformities (i.e., osteotomy) yielded an incidence of bladder dysfunction in 11%, including 2.8% permanent deficits.[26–30]

Our retrospective study showed an NCs incidence of 7%, and the majority of cases were reported in the perioperative period, which then subsided. However, some persisted until the late postoperative period (i.e., neurogenic bladder and radiculopathy up to 3 months after surgery), and muscle weakness of the lower limb in 1 patient (which subsided 12 months after surgery). The pre- and postoperative radiographs of 16-year-old girl who had a transient several hours paraparesis of lower limbs are shown in Figs. 1 and 2. All the functions returned within 8 h after surgery. Sometimes the elimination of symptoms required additional treatments, such as steroid blockade and rehabilitation. There were no neurological deficits at FFU.

Table 4 – SRS-22 score at the final follow-up.

Variable	Score
Function	4.2 ± 1.3
Pain	4.1 ± 1.5
General self-image	3.8 ± 1.8
Mental health	3.9 ± 1.3
Satisfaction	4.0 ± 1.6

We achieved similar proportion of NCs compared to the events described by the Harms Study Group in the correction of AIS from the posterior approach, as presented in Table 5.[31] The occurrence of intra-, peri- and postoperative complications is related to various factors. It should be noted that the effect of the treatment largely depends not only on the equipment and new implants, but also primarily on the manual skills of the surgeon.[20]

Our department is a relatively new center, and has been operating on spinal deformities in accordance with the latest trends in the field since 2007. From 2007 to 2015, we used about 9 000 transpedicular screws in the treatment of vertebral column deformities in children and adolescents. Although it is not a high number, it certainly gives us some experience with spinal scoliosis correction. Our spinal team consists of three experienced orthopedic surgeons who also work with adults. Each of us performs an average of five spinal surgeries per week. When we started to introduce the surgical treatment of AIS, we did not have the equipment to monitor the function of the nervous system during surgery. The wake-up test was the

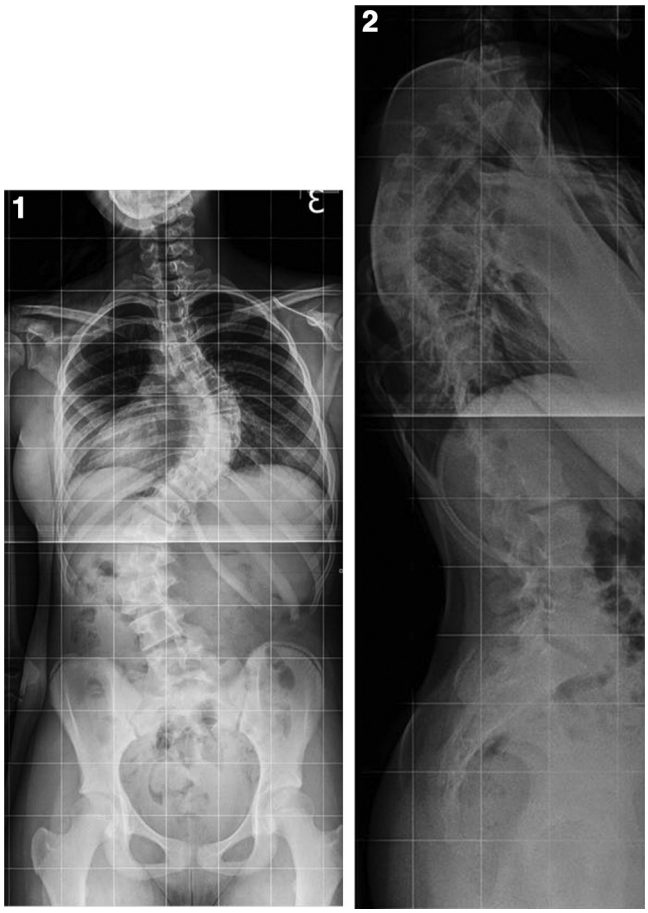

Fig. 1 – The preoperative radiographs of the patient.

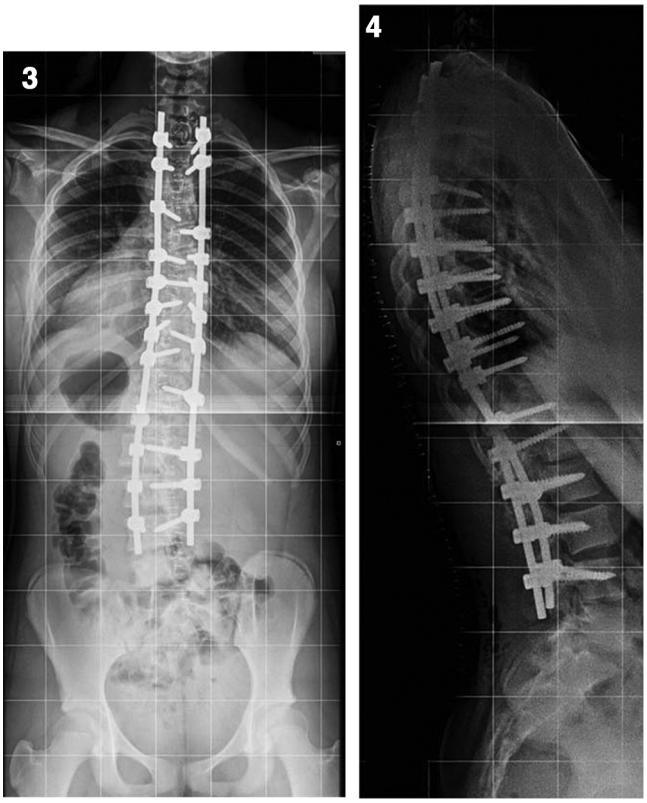

Fig. 2 – The postoperative radiographs of the patient.

standard. In 2011, neuromonitoring was introduced as a mandatory tool for each treatment. The aim of intraoperative monitoring of the spinal cord is to evaluate the integrity of the neural pathway, which may be damaged during the operation by direct injury of the spinal cord or nerves during osteotomy, or by applying excessive traction to correct deformities.[20,21]

Our study shows number of complications was higher in 2007–2011, when we did not use neuromonitoring. We had then 70% of all our NCs ($P < 0.05$). There was also a clear association between increasing Cobb angle of the main curvature (over 70°) and higher rates of NCs before using neuromonitoring. Patients who experienced complications were significantly had prolonged anesthesia time and excessive bleeding ($P < 0.001$).

According to Miyanji et al., classical open approaches may cause significant soft tissue and muscle morbidity including denervation, ischemia, atrophy, scarring, and decreased extensor strength, possibly contributing to increased perioperative morbidity and long-term pain.[32]

Table 5 – All complications rate.

	Our hospital	The Harms Study Group
Number of patients	380 (100%)	1 369 (100%)
Neurological complications	29 (7%)	82 (6%)
Other complications	351 (93%)	1 287 (94%)

Source: Newton et al.[12]

Spine surgery continues to progress. Every month, each year, improvements are observed, and new implants and surgical techniques are developing. What will the future bring? Perhaps the development of minimally invasive spinal surgery to perform most procedures with minimal risk of complications. However, what if all spinal deformities can be treated with minimally invasive spinal surgery? At present, there are few initial reports on these techniques.

6. Conclusions

In our study group, the rate of NCs is low and comparable to the available literature. These complications did not leave lasting locomotor dysfunctions, and the overall assessment of patient satisfaction after surgery was good at FFU. However, complications associated with the surgical treatment of idiopathic scoliosis in children and adolescents are numerous and can occur in any period (perioperative and postoperative). We should anticipate potential complications that can occur with any surgery. We should carefully carry out each treatment to minimize possible complications. Close attention to details in the position of the patient before surgery can reduce the incidence of neurological complications (i.e., damage to the nerve plexus, nerves). An efficient treatment together with proper anesthesia (i.e. anti-hypertensives) can minimize blood loss. Attention to detail, knowledge of the instruments, and precise actions can reduce related complications.

Each correction of spinal deformities in children and adolescents entails a high risk of complications; however, if diagnosed in time, they do not cause permanent dysfunction of the musculoskeletal system. The preoperative plan and teamwork can significantly reduce the number of adverse events. Long-term effects of the surgical treatment should be still studied, because it will help to set up standards of surgical procedures more precisely, for both patients and doctors. Understanding the complications associated with the treatment of spinal deformity is necessary for surgeons to make the right decisions. Postoperative neurological deficits should serve as a guide for doctors in preoperative planning and the surgical treatment of the spine; moreover, there should be a well thought-out and planned series of events where everything must be prepared, with the ability to respond properly and timely. The primary goal of treatment remains the welfare and safety of the patient, which should always be remembered.

Conflict of interest

None declared.

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