THE MODERN CONCEPT OF EARLY DIAGNOSIS AND TREATMENT OF IDIOPATHIC SCOLIOSIS*

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The article describes an approach for early diagnosis and treatment of idiopathic scoliosis adopted at the Novosibirsk Research Institute of Traumatology and Orthopedics (NRITO). Idiopathic scoliosis is a genetically determined disease. Screening examinations of children and adolescents are required for early diagnosis of the disease. The most effective conservative treatment is brace therapy. Surgical treatment is strictly differentiated depending on the patient age. Multi-stage treatment by means of VEPTR instrumentation has been used in patients of the first decade of life. One-stage surgery using transpedicular fixation throughout the curve has been performed in patients aged 11–13 years. One- or two-stage surgery, depending on the curve mobility, has been used in patients aged 14–20 years. Deformities of more than 90° require a multistage intervention with anterior and posterior spinal mobilization.
Keywords: idiopathic scoliosis, conservative treatment, surgical treatment, screening.

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The development of surgical vertebrology is inevitably associated with changes in our understanding of the possible, essential, and optimal in surgery of spinal deformities. Previously, we introduced a concept of diagnosis and treatment of idiopathic scoliosis [6]. More than 10 years have passed since that time, and much has changed. Unfortunately, the lack of a unified view of the key issues of surgical vertebrology has remained. And this is the cause for, mildly speaking, exotic techniques of surgical correction for severe progressive spinal deformities. We again assured ourselves of this at the meeting of the VIth Congress of the Association of Surgeons-Vertebrologists that was held in Krasnodar on May 29–30, 2015.

Disease pathogenesis

Idiopathic scoliosis (the term was introduced into practice by an American Algernon Whitman in 1922) still remains idiopathic in the sense that there is no full and clear understanding of the disease origin. However, the results of research in recent years, including that in Russia, suggest a certain sequence of events and processes that can be considered as a logical and reliable sequence. First, nobody has now any doubts that idiopathic scoliosis is a genetically determined pathology. The presence of a major gene was proved by mathematical genetics [1]. However, we do not know what this gene (or more exactly, genes) is, where it is located, and what happened to it. But the next stage is known to be a kind of failure of the nervous and endocrine systems. The result of this failure is the disharmony of longitudinal growth of the spine and spinal cord: the spinal cord begins to grow slower than its bone-ligament sheath that, in turn, leads to vertebral torsion, which is the key point of spinal deformity in idiopathic scoliosis [5]. Paradoxically, this very simplified summary of the results of complex long-term research may be satisfactory for the surgeon-vertebrologist who is actually interested in timely detection and correction of the deformity rather than in understanding its origin.

Early diagnosis

Examination of large population groups to identify a particular disease (screening) not only remains in the arsenal of vertebrologists but also gets to new quantitative and qualitative levels. In a number of countries (USA, Japan, the Netherlands, China, India, Greece, Australia, Singapore, Malaysia), screening examinations of school students for early detection of diseases are held on a statutory basis across the nation [15, 16]. Russia has not yet reached this level, but implementation of the computed optical topography (COMOT) system [9], which is available and extensively used in 78 cities, enables increasing the number of examined subjects. For example, specialists of the NRITO examine 45,000–47,000 children in the Novosibirsk region annually. And this method keeps improving.

Conservative treatment

Brace treatment is a conventional method of conservative therapy worldwide. Russia, which goes its own way, has a

network of special boarding schools where all possible methods of conservative treatment, including brace treatment, are used. The purpose of this article is not to discuss the efficacy of various brace types. They are embraced by the fact that some part of brace-treated patients is yet subjected to surgical treatment due to the deformity progression. In the 1960s, orthopedists had certain enthusiasm that turned to negativism in the 1980s. The situation ranged to categorical statements that brace treatment is not relevant [12]. As Winter noted [18], "the pendulum has swung too far". In the 1990s, the situation changed after a study by Lonstein and Karlson [15]. On the basis of large material, these authors demonstrated how scolioses progress (depending on the age, curve value, and Risser test), thereby providing the opportunity to compare the results of brace treatment with the natural course of the disease. This comparative study clearly demonstrated that brace treatment changes the disease course and outcomes, with the latter becoming better. We have used the Cheneau brace in our practice and are generally satisfied with the obtained results.

Surgical treatment

Almost 20-year experience with use of various types of modern vertebral instrumentation allowed us to develop a certain surgical strategy and a differentiated approach to the choice of surgery with allowance for the patient's age and numerous characteristics of a deformed spine.

Scolioses in the 1st decade of life. At present, deformities diagnosed in the first 10 years of life are defined as early deformities. This group automatically includes both infantile and juvenile scolioses. The main problem the surgeon faces in this situation is to choose a technique that enables correction of the spinal deformity in the space, supporting the correction in time and minimizing surgical manipulations on the spine to avoid the early formation of both artificial and spontaneous bone blocks. There are a number of techniques to resolve the problem with a certain efficacy. These include growing rods, Shilla, magnetically controlled rods, and VEPTR instrumentation [10, 11, 14]. Comparative characterization of these techniques is beyond the scope of this article. Over the years, we used the technique of growing rods, in particular elements of CD instrumentation. Numerous difficulties and, first of all, the formation of bone blocks of the vertebrae as well as the need in some cases to begin treatment as early as the second year of life prompted us to turn to VEPTR instrumentation that preserves the spine intact during the entire multi-stage treatment. Like other techniques, VEPTR has its disadvantages, but the accumulated experience (80 patients with deformities of various etiology, 10 of whom already completed the treatment) suggests that the emerging problems can be resolved, and an outcome satisfactory to all participants of the process is achievable.

Transitional group. As our experience gained, we gradually came to the conclusion that a special subgroup (arbitrarily defined as a transitional group between juvenile scoliosis and adolescent scoliosis) should be allocated within the adolescent scoliosis group (10 to 20 years). These are patients who are already overage for juvenile scolioses (4 to 10 years) but cannot be referred yet to the adolescent scoliosis group (14 to 20 years). Usually, these are children aged 11–13 years with a Risser sign of 2–3; in girls, there is amenorrhea and lack of secondary sex characters, but the potency of growth is largely exhausted, which can be confirmed by the Winter's shortening formula [17]:

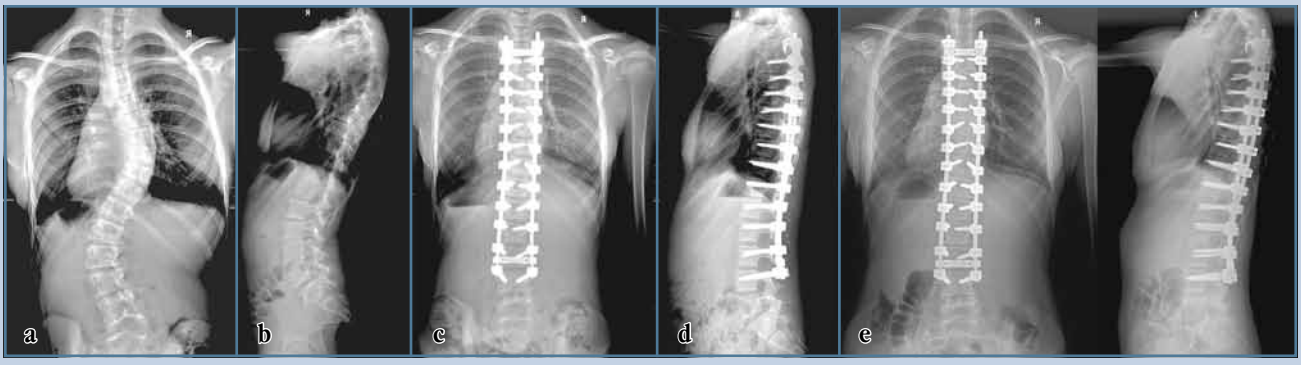

Fig. 1
Radiographic images of an 11-year-old female patient I. with idiopathic uncomplicated progressive compensated grade IV scoliosis (50°), with equivalent right-sided and left-sided lumbar curves and a posterior right-sided costal hump; the spinal deformity was corrected using NITEK instrumentation: **a** – preoperative values of the thoracic and lumbar scoliotic curves were 50° each; **b** – preoperative thoracic kyphosis and lumbar lordosis were 48° and 63°, respectively; **c** – a postoperative value of the thoracic scoliotic curve was 0°; **d** – postoperative thoracic kyphosis and lumbar lordosis were 20° and 45°, respectively; **e** – no changes were observed 2 years after the operation

N = 0.7 mm x (number of fused segments) x (number of years of remaining growth),

where N is the height lost in comparison to the result of normal growth (in cm); 0.7 mm is the height growth of one vertebral segment per year.

In these patients, we have carried out a two-stage intervention for many years:

1) discectomy and interbody fusion using an auto-bone graft throughout the major curve of the deformity;

2) correction of the deformity using segmental instrumentation in the classic arrangement and posterior fusion using an auto-bone graft.

The anterior stage in these patients played a double role. The primary task was to form a bone block in order to prevent the development of a crankshaft phenomenon. The second task (less significant) was additional mobilization of the spine before the corrective stage.

This surgery greatly corrected the deformity and also prevented the development of the crankshaft phenomenon [13].

However, the need for thoracotomy in each case, which is an additional large intervention worsening the patient's condition and associated with complications, prompted us to change the surgical approach in this group of patients. We have used pedicle screws throughout the scoliotic curve and structural anticurvature. We believe that scoliosis in children of this age subgroups is one of the indications for the so-called total instrumentation using transpedicular fixation. We hope that screws, which are adequately matched in length and penetrate into the vertebral body to a sufficient depth, serve as a reliable barrier to the development of the crankshaft phenomenon, i.e. to progression of vertebral torsion in the postoperative period (Fig. 1).

Adolescent scolioses. This group is the most numerous one. The purpose of surgical treatment of idiopathic scoliosis in patients aged 14–20 years is achieving reasonable correction of the deformity in three planes, stopping progression, normalizing the appearance, and balancing the body in the frontal and sagittal planes.

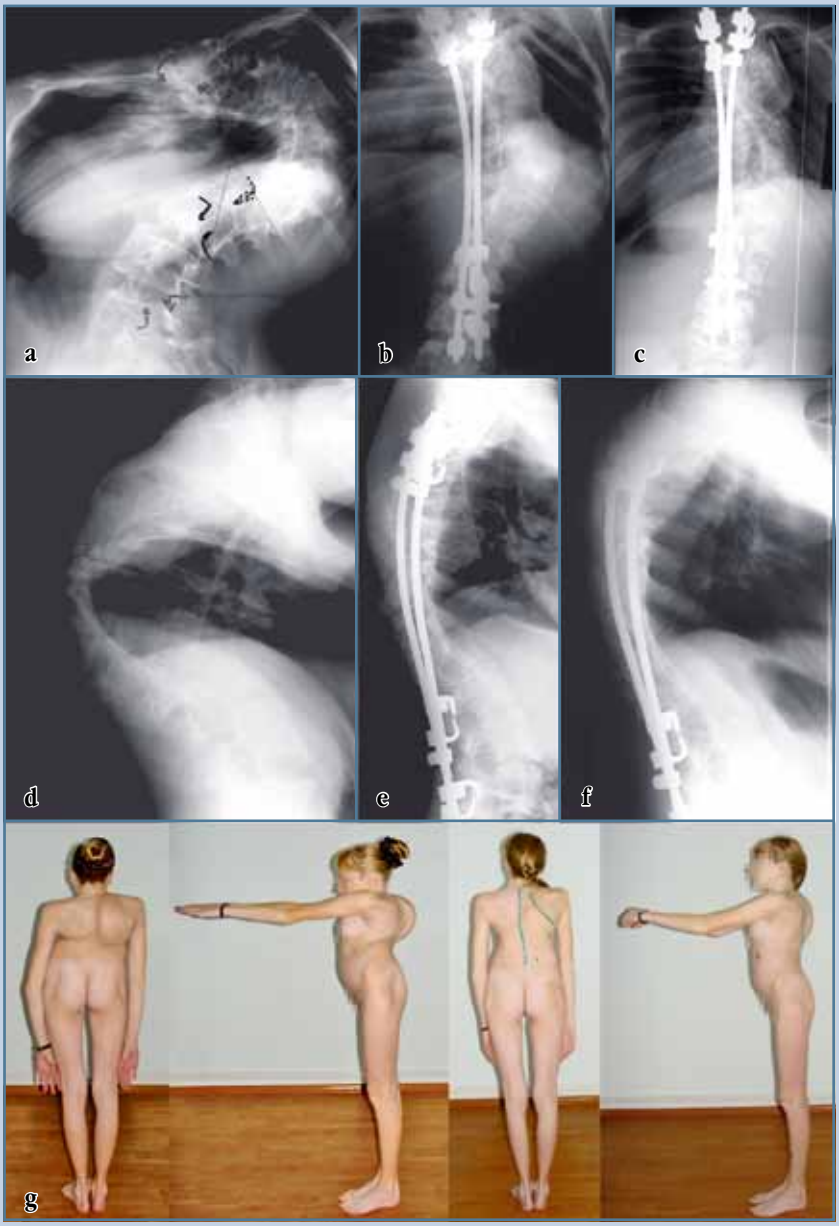

Fig. 2
Radiographic images and appearance of a 14-year-old female patient A. with idiopathic right-sided thoracic scoliosis: **a** – scoliosis before surgery: 148° in the upright position; **b** – scoliosis after correction: 64° in the upright position, the frontal body balance was restored; **c** – scoliosis 5 years after the surgery: 64° in the upright position, artificial anterior and posterior bone blocks were formed; **d** – kyphosis before surgery: 155° in the upright position; **e** – kyphosis after correction: 69° in the upright position, the sagittal body balance was restored; **f** – kyphosis 5 years after the operation: 69° in the upright position, artificial anterior and posterior bone blocks were formed; **g** – the appearance of the patient before and after surgical treatment

The scope of surgery is determined by the degree of stiffness of the deformed spine. The stiffness is traditionally evaluated on the bases of radiographic images with the patient in the lateral tilt position towards the convexity of the deformity. To date, there is no consensus on the boundary between rigid and mobile deformities. We assign a deformity to the mobile deformity group if the deformity in the lateral tilt position is reduced by at least 30%. We stick to this rule at least for standardization of the treatment protocol.

In the case of rigid deformities, we perform discectomy on the curve apex and interbody fusion (using only an autobone as plastic material in both the anterior and posterior approaches) as the first step. In the case of mobile deformities, we limit surgery to a posterior intervention.

During corrective surgery, we prefer to use hybrid instrumentation: a combination of pedicle screws and hooks, with the screws being used in the lumbar and thoracolumbar spine and the hooks being used in the thoracic spine only. We do not share the opinion of those colleagues who stick to using pedicle screws as the only fixation elements, regardless of the type and localization of the deformity. The use of hybrid constructs decreases the time of surgery and blood loss, reduces the risk of complications (primarily neurological), and, most importantly, provides the same amount of correction as in the case of endocorrectors only with pedicular fixation [4]. This does not mean that we totally reject this approach. We consider total instrumentation with pedicle screws to be reasonable in scoliosis patients aged 11–13 years (see above), lumbar and thoracolumbar deformities, Scheuermann's disease, and paralytic scoliosis. However, in all these cases, we use hooks as a proximal clamp to reduce the risk of proximal junctional kyphosis.

The use of anterior correcting systems can be very effective but is associated with extended approaches (thoraco-phreno-lumbotomy), damage to the truncus sympaticus, and the lack of advantages over posterior pedicle systems regarding the extent of correction.

Advanced deformities. Spinal deformities of over 90° have been less common in the last few years. This is undoubtedly the result of collective efforts of leading domestic vertebrology centers. For example, the mean value of the scoliotic curve in patients hospitalized for surgery to our clinic has declined from 80 to 70° for the past five years.

Treatment of advanced deformities is performed based on the following basic principles: the spine should be maximally mobilized, i.e. anteriorly and posteriorly: discectomy, multilevel Ponte osteotomy, intraoperative traction, mandatory monitoring of the spinal cord function, and correction of the deformity using hybrid instrumentation (Fig. 2) [2, 7, 8].

In the most rigid spinal deformities (e.g., severe kyphoscolioses with a nearly horizontal upper knee of the curve), we use halo-pelvic traction as preoperative preparation and fix the achieved effect using an external correction construct.

Our attitude to intraoperative monitoring of the spinal cord function is as follows. In deformities of up to 90°, we use a neurological examination and do not use monitoring in the absence of symptoms (i.e. with rare exceptions). In severe deformities, we perform, in addition to a routine neurological examination, a traction test with the full weight of the patient [3]. The emergence of neurological symptoms during the test determines the use of intraoperative traction (which is refused) and necessitates monitoring of the spinal cord function. We use a wake-up test, sensory and motor evoked potentials, and cutaneous thermometry [8].

Postoperative management. An axillary drainage tube placed during wound closure is removed after two days, and then we start activation of the patient. After starting walking, almost 100% of our patients have the feeling of a developed spinal deformity: "I got distorted". This is an absolutely normal reaction of an individual who lived with a deformed spine for several years but did not feel it physically. In this situation, a large mirror is very helpful, to which patients, after getting to their feet, come first (90% of our patients are girl children and young girls). With the help of a treating doctor and a biological feedback, patients quickly learn to correct the position of the shoulder girdles and pelvis and adjust to their new body. This mainly constitutes postoperative rehabilitation.

Conclusion

All of the above is a demonstration of the changes that have occurred in surgical vertebrology as exemplified by the idiopathic scoliosis issue. Views of components of the therapeutic strategy have changed to a certain extent at all points for 10–12 years. We have gained a better understanding of scoliosis and improved care to patients but still remained far from the main thing – pathogenetic treatment of idiopathic scoliosis.

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