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SURGICAL TREATMENT OF CHILDREN WITH IDIOPATHIC THORACOLUMBAR SCOLIOSIS USING TRANSPEDICULAR SPINAL SYSTEMS

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Purpose of the study. Evaluation of the surgical treatment of children with idiopathic scoliosis of thoracolumbar localization.

Materials and methods. Surgery was performed on 33 patients aged from 13 to 17 years with a curve approximating 42°–123°, according to Cobb. Surgical correction of the deformity was performed using three tactical options with the use of a transpedicular multi-basic metallic device.

Results. In idiopathic thoracolumbar scoliosis, the surgical correction ranged from 74% to 100%. Loss of correction in the follow-up period from 2 to 5 years was 2°–4°.

Conclusion. Surgical treatment of children with idiopathic thoracolumbar scoliosis depends on the degree of the main curve, spinal mobility, and the patient's age. Application of a multi-basic transpedicular metallic device allows significant correction of the angle of the curve, a true de-rotation of vertebral bodies at the apex of the curve to be performed, and the frontal and sagittal profile of the spine to be restored while maintaining the results achieved in the late postoperative period.

Keywords: idiopathic thoracolumbar scoliosis, children, surgery, transpedicular fixation.

Introduction

Treatment of children with idiopathic scoliosis remains a challenging problem in orthopedics. Surgery is the preferred treatment for children with severe and progressive spinal curvatures, and thus, corrects the deformity, improves or restores the physiological balance of the torso, and provides lasting stabilization of the achieved result via a transpedicular fixation system and in turn, improves the patient's quality of life [1-3]. Recently, metal–alloy transpedicular spinal systems have been used to treat children with idiopathic scoliosis [4-11]. The use of these systems provides an opportunity to repair all three columns of the deformed spine, thereby achieving effective correction of scoliotic and kyphotic curvatures and approximate physiological frontal and sagittal profiles of the spine during surgery. The spinal transpedicular screw support systems provide stable and reliable fixation of the deformed area of the spinal column and preserve the achieved correction for long terms. However, many surgeons do not use these systems in cases of idiopathic scoliosis because of the risk of complications during surgery and the technical complexity in installing pedicle screws into the vertebral bodies along the arch of deformation. These problems are primarily associated with anatomical and anthropometric characteristics of the vertebral bodies and the spatial relationship between the arch and base of the vertebra along the main scoliotic curvature.

The use of intraoperative navigation equipment for surgically treating children with idiopathic scoliosis makes it possible to evaluate the anthropometric dimensions of the vertebral bodies and the main curve deformity as well as preoperatively plan the installations of transpedicular screws. During the surgery, navigation systems assist the surgeon to correctly and precisely install the elements of fixation along the scoliotic curvature, which significantly reduces the risk of intraoperative complications [12-17]. The use of three-dimensional computed tomography (3D-CT) navigation during surgery in children with thoracolumbar idiopathic scoliosis enables the achievement of the desired correction of the spinal deformity [18].

This study aimed to analyze the results of surgical correction of spinal deformity in children with thoracolumbar idiopathic scoliosis using transpedicular fixation systems aided by 3D-CT navigation.

Materials and methods

We analyzed the surgical results of 33 patients (eight boys, 25 girls) between the ages of 13 and 17 years with grades III-IV (according to V.D.Chaklin) thoracolumbar idiopathic scoliosis. The curvature was **dextroscoliotic** in 21 (64%) adolescents and **levoscoliotic** in 12 (36%). The Cobb angle measurement of the main thoracolumbar curvature was between 42° and 123°. Patients underwent the usual preoperative physical examination. X-rays of the spine were performed in two projections (frontal and lateral) while the patient was standing and lying down. Furthermore, functional radiography was performed when the patient was bending to the right and left for the evaluation of the thoracolumbar segment. The deformity was considered mobile if the value of the primary deformity curvature on radiographs changed by >30% compared with the initial value under conditions of simulated load. Magnetic resonance imaging was performed to exclude intraspinal pathology and to access the condition of the spinal cord and its elements. Anatomy of bone structures of the deformed vertebrae was determined by CT from the Th1 to S1 vertebrae with 11 mm thick sections.

CT data were transferred into a navigation system that uses SpineMap 3D software. External transverse and longitudinal size at the base of the vertebral arch was measured in a plane, relative to each vertebra, and in the spatial orientation of the arch, relative to the body of the vertebra. These anatomical and anthropometric data helped in determining the feasibility of the installation of transpedicular screws in the body of each vertebra along the main curve deformity. The criterion for the correct installation of the screw was an external transverse and longitudinal diameter at the root of the arc that was >4 mm. If the transverse diameter was <3.5 mm at the base, screws were not installed. The apical vertebral rotation was measured according to the Dahlborn method in the sagittal plane before and after surgery.

Preoperative planning was based on the results of X-ray and CT data using the navigation station. Installation zones and the path of supporting elements through the vertebral arch were planned with regard to the principles of segmental correction (distraction and compression). Only transpedicular screws were used as support elements.

Depending on the main arch of curvature and its mobility, three tactical versions of surgery were used.

In the first group of patients, correction was implemented using the posterior spinal fixation system with the application of a halo-tibial traction combined with posterior local spondylosyndesis autografts along the fixation system. This variant of surgery was used in 15 patients with the Cobb scoliosis angle between 42° and 85° and mobile scoliosis curvature. Thoracic kyphosis was between 7° and 36° (average angle of kyphosis, 21°), and lumbar lordosis was between 20° and 54° (average lordosis angle, 34°) in these patients. The apical vertebral rotation ranged from 16° to 33° (average rotation angle, 24.5°).

For the second group of patients, the surgery was performed through two incisions during the same procedure. First, a thoraco-phreno-lumbotomy incision was used to perform discectomy, thoracoplasty along the apical part of the curvature, and anterior interbody spondylodesis with the bone autograft. During the second part of the surgery, spinal fusion instrumentation elements were installed under a halo-tibial traction through a posterior incision for the correction of the spinal deformity. The final step was posterior spondylodesis with autografts along the spine. This procedure was performed in 10 patients with the Cobb angle ranging from 85° to 100°, thoracic kyphosis from 43° to 46° (average kyphosis angle, 45°), and lumbar lordosis from 26° to 31° (average lordosis angle, 20°). The range of apical vertebra rotation was from 19° to 33° (average rotation angle, 26°).

The third version of corrective surgery was performed on eight patients with the Cobb scoliosis angle >100°, the angle of thoracic kyphosis between 17° and 69° (average kyphosis angle, 43°), lumbar lordosis angle between 22° and 30° (average lordosis angle, 25°), and rigid thoracolumbar curvature. The first step of surgery was thoracoscopic anterior release combined with interbody fusion and bone autograft at the apex of the thoracolumbar curve. The surgery was performed from an anterolateral approach with the application of a halo-femoral traction. After this, the patient spent 14–16 days in a corrective position and under traction with a gradual increase of load up to 40% of the patient's body weight. The next step was posterior correction of the scoliotic deformation with transpedicular fusion instrumentation combined with local spondylosyndesis autograft. This surgery was performed through a posterior approach and under intraoperative halo-femoral traction. The angle of apical vertebral rotation in this group was between 24° and 50° (average rotation angle, 37°).

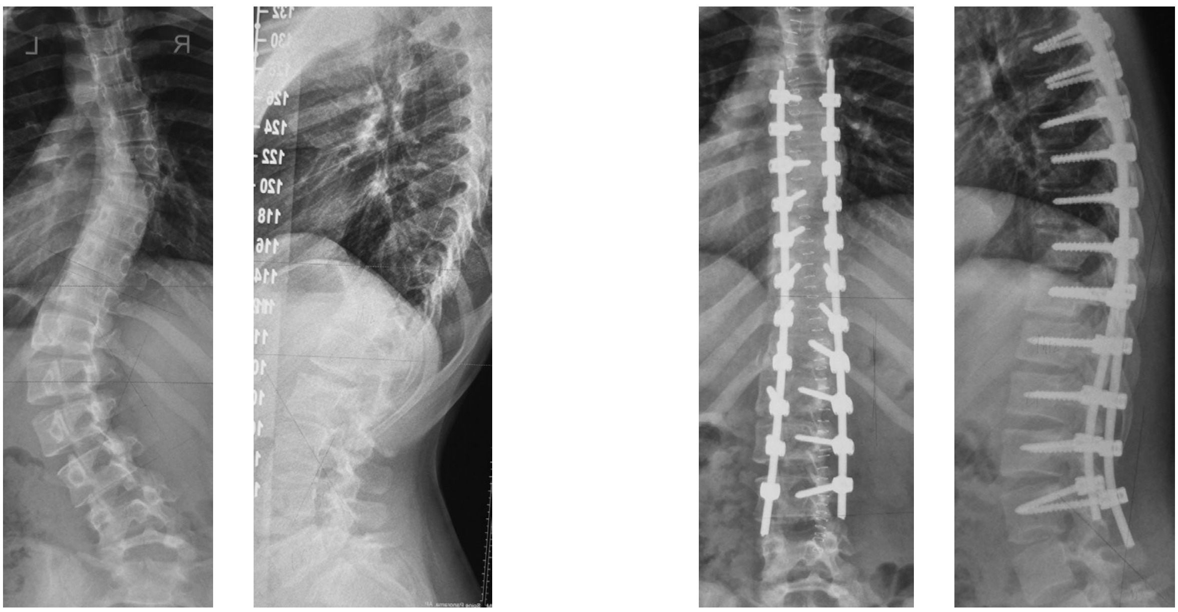
Surgical correction in children with thoracolumbar idiopathic scoliosis using fusion instrumentation elements was performed as follows. The posterior spinal column was approached through a dorsal incision. Then, transpedicular screws were inserted along the convex and concave sides of the deformity under the control of 3D-CT navigation. Halo-tibial traction was applied and the first rod, which was bent according to the physiological curve, was inserted into support elements (posts) of the instrumentation on the convex side of the curvature. The kyphotic deformity was reduced by applying direct pressure on the apex of the curve and translation, and the scoliotic component was reduced by contraction of segments along the rod. Next, the second rod, which was bent according to the physiological sagittal curve of the spine, was inserted in the opposite side of the deformity, and the final segmental correction was made by distraction along the rod. The surgery concluded with bone autograft spondylodesis along the spinal implant.

Postoperative rehabilitation included breathing exercises, massage of the lower and upper limbs, physical therapy, and exercises. Patients were ambulated on 3rd or 4th day after surgery and were discharged from the hospital after 12–14 days for outpatient follow-up observation. All children were examined before surgery; immediately after surgery; after 6, 12, and 18 months; and subsequently once a year.

Results

In all patients, physical examination demonstrated improved or completely restored frontal and sagittal balance of the torso (Figs. 1 A, B). A retrospective analysis demonstrated that the greatest degree of scoliosis curvature correction was observed in patients who underwent version II surgery.

Patients who underwent the version I procedure had a residual scoliotic curvature deformity between 0° and 17° (average value, 7°), and the



A B

Figure 1. Radiographs of the spine of the patient P, a 15-year-old female, shows idiopathic left-sided thoracolumbar scoliosis, IV degree. (A) Before surgery, the Cobb angle of deformation was 61°. (B) After surgery, the Cobb angle of deformation was 2°.

Table 1

The results of surgical correction of the deformity in patients with thoracolumbar idiopathic scoliosis

Version of Surgery	Cobb Scoliosis Angle Before Surgery	Cobb Scoliosis Angle After Surgery	Correction Rate
Version I	from 42° to 85°	from 0° to 17°	86.6%
Version II	from 85° to 100°	from 11° to 13°	87%
Version III	>100°	from 12° to 40°	74%

correction rate was from 74% to 100% (average, 86.6%). The kyphosis angle ranged from 10° to 40° (average kyphosis angle, 21°), and the lordosis angle was between 20° and 53° (average lordosis angle, 35°). Residual apical vertebral rotation angle ranged from 10° to 27° (average, 18.5°). Average apical vertebral derotation rate was 24.4%. These treatment results are explained by the facts that scoliosis did not exceed 85° and scoliotic curvature was mobile and by the transpedicular spinal system. Total transpedicular fixation used for the correction of scoliotic deformation enabled even distribution of the load along support elements of the system and prevented deterioration of the achieved results in the remote period of postoperative follow-up observation.

In patients who underwent version II surgery, the residual scoliotic curvature deformation was between 11° and 13° (average, 12°), and the correction rate was between 86% and 88% (average, 87%). Kyphotic deformation angle was between 32° and 35° (average kyphotic angle 34°) and lordosis between 31° and 32° (average lordosis angle, 32°). Residual rotation angle of the apical vertebra was between 16° and 27° (average rotation angle, 21.5°). Average derotation of the apical vertebra was 17.3%.

The deformity in these patients was corrected by discapophysectomy, resulting in additional mobility of the main scoliotic curvature and by the transpedicular fixation system.

In patients with a very extreme scoliotic deformity of the spine (version III surgery), the residual scoliotic curve was between 12° and 40° (average, 26°), and the correction rate was between 67% and 81% (average correction, 74%). Kyphotic angle was between 21° and 36° (average, 27°), and lordosis angle was between 26° and 35° (average, 29.5°). Residual apical vertebral rotation angle ranged from 16° to 43°; the average rate of derotation was 20% (Table 1).

The sagittal profile of the region of thoracolumbar transition was restored in all patients, from thoracic kyphosis to lumbar lordosis. The span of the instrumental fusion in patients with thoracolumbar idiopathic scoliosis who underwent surgery varied between 10 and 14 vertebrae (average, 11 vertebrae).

To assess the correctness of the positioning of transpedicular support elements, CT of the thoracolumbar spine was performed in all patients. In all cases, the support elements were correctly installed, and there were no signs of vertebral arch fractures or of spinal canal stenosis.

During 2–5 years (average, 3 years 9 months) of follow-up observation, a decline of scoliotic curvature correction was noted in only four patients. The decline was by 2°–4°, which is within the error of the Cobb angle of deformation measurement on X-ray images. No patient had neurological or pyoseptic complications or destabilization of instrumentation after surgical treatment.

Conclusion

The choice of surgery for children with thoracolumbar idiopathic scoliosis depends on the degree of deformation of the main scoliotic curvature, its mobility, and the patient's age. The greater the degree of scoliotic curvature, the greater is the angle of apical vertebra rotation. In children with thoracolumbar idiopathic scoliosis, 3D-CT-assisted correction with instrumentation enables efficient correction of the scoliotic curvature, true derotation of the apical vertebrae during surgery, and lasting results.

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ОПЕРАТИВНОЕ ЛЕЧЕНИЕ ДЕТЕЙ С ГРУДОПОЯСНИЧНЫМ ИДИОПАТИЧЕСКИМ СКОЛИОЗОМ ТРАНСПЕДИКУЛЯРНЫМИ СПИНАЛЬНЫМИ СИСТЕМАМИ

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Цель исследования. Оценка результатов хирургического лечения детей с идиопатическим сколиозом грудопоясничной локализации.

Материалы и методы. Прооперированы 33 пациента в возрасте от 13 до 17 лет с величиной деформации 42–123° по Cobb. Хирургическую коррекцию деформации выполняли тремя тактическими вариантами с применением многоопорной транспедикулярной металлоконструкции.

Результаты. При идиопатическом грудопоясничном сколиозе операционная коррекция варьировала от 74 до 100 %. Потеря коррекции в срок наблюдения от 2 до 5 лет составила 2–4°.

Заключение. Тактика хирургического лечения детей с идиопатическим грудопоясничным сколиозом зависит от величины основной дуги искривления, ее мобильности и возраста пациента. Применение многоопорной транспедикулярной металлоконструкции позволяет значительно исправить угол деформации, выполнить истинную деротацию тел позвонков на вершине искривления, восстановить фронтальный и сагиттальный профиль позвоночника и сохранить достигнутый результат в отдаленном послеоперационном периоде.

Ключевые слова: идиопатический грудопоясничный сколиоз, дети, хирургическое лечение, транспедикулярная фиксация.

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