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# Adolescent Idiopathic Scoliosis

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The Scoliosis Research Society (SRS) distinguishes three different types of idiopathic scoliosis: infantile (birth to the age of 3 years), juvenile (age 3–9 years), and adolescent (age 10–18 years). A distinction has been made between the early-onset type (before the age of 5 years) and the late-onset type (after the age of 5 years) because of a dissimilar prognosis. The adolescent form represents 80% of all idiopathic scoliosis, and its prevalence is estimated to be between 2% and 4% of all adolescents between the ages of 10 and 16 years [1]. The prevalence of curves greater than 30° is approximately 0.2%, and the prevalence of curves greater than 40° is approximately 0.1% [2]. The ratio of girls to boys is 10:1 for patients with curves greater than 30°.

Treatment of adolescent idiopathic scoliosis varies from simple observation in cases that are nonprogressive to bracing to surgery in curves that do progress. Surgical intervention may be considered in progressive curves greater than 45° to 50°.

## Case 1: the need for brace treatment

### *Case description*

A 10-year-old boy had chest radiographs for bronchitis. At that time, no attention was paid to the scoliosis that was evident on the radiographs (Fig. 1A); hence, no specific treatment was given. The boy was seen 4 years later at our spinal deformity clinic, because the parents were concerned by the increasing spine deformity. Radiographs of the spine demonstrated a 90° curve (see Fig. 1B, C). Naturally, such a curve is far beyond conservative treatment. After MRI was performed and spinal dysraphism was ruled out, the patient was surgically treated for scoliosis. A case such as this raises an important question, however. Would timely brace treatment have prevented such a catastrophic progression of scoliosis?

### *Rationale for brace treatment*

Lonstein and Carlson [3] studied the natural history of idiopathic curves before skeletal maturity. They reviewed 727 patients with idiopathic scoliosis in whom the initial curves measured from 5° to 29°. In this study, the three strongest factors found to be associated with curve progression were the initial magnitude of the curve, the Risser sign, and the patient's menarchal status. Curves between 20° and 29° in patients who were Risser zero were found to have a 65% chance of progression. Patients aged 10 to 12 years and with curves greater than 30° had a 90% chance of progression.

With these figures in mind, the 24° curve in the 10-year-old patient had a significant chance of progression and should have been treated with a brace to prevent this catastrophic evolution.

### *Indications for brace*

Classic indications for brace treatment are curves that are progressive with a magnitude of 25° to 30° in patients who are skeletally immature with significant growth remaining [4]. The best study reported on the efficacy of bracing so far is by Nachemson and Peterson and the members

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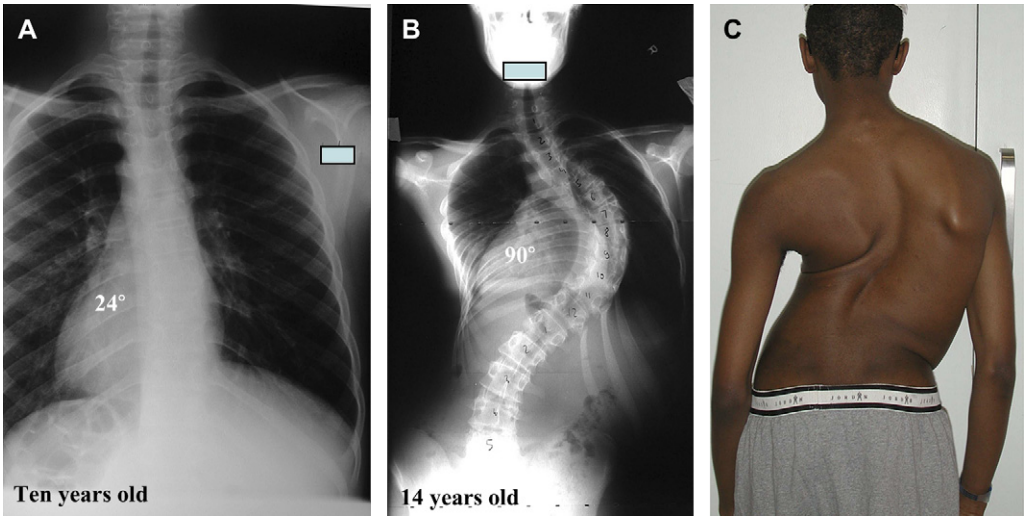


Fig. 1. Progression of a 24° curve in a 10-year-old boy without treatment. (*A*) Standing radiograph of the 10-year-old patient with a 24° curve. (*B*) Standing radiograph of the same patient after 4 years with a 90° curve. (*C*) Clinical photograph of the patient shows severe spinal deformity after 4 years without any treatment.

[5] of SRS Study Group. In this study, treatment with a brace was associated with a 74% success rate. These findings were supported by Rowe and colleagues [6] in a meta-analysis on the efficacy of nonoperative treatment for adolescent idiopathic scoliosis. In this study (n = 1910), three different groups (bracing, electrical stimulation, and observation) were treated. These investigators found that 23 hours of bracing is effective in preventing curve progression in adolescent scoliosis. In the same study, they found that the Milwaukee brace was the most effective for halting progression.

## Case 2: conservative treatment with surgery later

### *Case description*

A healthy, athletic, 16-year-old girl was seen for right thoracic scoliosis of 45° (Fig. 2A). The patient had no complaint whatsoever apart from the appearance of her right thoracic hump. The findings of the clinical examination were otherwise perfectly normal. The patient began menarche at the age of 12 years and was Risser five on the radiographs. The patient and family were advised regarding the risk of progression of her curve and to have regular radiographs taken at least every 5 years to detect possible progression.

Fourteen years later, the patient was seen for mild low back pain that increased at the end of the day and concern for curve progression. Radiographs showed a curve of 55°, an increase of 10° over the past 14 years (see Fig. 2B). Fearing further progression, the patient wished to proceed with surgery. Further workup, including MRI, did not identify any other possible source of low back pain. The patient underwent a posterior spine fusion that improved cosmesis and relieved her from back pain.

### *Rationale for initial conservative management*

When the patient was 16 years of age, the right thoracic curve measured 45° and the patient was fully mature. For a long time, it was believed that curves less than 50° after skeletal maturity would not progress. The rate of curve progression after skeletal maturity was studied in depth in the Iowa series by Weinstein [7]. He reported on a selected group of patients with 40 years of follow-up after skeletal maturity. For thoracic curves, those less than 30° were not found to be progressive, but curves between 30° and 50° were found to progress an average of 10° over 40 years. Curves of more than 50° progressed an average of 30°. Our patient fits this predictive rate of progression. Because she was initially involved in athletics and the curve was not threatening to progress, initial conservative management was the right choice. It is important to counsel patients to keep their radiographs to monitor the rate of curve progression.

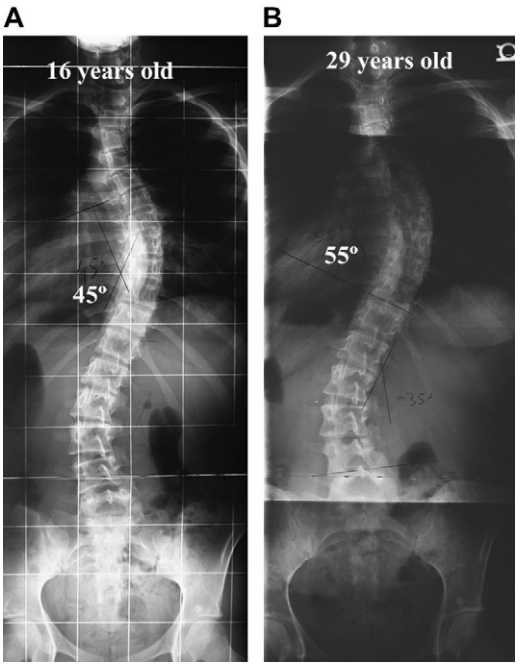


Fig. 2. Progression of a right thoracic curve in a skeletally mature woman. (*A*) Standing radiograph of the patient at 16 years of age shows a 45° right thoracic curve. (*B*) Standing radiograph of the same patient at 29 years of age shows a 10° progression of the right thoracic curve over 14 years.

*Discussion*

This case raises the issue of indications for surgery in skeletally mature patients with curves that are likely to progress. In his recent 50-year follow-up study on late-onset idiopathic scoliosis, Weinstein [8] reported that shortness of breath was seen for curves more than 80°. It was concluded that adult idiopathic scoliosis caused little impairment other than mild or moderate back pain and cosmetic concerns. His conclusions were specific to his patient population studies and are difficult to apply to each individual, especially when cosmetic concerns and self-awareness play an important role in patient decisions.

## Surgery

*Case 3: goals to achieve with surgery for adolescent idiopathic scoliosis*

*Case description*

A 16-year-old boy underwent surgery for adolescent idiopathic scoliosis (Fig. 3A). To review the goals achieved through surgery in this patient, we covered the instrumented part of the spine and studied only the noninstrumented lumbar part of the spine that is straight below the instrumentation (Fig. 3B). In the sagittal plane, the spine is balanced (Fig. 3C). A residual rib hump was assessed by clinical photographs (Fig. 3D). Clinically, the patient's shoulders are balanced (Fig. 3E).

The classic goals to achieve in surgical correction of idiopathic scoliosis are as follows:

- Avoid any complication, specifically neurologic. This is also a major concern of patients and parents before surgery [9]. In the last SRS report, the rate of overall complications was 5% and the rate of neurologic complications was estimated to be 0.21% for posterior instrumentation [10]. These figures underestimated the actual number of neurologic complications, because the statistics relied on the SRS membership response.
- Rebalance of the spine. This is critical because not only is it important to make sure the trunk shift is corrected, but it is equally important to make sure the shoulders remain balanced or corrected to be balanced.
- Achieve a long-lasting fusion.
- Achieve a satisfactory cosmesis correction according to the patient's perception. Cosmesis goals to achieve may be to rebalance the trunk, make the hips symmetric, decrease the rib hump, or all these.
- Protect vertebral segments that do not need to be fused. In the lumbar spine, the rule of thumb is that each level provides 15° of flexion and extension. Preserving distal motion segments is therefore critical to maintaining function and possibly avoids late degeneration of the lumbar spine below the fused segments.

*Discussion*

Numerous publications unjustly focus on surgical correction of the Cobb angle. Instead, attention should focus on the noninstrumented spine, the number of saved levels, the overall balance of the spine, and the alignment of the unfused spine below the fusion and cosmesis. One should judge the surgical result not on the basis of the instrumented spine but rather on the basis of the noninstrumented mobile spine, because the former is nonfunctional. It is a wrong to assume that the straighter the instrumented spine, the better is the outcome [11].

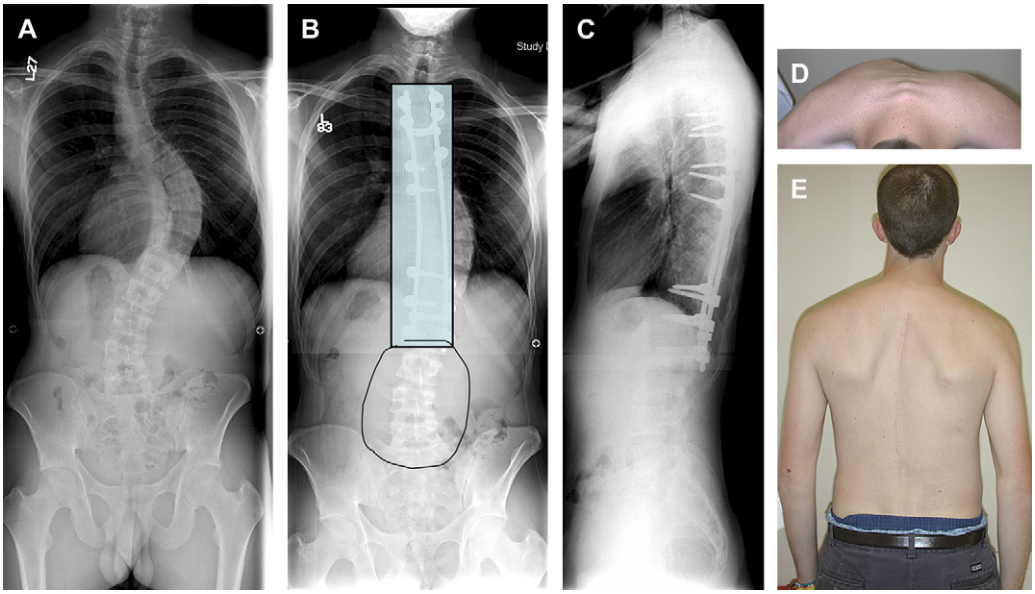


Fig. 3. Evaluation of postoperative result at 3 years of follow-up. (*A*) Standing radiograph of a 16-year-old boy. (*B*) Standing radiograph of the patient with the instrumented part of the spine concealed to bring focus to the noninstrumented part that is straight. The instrumented spine is not important any longer because it is nonfunctional. (*C*) Lateral radiograph shows the instrumented spine. (*D*) Clinical photograph shows residual rib prominence in the patient. (*E*) Clinical photograph shows a posterior view of the patient at 3 years of follow-up. Note that the shoulders are balanced.

Some curves, such as the Lenke IA or Lenke V curve, can judiciously be corrected completely. Complex curves, such as the Lenke IC or Lenke II curve, may not benefit from maximum correction if only the main curve is treated, however. Overcorrection of the main thoracic curve has, for instance, been attributed to decompensation or imbalance of the spine [12,13]. Likewise, overcorrection of the main thoracic curve may lead to left shoulder elevation when the upper thoracic curve has become structural even if the latter is instrumented. We have observed cases in which we had to decrease the correction of the main thoracic curve to regain balance [14]. Therefore, like surgical treatment of Scheuermann kyphosis, straighter is not always better for surgical treatment of adolescent idiopathic scoliosis [15].

Outcomes of treatment for adolescent idiopathic scoliosis must be based on the following:

- Questionnaire outcome instruments, such as the SRS-24 questionnaire
- Serial radiographs with long-term follow-up (a minimum of 5 years)
- Clinical photographs

Determining outcomes with the Cobb angle correction alone is, in our opinion, of little value.

Further case studies are available online [16]. Dr. Arlet evaluates case examples of Lenke type I through type VI curves with illustrations and radiographic images.

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