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STUDY ON CHILD AND ADOLESCENT IDIOPATHIC SCOLIOSIS

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ABSTRACT. The paper analyzes a sample of 403 patients diagnosed with scoliosis and hospitalized in the orthopedics department Emergency Hospital for Children "Grigore Alexandrescu" in the period 1999-2009. The present study was performed using retro-and prospective analysis based on observation sheets during hospitalization. Diagnosis in an early stage is crucial in determining therapeutic behavior and further development of patient. It represents a problem not having a specific network to detect scoliosis, in Romania there are a large number of children and adolescents with these severe illness. Poor posture is not the cause of Scoliosis, the primordial causes are genetics and hormonal. Therefore early detection is necessary when the extent of scoliosis curvature is small and there are no significant changes in spine and rib cage with repercussions on cardio-respiratory function. Screening should be done in school network by standardization of knowledge in the medical school and by the family physicians to refer children to specialists, thus benefiting from appropriate treatment.

Keywords: scoliosis, adolescent, child, spinal cord

INTRODUCTION

Evaluation of scoliosis over time

Studies of growth are performed taking into consideration the following:

- The growth curve, the total waist measurement and waist and torso;
- The stage of sexual maturation assessed by Tanner's international classification, evaluating secondary sexual characters, and for the girls the date when the first menstruation appeared;
- Peripheral bone maturation stage by determining the bone age and axial bone maturing, the Risser test.

These items are recorded at each consultation and entered into a chart.

Puberty starts at 11 years bone age in girls and 13 years bone age for boys. Onset of puberty is pubic hair growth which is associated with breast development in girls and volume growth of the testicle in boys. During this period growth is not constant and consists of two phases: first a strong increase which lasts 2 years, from 11 to 13 years in girls and from 13 to 15 years in boys, the second with a lower growth. In early puberty growth rate is different at the level of the segments: 2/3 for the trunk and 1/3 for the limbs. From 13 years of age for girls and 15 years of age for boys growth is carried out only at the level of the torso, at the level of the iliac crest the first signs of ossification appear (Risser 1).

The anatomic-pathological studies, clinical and radiological examination form the basis of the three-dimensional analysis. Roaf has demonstrated that on a scoliotic column the length of the interspinous ligament is much smaller than the previous vertebral ligament; they are virtually equal to the normal people. This means that the vertebrae are in a position of extension one to another. Perdiole, has carried out several X-rays in many incidences, from the profile he has found out that the vertebrae are in extension of one another, at front or in axial plan the vertebrae are differently disposed at the extremities of the curve. At the level of the upper neutral vertebra and the two vertebrae adjacent to the vertebrae, they are parallel to each other but there is an intervertebral rotation. Under this area and the apical region there is a deformity

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- tilt associated with a disc asymmetry and with cuneiform vertebrae at the level of the top vertebra. Graf has shown that most of the scoliosis has a form of lordo-scoliosis. All these studies have explained the different clinical forms from one patient to another based on specific intervertebral movement from one region to another with a variable magnitude of the scoliotic curvature. At the ends of the curvature there are two particular areas where the intervertebral rotation. The center of curvature is part of the torsion. When this torsion is important the extension is clinically and radiologically visible under the form of a lordosis.

When the torsion is of 90 degrees, the top vertebra is present in the profile on the X-ray radiography and in front on the profile X-ray. The convexity of the curvature is faced towards the rear giving the appearance of a kyphosis both clinically and radiologically.

CLASSIFICATION

Scoliosis can be divided into:

1. Non-structural or functional scoliosis or scoliotic attitude is transient and can be corrected in the supine position. It is symmetrical without changes of the vertebrae and discs. It is a simple lateral deviation of the spine, without rotation of the vertebrae. Functional scoliosis does not develop until an irreducible deviation, except for the asymmetric paralysis of the torso muscle of poliomyelitis type. The causes of non-structural scoliosis may be: unequal legs, contracture of the trunk muscles (in spinal injuries, fractures), asymmetry of the lumbar-sacral joint, retraction of the sternocleido-mastoid muscle in torticollis, unilateral atrophy of upper limbs, upper limb amputation, schoolchildren that adopts a bad attitude, the scoliotic attitude of young girls.

2. Structural scoliosis is characterized by persistence of curves, of the rotation of the vertebrae and vertebral and rib deflections prior to flexion of the spine in supine or suspension. These are classified in:

- Idiopathic scoliosis: infantile, juvenile and of the adolescent;
- Congenital scoliosis: bone-hemivertebrae cuneiform vertebrae, vertebral block, bifida spur, sacralisation L5, neurological-syringomyelia and dyastomyelia;
- Osteogenic scoliosis;
- Neurogenic scoliosis:
  - of central etiology: cerebral motor infirmity, Freidreich disease, spinal tumors, obtained syringomyelia;
  - of peripheral etiology: peripheral neuropathies, Charcot-Marie disease, poliomyelitis, infantile spinal amyotrophy, neurologic arthrogryposis;
- Myopathic scoliosis: muscular dystrophy (dystrophy), muscle arthrogryposis, muscular hypotonia;
- Dismetabolic Scoliosis: rickets, imperfect osteogenesis;
- Scoliosis out of infectious cause: spondylitis, Pott disease;
- Toracogene Scoliosis;
- Scoliosis encountered in system diseases: Marfan's disease, neurofibromatosis type 1;
- Rare cases scoliosis: osteoid osteoma, concave foot;
- Scoliosis of brain tumors.

Anatomic and radiological classification described by Ponseti and Friedman based on topographic location of spinal curvature. The major structural curve is the least reducible curve which has the highest angular value and the rotation which is the most obvious. The minor structural curve is the curvature with the smallest rotation angle and the most reducible one. The compensation curves allow the spine to find the above and below structural alignment.

Scoliosis that have a major curvature:

- Thoracic scoliosis is included between T4-5-6 and T11, T12. Thoracic scoliosis has a convexity to the right and a minor lumbar compensation curvature. The thoracic deviation leads to an important gibbosity with respiratory disorders when the curvature is very severe.
- Thoraco-lumbar scoliosis is included between T9 and L2/L3 with its point in the dorsal-lumbar junction. It has a convexity to the right with two compensation semi-

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curvatures. It leads to an obvious gibbosity with morphological and weight imbalance.
- Lumbar scoliosis is included between T12 and L4, L5, has the convexity to the left and is accompanied by a dorsal compensation curvature. It appears in adolescence and it rarely exceeds 60 degrees, with an oblique orientation of the pelvis and is inclined to the convex part.
- Cervico-dorsal scoliosis or high dorsal scoliosis – T1 and T7. It has a convexity to the left, the compensation dorsal curvature or the right dorsal-lumbar curvature rapidly becomes structural. This causes a serious aesthetical deformity due to the imbalance of the shoulders.

Double major scoliosis
- Double thoracic and lumbar scoliosis, has a right dorsal convexity and a left lumbar one. The borderline vertebrae of the dorsal curvature are T5-T6 and T11-T12; those of the lumbar curvature are T11-T12 and L4-L5. Between the two of them there is a vertebra with neutral rotation named intermediary or transitory vertebra. Double toracal and lumbar scoliosis has a right dorsal convexity and a left lumbar convexity. These are the most common ones and they have a small aesthetic prejudice.
- Double thoracic scoliosis has a superior dorsal curvature with the convexity on the left, with its point at T3-T4 and the limit vertebrae at T1-T2 up and T5-T6 down. The inferior dorsal curvature has a convexity on the right and stretches from T5-T6 to T12-L1.These two curvatures are structural, accompanied by a compensation left lumbar curvature that stays reducible for a long time.
- Double thoracic and toracal-lumbar scoliosis. The thoracic component is a short, structural curvature, with the convexity on the right. The borderline superior vertebrae are T1-T2 and the inferior ones are T8-T9, with the point at T5-T6, the dorsal-lumbar curvature has a left convexity. It stretches from T8-T9 to L2-L3. The inferior curvature is more mobile than the superior dorsal curvature.

Classification depending on the age of appearance

The infant's scoliosis at birth or acquired during the seating position present partial irreducible scoliotic curvatures. We can distinguish two types of curvatures:

- long-range curvature, rotation moderate structural non-reducible. It is quick regressive. It is probably due to an inadequate or a delay of intrauterine placement of acquiring postural balance;
- short and rigid curvature, dorsal left, with a rotation marked by a more stable and irreducible gibbosity. The prognosis is very severe

Infant scoliosis has a variable progression, often rapid and significant. They can be:

- large regular curvature, partially reducible with a moderate rotation;
- short curvature, quasi-irreducible with prominent gibbosity.

Juvenile scoliosis appears between 4 years and early puberty. These are classified into three subgroups:

- juvenile 1: from 4 to 7 years;
- juvenile 2: from 8 to 10 years;
- juvenile 3: from 11 until the appearance of menstruation.

Adolescent Scoliosis occurs between puberty and bone maturation. Usually they are lumbar and less progressive.

MATERIAL AND METHOD

Imaging Studies

Three examinations are needed:
- standard examination;
- control examination;
- Pre-therapeutic evaluation necessary to elaborate the orthotic and surgical treatment.

The front X-ray with the balanced pelvis is made on a 30/90 cm box, which allows us to visualize the entire spine from skull base to the sacrum. The quality criteria are:
- the pelvis must be horizontal
- symmetrical iliac crests
- coccyx which is projected on the pubic symphysis

The Scoliotic attitude is radiologically defined by a lateral deflection of the spine

without gibbosity or vertebral rotation. The lateral deviation disappears in lying position.

The front X-ray allows us to:

- confirm the clinical diagnosis of scoliosis;
- measure the level of the curvature of the scoliosis;
- study the aspect of the vertebrae;
- study the aspect of the inter-vertebral discs from the concave and the convex side of the curvatures of the spine.
- examine the pelvic bones in order to determine the bone age and the aspect of the growth cartilage.

The study of the reducibility is made using a front X-ray in traction on a correction framework. The front X-ray with lateral bending or the anterior-posterior forward bending study the reducibility of the main curvature through comparative measurements of the angle and rotation. On the lateral bending X-ray the angle allows us to appreciate the orientation of L4 and L5 proportional to the bi-iliac line. A curvature is reducible when its angle decreases with more than 50% of its initial value.

The forward bending X-ray may allow us to visualize the bony pelvis, the proximal femoral extremity and to study the static of the spine. On this incidence we can see the mastoid and the external ear meatus, and the femoral ends overlapping one another in the middle. The profile X-ray is made on the side of the concavity of the scoliosis, and the superior limbs are horizontal.

The quality criteria are:

- good visibility of the vertebral bodies;
- good visibility of the pedicles;
- of the transverse apophysis;
- of the posterior joints;

The balance of the spine can be appreciated by a line that crosses through the body of the T6 vertebra, L3 and the middle of the sacrum. Thoracic kyphosis corresponds to the angle formed at the intersection of the tangents of the superior disc of the first thoracic visible vertebra T4 and that of the inferior disc T12.

Lumbar lordosis corresponds to the angle formed by the tangents of the superior disc of the first lumbar vertebra L1 and that of the inferior disc of the vertebra L5. Neutral vertebrae do not show rotation. There is a curvature between the two limit vertebrae and they determine the convexity.

Methods of measuring the degree of rotation in scoliosis

Nash and Moe Method

The vertebrae are divided into six equal parts, using as a benchmark pedicles and the vertebral body.

- Level 0: symmetric convex and equidistant pedicle;
- Level 1: the convex pedicle migrates into the first segment;
- Level 2: the convex pedicle migrates into the second segment;
- Level 3: the convex pedicle migrates into the middle segment;
- Level 4: the convex pedicle crosses the median line on the side of the concavity.

The Perdriolle method uses a transparent "torsionmeter" that overlaps the X-ray. The first guide mark is the big axle of the convex pedicle; the second guide mark is the median point of the vertebral body. The level of rotation is measured with the tension-meter. This method has an accuracy of measurement of rotation less than 30 degrees.

Methods of measuring the degree of curvature in scoliosis

The Cobb method: the tangents to the superior disc of the upper limit vertebra and on the inferior disc limit vertebra are marked, their convergent form an angle in the concavity. The limit vertebra is the one that has the greatest inclination to the horizontal.

When we can't see the discs well we can use as guide marks the vertebral pedicles. Measuring the degree of the vertebral rotation can be determined by the Perdiolle torsion-meter, which is graduated from five to five units allowing an assessment of the rotation of the top vertebra or of the intermediary vertebrae.

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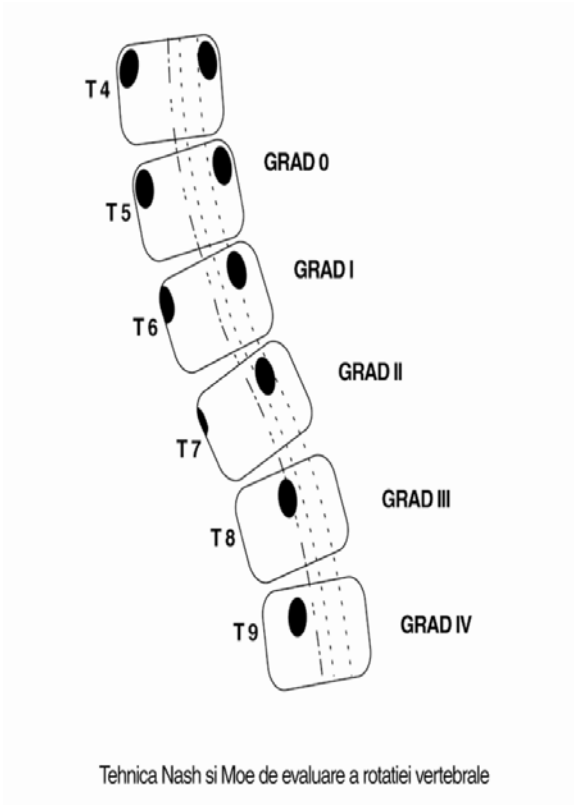

Fig. 1 Nash and Moe technique of assessing the vertebral rotation

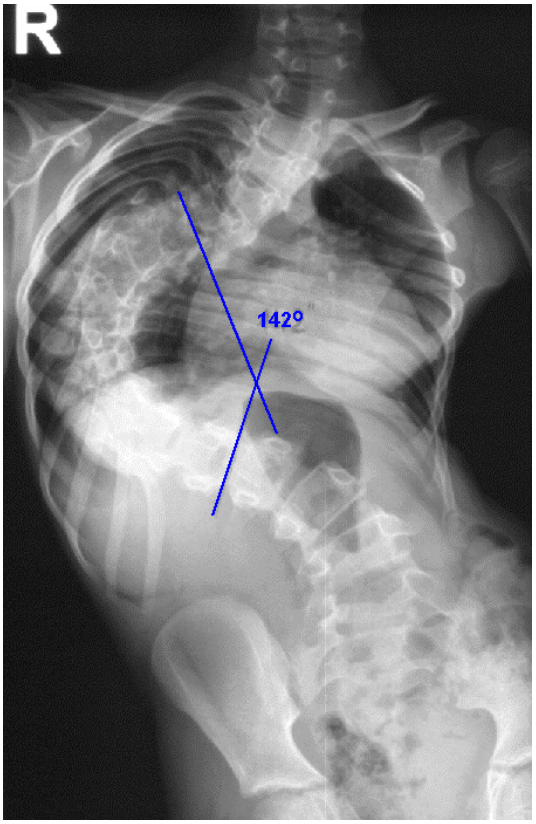

Fig. 2 The Cobb method of measuring the level of the curvature in scoliosis

The Reiser-Ferguson method is rarely used. Here the guide mark is the center of the limit vertebrae and the vertebra at the top limit of scoliosis. The angle measured by the method is less than that measured by the Cobb method. Vertebra at the top of scoliosis has the biggest rotation.

Besides the main curvature, the one with maximum amplitude, there is a compensatory secondary curvature, and sometimes two. It is important to determine the degree of reducibility of curvature by performing an X-ray with lateral bending on which the compensatory curvature disappears or reduces its level of curvature.

The lateral X-ray is made holding the hands on the occiput and the elbows projected anterior. On this incidence the level of lordosis or associated kyphosis is assessed or the existence of a spondylolisthesis.

In level 4 scoliosis the ribs overlap one over another on the concave side and on the convex side they are fan-shaped.

On the front X-ray, the sagittal curvatures are measured using the Cobb method (dorsal kyphosis and lumbar lordosis). In order to assess the reducibility and the probable correction of the scoliotic curvatures, complementary X-rays are going to be performed in maximal lateral flexion (Bending test) or in suspension, the limit vertebrae will remain unchanged during measuring.

The front X-ray in clinostatism is useful for assessing all minor scoliotic deformities. It allows us to distinguish between scoliotic attitudes, which disappear completely in discharge and Structural Scoliosis, which persists in lying position.

The balance of the spine is appreciated within the AP incidence by a line beginning from the odontoid and passes into the middle

of the sacrum. If this line is traversed, the curvature is unbalanced to the right or left, if not displaced the curvature is balanced.

On the LL X-ray the balance of the spine is measured by lowering a vertical line of the external ear canal to intersect the center of the femoral head. If this line passes in front or behind the femoral head center, the curvature is unbalance. This is important in the rehabilitation program.

MRI investigations

MRI is performed in order to detect neurological abnormalities. It allows the diagnosis of dyastematomyelia, syringomyelia, Arnold-Chiari malformation, expansive intra-spinal processes.

It is used at those who have developed an atypical scoliosis out of the idiopathic one. These patients have soared throat and headaches, and the neurological examination shows ataxia, weakness and deformity of the leg and have a rapid evolution of the curvature. MRI is not performed on teenagers with a normal neurological examination.

MRI relies on the fact that some anatomical nuclei resonate and emit radio signals. The images are superior to the flat X-rays, CT due to the clearly demarcated contrast between the structures of the soft tissue and bone. MRI does not allow the minute image of bone structures and they appear as an amorphous black body, and does not allow to visualize some pronounced changes in shape.

MRI Indications/instructions:

- Vertebral abnormalities of the spinal marrow;
- Idiopathic scoliosis with neurological disorders;
- Traumatisms of the spine;
- Scoliosis associated with herniated disk;
- Neoplastic and inflammatory scoliosis.

If the main deformity is kyphosis, there will be sagittal sections performed, if the rotation is more important, the informative plan will be the frontal one. Depending on the abnormalities that are found, an axial section will be made.

Instructions:

- neurological scoliosis: painful, intra-spinal or para-vertebral tumour suspicion, neurological signs, uni-bilateral annulment of the abdominal cutaneous reflexes;
- malformation scoliosis;
- the existence of three curvatures , the left or right lumbar thoracic curvature, the cervical curvature.

Cassar-Pullicino does not recommend performing MRI on teenagers with idiopathic scoliosis and normal neurological examination; all others have a pre-operational MRI examination. Performing a MRI examination has led to a decrease of the cases of the so-called idiopathic scoliosis, when Chiari 1 malformations were emphasized.

EOS system

The EOS system is a classical tube of X-rays and a gas detector that works with xenon. The interaction of the photons with the xenon after they cross the patient's body leads to the appearance of a cloud of electrons that amplifies , this allows that from a bit of information to obtain a very important signal, reducing this way the amount of irradiation that is being used. The images are obtained through scanning. The obtained data, under numerical form, are then analysed and allow the 2D and 3D reconstruction.

Advantages:

- the amount of irradiation is considerably diminished, approximately 80-90% proportional to the conventional X-ray. For a front X-ray the decrease is of 91%, 88.5% for the profile X-ray and 86% for that at the level of the pelvis;
- a better quality of the images, especially at the cervical-thoracic level;
- the patient is orthostatic and the images are taken simultaneous from the front and profile, hear to feet;
- ENSAM has elaborated an informational 3D reconstruction with an excellent accuracy. Using this technique allows us to diminish the amount of irradiation for 100-600 times;

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- it allows a minute analysis of the obtained images, both of the soft tissues and of the skeleton.

Scoliosis is not only a vertebral malformation, so a 3D reconstruction obtained in this way, increases the therapeutic efficacy, helps us when setting the corset, emphasizes the thoracic deformities that are necessary for a pre-operational survey.

The 3D reconstruction through scanning allows us to visualize in 3 dimensions, this is close to the real one and needs 3 types of proceedings:

- Spine system 91TM
- Stereo X-ray 3D;
- Integrated shape imaging System, (optic scanning ISIS – Integrated Shape Imagining System), Orten optical system.

RESULTS AND DISCUSSIONS

A study made on 46 cases regarding the three-dimensional quantitative analysis shows the following aspects. This group includes 33 girls and 13 boys who have severe idiopathic scoliosis with Cobb angle between 36-82 degrees; 36 thoracic, 8 double and 2 lumbar, aged between 10 and 18 years for 41 patients, the average age is of 14 years. For each patient a front and sagittal X-ray in orthostatism was performed.

The 3D reconstruction from T1 to L5 is made using a semi-automatic identification method, in collaboration with LBM-ENSAM and LIO-Montreal. The following parameters were measured.

1. The axial rotation of the apical vertebra;
2. The axial inter-vertebral rotation in the inferior and superior junction area;
3. The torsion index which has an average value between the accumulated vertebral rotations;
4. DRSI index the difference of inter-vertebral sagittal rotation proportional to about 30 normal subjects. The Cobb angle is accompanied by a level of torsion of more than 10 degrees.

There is an inter-vertebral axial rotation in the junctional area; the overlying vertebra is rotated proportional to the underlying one with an angle between 5-10 degrees. The axial vertebral rotation is maximum in the apical area. The DSRI index is negative in the main curvature, which indicates a reduction of the local thoracic kyphosis. This index is positive in the overlying curvature showing an increase of the local high thoracic kyphosis. This index is changing in the lumbar area. The Cobb angle measured in a thoracic scoliosis is reliable, and the lumbar one requires a bias of estimation.

The applied therapeutic protocol

In the case of the group that was analysed, the treatment chart was established for each patient individually, depending on the stage of the disease and the age of the patient. For assessing the treatment, the following elements were put down in the individual questionnaire:

- The age when the disease appeared;
- The level of evolution of the curvature after the imagistic examinations;
- The level of reducibility of the curvature;
- Alterations of the respiratory functions;
- The age of the patient when he submitted to the doctor.

For the group that was studied, the data obtained from the questionnaires were statistically processed and the results were expressed as indicators of central tendency.

For each subject included in the study a standard data recording sheet was completed during hospitalization. These sheets were then centralized in a database and processed for statistical analysis. The statistical analysis was performed using the SPSS programme (Statistical Software Package Systems, Cary, NJ). The information that was inserted was either qualitative or quantitative. The quantitative ones were numerical data recorded with two decimals. The qualitative ones were dichotomic (for example yes or no, masculine (M) or feminine (F), or they had many ways of being answered.

The statistical analysis included a descriptive and an analytical part. In the descriptive part the quantitative and qualitative variables were presented.

For the quantitative ones, the features that individualize the distribution were presented. A normality test of distribution has been run (Kolgomorov-Smirnov). In the case of normal distribution, the average values and the standard deviation have been presented, calculating the confidence interval with a probability of 95%. If the distribution wasn't normal, the median and the percentiles 25 and 75 were presented, and other variable that characterized it: module, skewness, curtosis.

For the qualitative variables the absolute values and the percentages were presented. The graphic representation was made under the form of pie-like graphs or of similar graphs that would graphically present the proportions.

In the analytical part some correlation and comparison tests were made. In all the cases, the statements that had an error probability less than 5% were considered to be true ($p<0.05$).

The correlation tests were made between the quantitative variables, watching the correlation value „r" Pearson – in the case of normal distribution or Spearman in the case when this factor was not taken into account.

CONCLUSIONS

The therapeutic algorithm for idiopathic scoliosis in children and teenagers:

a) The family and school doctor has to observe:

- The asymmetry of the shoulders;
- The disparity of scapula's prominence;
- The large space between the superior limb and body from the concave part of the curvature;
- Gibbosity;

b) The specialist doctor, on the basis of an X-ray of the spine (front and profile) establishes the following:

- If the curvature is below 30 degrees he will monitor the patient for 6 months in order to establish if the scoliosis is progressive or not and recommends physiotherapy;
- If the curvature is of 30-50 degrees, physical therapy and corset is recommended. Also, there is recommended the examination once every 6 months during pre-puberty and in 4 months during puberty with profile X-ray with or without corset.
- If the curvature is of 30-50 degrees physical therapy and corset is recommended. Also, there is recommended the examination once a month, then once in 3 months for adjusting the corset. Physical therapy is performed by a specialist. If the curvature maintains the same values, treatment will be continued for 3 years after the appearance of menstruation for girls and 17 years of age for the boys. Premature interruption of wearing the corset leads to the aggravating of scoliosis. The corset is worn 18-20 hours/day.
- If the curvature is more than 50 degrees, physical therapy is recommended and corset until bone maturity. In infantile scoliosis physical therapy is important in straightening the curvature and maintaining it at a lower angle during the entire period of growth of the trunk, until it can be operated. The orthopaedic treatment is considered to be efficient when at the end of the bone growth the curvature is of ± 5% from the initial value of the angle. Surgical treatment (segmentary spinal synthesis) can be performed at the minimum age of 11-12 years for girls and 14-15 years for boys, Risser score over 1, and minimum 1 year after the menstruation. Physical therapy shall be employed after the surgery.

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