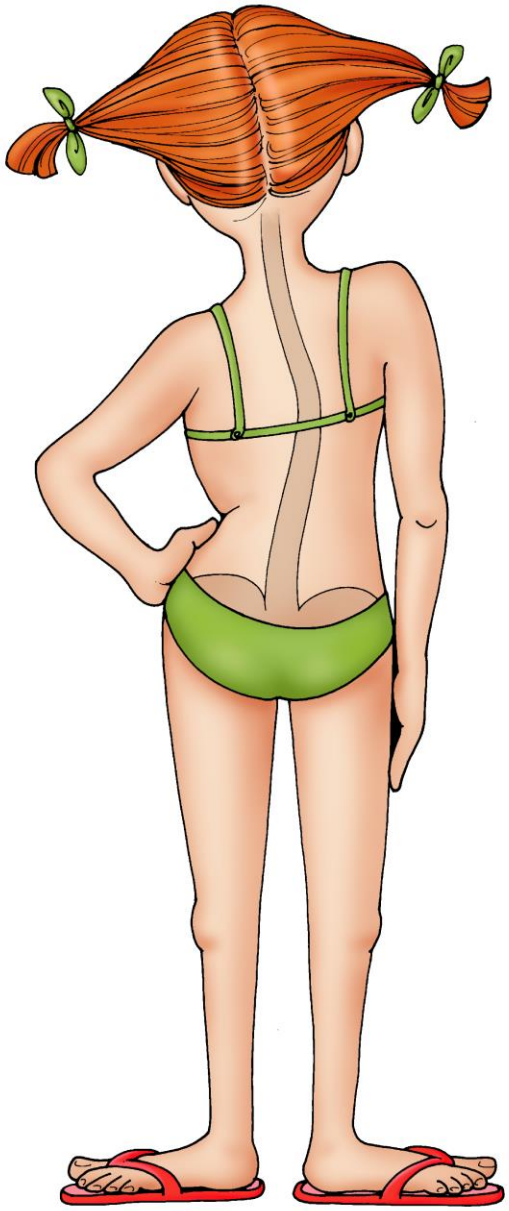
# Adolescent Idiopathic Scoliosis

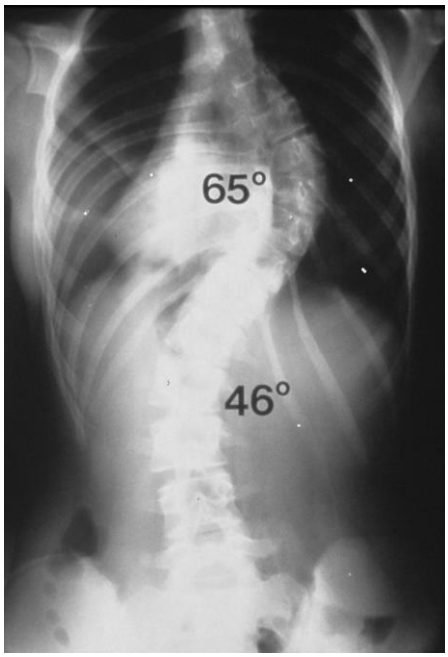


Adolescent idiopathic scoliosis is characterized by a lateral bending and twisting of the spine. It is the most common spinal deformity affecting adolescents 10 to 16 years of age. Children with scoliosis are frequently referred to the patient's primary care physician by way of scoliosis screening programs, school nurses, and concerned parents. Although scoliosis is most common in adolescents, the general principles of the evaluation and diagnosis of scoliosis in adolescents may be easily applied to younger children.

**Causes**

The development of changes in the alignment of the spine in adolescents has been the focus of numerous studies. Multiple causes for this condition have been considered. The role of genetics in idiopathic scoliosis has received the most attention and twin studies show that identical twins have a higher incidence than non-identical twins for developing scoliosis. In addition, there is another family member with scoliosis in approximately 30% of children who present with a scoliotic curve. Studies to identify the specific gene that causes scoliosis are underway. Research has also evaluated the possible effects of hormones and the adolescent growth spurt on changes in spinal alignment. To date, a link between adolescent scoliosis and the effects of hormones, such as growth-stimulating hormone, has not been established. Abnormalities in connective tissue which affect the

structure and function of the spine, the muscles of the back and platelets have been found in patients with scoliosis. However, it is unknown whether this abnormality is a cause or an effect of the abnormal spinal curvature. Finally, the equilibrium system of the adolescent which controls balance and helps us to be aware of the position of our bodies in space, has been considered a possible factor in idiopathic scoliosis. Additional research is ongoing.




**PATIENT EVALUATION**

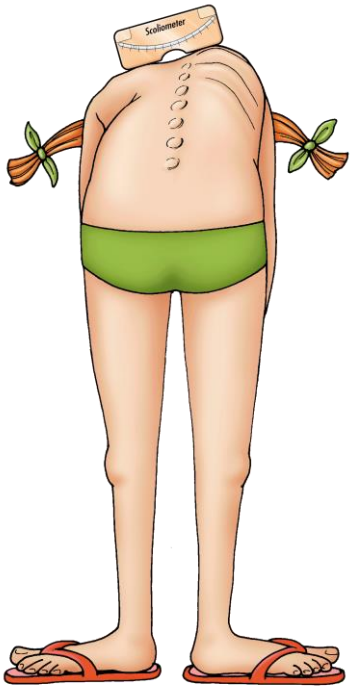
**History and Physical Examination**

Adolescents may present for evaluation of a spinal deformity in a wide variety of ways. They may have had an abnormality noted during a scoliosis screening examination in school, or they or their parents may become concerned about shoulder asymmetry, excessive "round back" deformity, upper back pain (especially associated with the use of book bags), waist asymmetry, uneven pelvis, or rib deformity. Once these concerns have been brought to the attention of the pediatrician, family physician or orthopaedic surgeon a thorough history and physical are necessary to differentiate idiopathic scoliosis from scoliosis caused by trauma, infection, tumor or spinal cord abnormality. It is important to note whether the child or adolescent has experienced back pain. If pain is present, it is important to clarify its character, duration, severity, and whether medications have been taken in an attempt to relieve pain. Idiopathic scoliosis, in and of itself, is seldom a source of pain. Complaints of bowel or bladder incontinence, difficulty ascending or descending stairs, or pain radiating below the knee suggest neurological involvement and are atypical in idiopathic scoliosis.

The physical examination for scoliosis emphasizes a comprehensive evaluation from the adolescent's head to his or her toes. Muscle strength, range of motion and sensation of both arms and both legs are tested. Hamstring tightness, sometimes seen as a limitation of forward bending with the knees fully extended, should be noted. Reflexes at the knee and ankle and sometimes the abdomen are also important parts of the physical examination. The feet should be examined for any obvious asymmetry, clawing of the toes, a rigid high arch, or abnormal calluses.

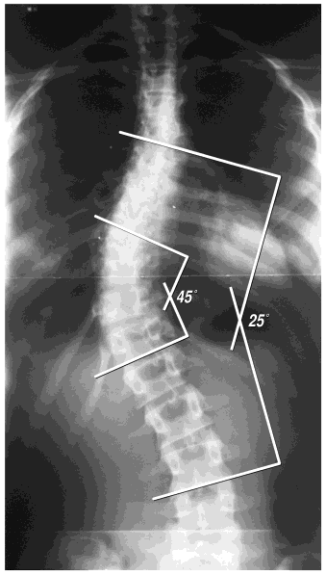
With the patient standing in front of the examiner, the spine should be viewed from behind. Neck range of motion is evaluated. This range of motion should be possible without significant involuntary muscle guarding or spasm. Examination of the spine begins at the base of the neck and extends to the pelvis. The spinous processes should be examined and palpated to evaluate alignment. Symmetry of the neck outline should also be noted. The two shoulder blades should appear to be at the same level on the back. Motion of the shoulder blades should be assessed by having the patient raise both arms over his or her head and then lower them. Asymmetry of the lower spine is assessed by the presence or absence of muscle fullness on either side of the spine, asymmetry of the waist, or the appearance of an uneven pelvis.

The *Adam's forward bend* test is considered a standard in the examination for scoliosis. The patient bends forward until the trunk is horizontal to the floor, with hands hanging freely and knees fully extended. While standing behind the patient, the examiner can assess asymmetry of the rib cage as well as the lower back. This asymmetry is noted as fullness or as an elevation of one side in comparison to the other.



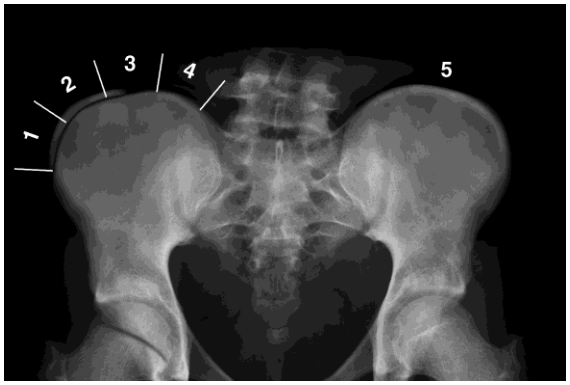

The need for a reliable screening tool to be used in school settings gave rise to the development of the Scoliometer. This specially designed protractor measures the angle of trunk rotation, and has been a simple and effective tool for identifying patients who might benefit from referral for a secondary evaluation and/or treatment of their scoliosis. The Scoliometer is placed over the spine and the angle formed while the Scoliometer is in contact with the back is measured. An angle of 7° or greater is an indication for further evaluation. Typically, a measurement of 7° on the scoliometer correlates with a 20° scoliotic curve on x-ray. The patient is considered to need further evaluation and a spinal x-ray if there is (1) an obvious deformity on the Adam's forward bend test, (2) a Scoliometer measurement of 7° or greater, (3) a markedly uneven pelvis, or (4) asymmetry of the shoulder blade or neck not due to poor posture.

## X-Rays




The gold standard for evaluation of the child with a potential spinal deformity is an x-ray of the entire spine on a single film. The total radiation exposure is generally considered minimal. The proper measurement of a scoliosis curve defines the angle formed by the least number of vertebrae that produce the maximum degree of angulation or curvature of the spine. The correct selection of these two vertebrae is critical to an accurate measurement. By definition, the term scoliosis is used only for curves that measure in excess of 10° by this technique. Accurate measurement of the *initial* curve is paramount to follow progression and to determine a treatment regimen for the patient.

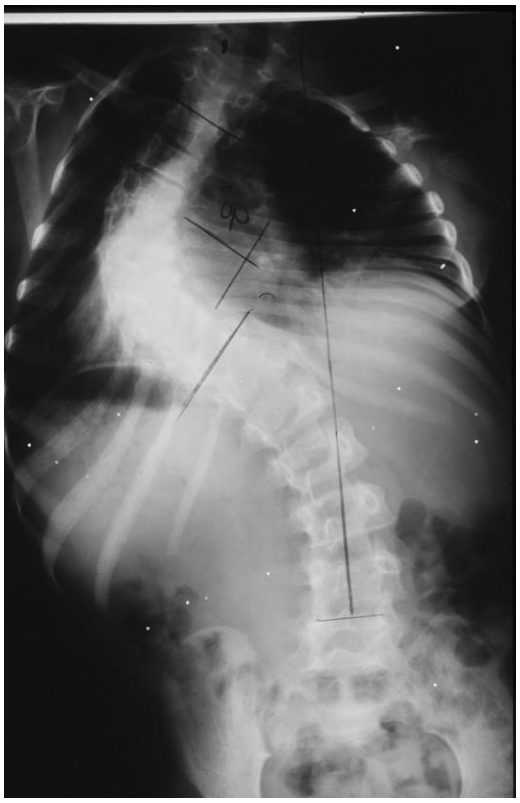
Skeletal maturity is an important factor in scoliosis because progression will slow or end (unless scoliosis is severe) when vertebral growth is finished. The disappearance of the growth plates in the upper end of the thigh bone and the hip socket and the appearance of a growth plate at the top of the pelvis are important indicators of skeletal maturity. The growth plate at the top of the pelvis helps to define the **Risser sign**. The Risser sign appears near the end of the adolescent growth spurt and is seen as a white line across the top of the pelvis on the scoliosis x-ray. The appearance of the Risser sign is divided into five stages. A Risser 1is when the line extends ¼ of the distance across the pelvis, Risser 2 is halfway across, Risser 3 is ¾ of the way, and Risser 4 is all the way across. The separation between this line and the rest of the pelvis eventually disappears and when this happens the child is considered to be a Risser 5, indicating skeletal maturity. As mentioned previously, the x-ray provides useful information beyond the degree of scoliosis. A thorough inspection of the spine x-ray reveals the presence or absence of abnormal vertebrae, the degree of vertebral body rotation, whether the child's head is centered over the pelvis, and the pattern of the curve.



**Ongoing evaluation and Treatment**

The probability of curve progression is the primary consideration when deciding whether to refer a patient to a pediatric orthopedic surgeon. Several factors influence curve progression prior to the completion of skeletal growth. These include (1) a rapid increase in the rate of spinal growth during puberty; (2) menarchal status; (3) skeletal immaturity based on Risser sign or bone age; (4) whether the patient is male or female; and (5) curve pattern.

The most rapid spinal growth occurs from 10 to 12 years of age in girls and 12 to 14 years of age in boys. This increase in growth velocity means that there is a greater risk of significant curve progression at 12 years of age than at 15 years of age. The increase in the Risser stage and closure of the growth plates in the hand x-ray are indicators of completion of skeletal growth. Potential curve progression is greatest at Risser 0 and Risser 1 stages; however, there is variability between girls and boys in the correlation between the Risser stages and risk of progression.



The curve pattern by x-ray is also important. The curve is described by the total number of vertebrae included in the deformity, which direction the spine curves (left or right), and, finally, the location of the curve. Thoracic curves (curves in the upper part of the spine) most commonly have the apex to the right. A left thoracic curve should raise suspicions for possible involvement of the spinal cord as well as the vertebrae. In general, double curves progress more frequently than single curves, and, of the single curve patterns, a thoracic curve has a higher likelihood of progression than a lower (lumbar) curve.

**TREATMENT**

The pediatric orthopedic surgeon will take into account the patient's physical examination, the x-ray appearance of the curve, and the degree of skeletal maturation in determining a treatment plan. The

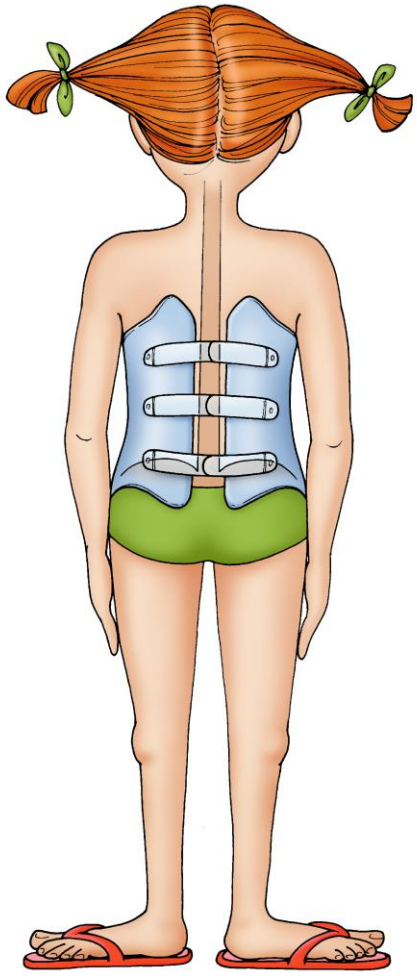
choices include (1) reassurance, (2) observation, (3) brace wear, and (4) surgery.

**Reassurance**

Reassurance regarding the condition is offered to patients in whom the likelihood of progression is extremely low and the present curve is minimal. Most pediatric orthopedists will counsel patients about the low probability of curve progression if the curve is small and they have completed their growth spurt. In all likelihood, follow-up will not be necessary.

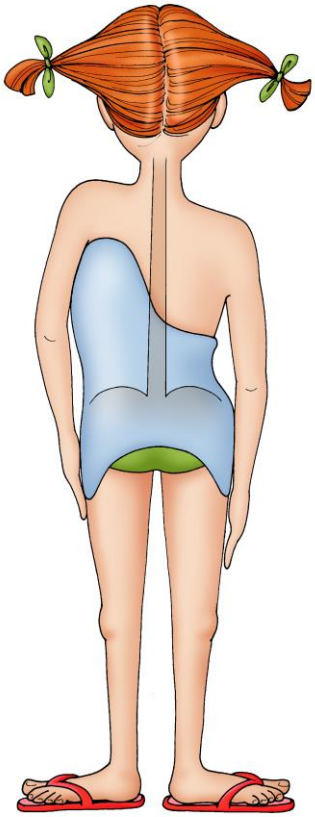
**Observation**

For the patients who are considered skeletally immature because they have open growth plates, a Risser stage less than 2, or are premenarchal, and for those who present with a curve that measures between 20° and 25°, observation and follow-up are indicated. Follow-up x-rays and examinations are necessary to document the lack of significant progression until the completion of skeletal growth. Evidence of significant progression warrants consideration of brace wear.



**Brace Treatment**

The indication for offering brace wear to an adolescent is the presence of a curve between 25° and 45° and a high probability of progression. The majority of brace wear now offered to patients is an underarm thoracolumbosacral orthosis (TLSO). The underarm brace is a custom-molded device prepared in such a manner as to control curve progression through padding, contouring, or both. The majority of brace wear offered in the United States fits beneath the clothing and is worn for most of the day and night. However, extracurricular activities are encouraged and may be participated in out of the brace. The full-time underarm brace is preferred for management of most curves.



An alternative to the TLSO is the Charleston or Providence bending brace. This brace is primarily for single small lumbar curves and it is worn only at night. When fitted properly it should bend the trunk in the opposite direction, straightening out the scoliotic curve.

Monitoring progression of the curve until skeletal maturation is necessary with both the TLSO brace and the Charleston brace.

With any bracing option, the goal is to prevent or slow the rate of progression of the curve during the rapid adolescent growth spurt. It is felt that the effectiveness of the brace is directly related to the amount of time spent in it. However, despite the best efforts of some patients and their families sometimes the curve can progress in the brace.

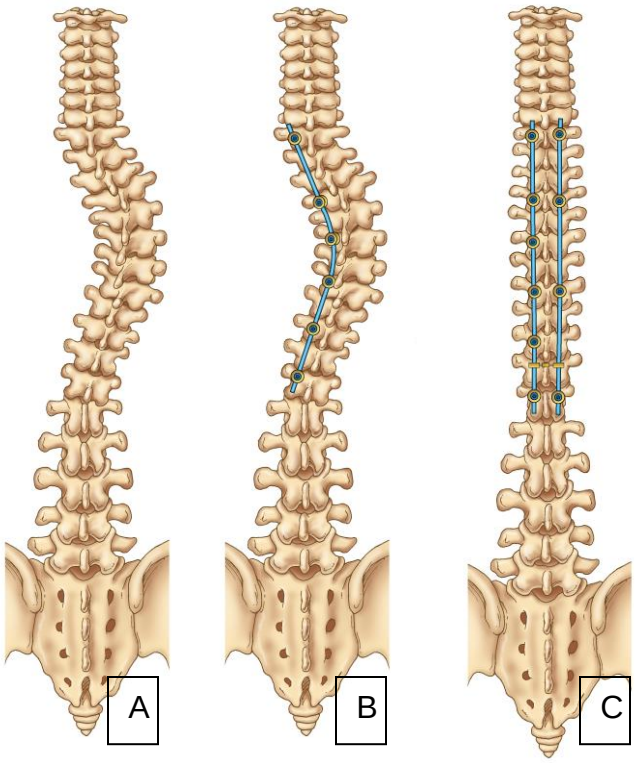
Physical therapy, exercise programs, chiropractic manipulations, electrical stimulations, and special diets have all been studied as alternative treatments for scoliosis. To date, none of these have been proven to prevent or slow curve progression.


Without brace

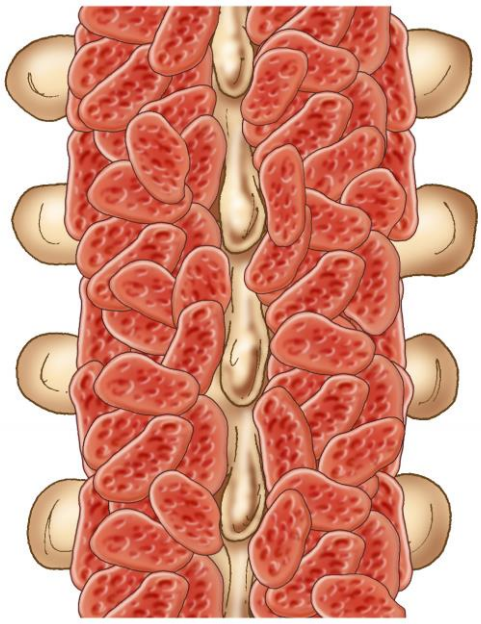

With brace

**Surgery**

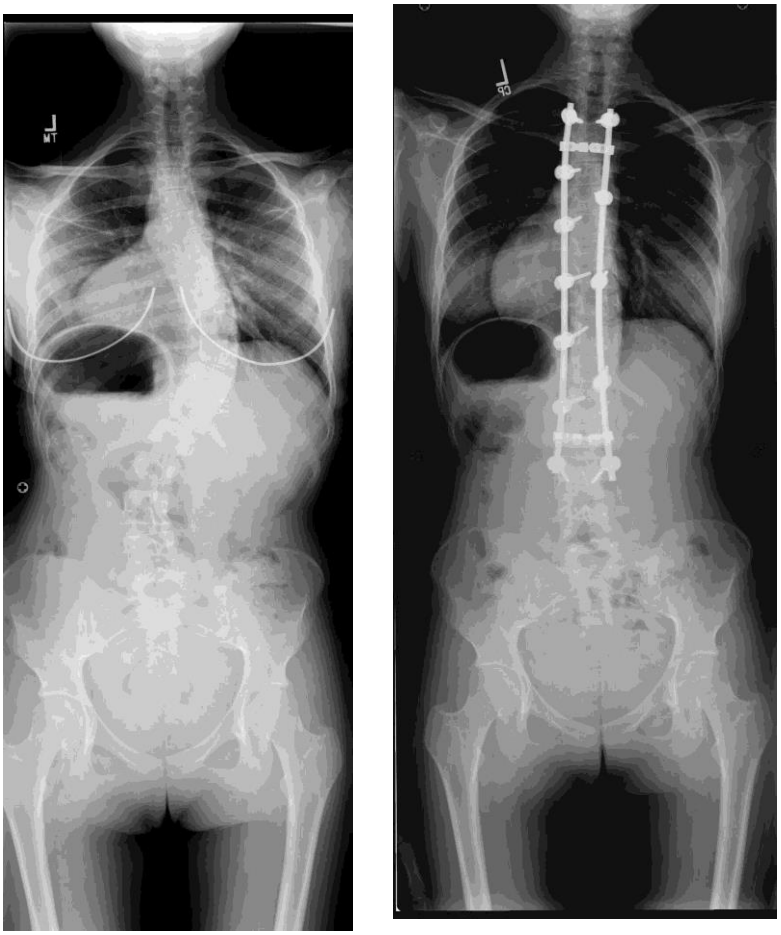
Spinal surgery is recommended for mature adolescents with large curves that are likely to progress in adulthood. It is also recommended for growing adolescents who have curves that are already 40° to 50° and have significant potential for worsening with continued growth. The goal of surgery is to diminish the scoliotic curve, then maintain the corrected position during the 6 months required for complete healing. The use of instrumentation (metal rods, hooks, screws and wires) has eliminated the need for a cast or brace after surgery in most cases. There are few long-term limitations after successful fusion.




The vertebra to be fused are identified and then screws or hooks are attached to the bones (A). The first rod is shaped or rotated to provide safe correction of the spinal curvature (B). A second rod is added to help maintain the correction (C).



Bone graft is added over the spinal instrumentation to produce the spinal fusion



Fifty degree scoliosis is reduced to ten degrees with two rods and multiple screws

**CONCLUSION**

Adolescent idiopathic scoliosis is usually a benign condition that results in a mild to moderate deformity associated with few limitations of function. The vast majority of patients presenting for an evaluation will ultimately be diagnosed with a curve that measures less than 15°. In general, these patients will not require follow-up with the specialist. Bracing will be offered to those adolescents who have curves between 25° and 45° and who are considered skeletally immature. The skeletally mature 15- to 17-year-old with a curve between 25° and 40° should be reassured that long term problems related to their scoliosis are unlikely.