



current concepts in scoliosis treatment

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Scoliosis comes in many forms including congenital, neuromuscular, syndromic and idiopathic. The most common scoliosis seen in the pediatric population is the idiopathic form, classified as infantile, juvenile or adolescent. Adolescent idiopathic scoliosis (AIS) is the most common form, which presents from age 11 to 17 years. AIS is defined as a spinal curvature of 10 degrees or more seen in the coronal plane. Although the definition for scoliosis is based on what we see in two-dimensional images, it is actually a three-dimensional deformity. Therefore, scoliosis represents a spinal deformity in the coronal, sagittal and axial planes. It has a prevalence of about 3 percent in the general adolescent population.^{1,2} Curves progress in approximately 10 percent of patients with AIS before skeletal maturity, and large curves (greater than 50 degrees) may be associated with adverse health outcomes.

learning objectives

Following the completion of this article, the reader should be able to:

1. Define idiopathic scoliosis.
2. Understand how growth is important in the prognosis of curve progression.
3. Learn valuable non-operative options that help manage curve progression.

Adolescent idiopathic scoliosis accounts for about 90 percent of the idiopathic forms of scoliosis. Some pieces of the puzzle that make up idiopathic scoliosis have been discovered, but not enough have been found to explain the whole picture. Promising links to vitamin D levels have been seen in recent studies performed internationally.³ Studies are underway researching the genes linked to scoliosis,⁴ though reasons why some individuals develop it and others do not are unknown.

The curves in adolescent idiopathic scoliosis have the highest potential of progression at the peak of adolescent growth velocity. In

females this peak growth velocity typically occurs just before menarche. There are radiographic signs that can help physicians estimate where adolescents are on the pubertal growth velocity curve, such as the closure of the triradiate cartilage in the pelvis, the Risser staging of the iliac crest, or a bone-age hand X-ray. The onset of the adolescent growth spurt is around age 11 in females and age 13 in males. Peak growth velocity usually occurs between the closure of the triradiate cartilage and before Risser stage I. On average, this is around age 13 in females and age 15 in males.

During this time of rapid growth, it is important to monitor the curve magnitude closely. This requires X-rays of the spine every four to six months to look for signs of progression. As part of the scoliosis X-rays, the pelvis can also often be seen and help assess skeletal maturity.

Only about 10 percent of those diagnosed with adolescent idiopathic scoliosis will require some form of treatment. Bracing treatment is indicated in curves that are between 25 to 30 degrees with signs of significant growth remaining, or if there are signs of rapid progression or strong family history. Good prognostic signs include curve magnitudes less

than 20 degrees and advanced skeletal maturity (Risser stage ≥ 2). Females have a higher risk of their curves progressing to 30 degrees or more. When curves are approaching 30 degrees and the Risser stage is 3 or less, most surgeons will initiate bracing treatment.

A variety of braces are used. The most common forms in use in the United States can be classified as full-time braces (Boston and Wilmington) or nighttime braces (Charleston or Providence). Full-time braces are designed to be used throughout the day in standing, sitting or supine postures; they can be prescribed anywhere from 13 to 23 hours a day. Nighttime braces aggressively bend the

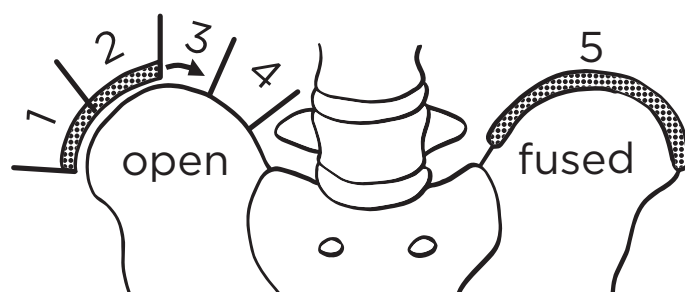


figure 1. Risser grade.

type	age
Infantile	< 4
Juvenile	4-10 years
Adolescent	11-17 years

table 1. Types of scoliosis.⁵

curve	prevalence (percent)	female: male ratio
11°-20°	1.5-3	1.4:1
21°-40°	0.2-0.5	2.8-5.4:1
>40°	0.04-0.3	7.2:1

table 2. Prevalence and female-to-male ratio of different curve magnitudes in AIS.

spine and are designed for use in a recumbent position for about 10 hours at night. The goal of bracing treatment is not to correct or cure the scoliosis, but to halt further progression. Several studies have confirmed the efficacy of bracing for reducing the progression of high-risk curves.^{6,7,8} A recent prospective study from Europe combining exercises with bracing demonstrated better results than bracing alone.⁹ It is important to inform patients and families that the patient's curve at the initiation of bracing is likely to be the curve they will continue to have even if the treatment is successful. Exercise programs can be implemented along with bracing that may help improve flexibility, comfort and compliance with the overall treatment plan. These are discussed below.

The overall goal of non-operative therapies is to prevent the curve or curves from progression to greater than 45 to 50 degrees. Most surgeons will begin discussing surgery when curves reach this magnitude. Studies on the natural history of idiopathic scoliosis have shown that curves with severe magnitudes greater than 45 to 50 degrees can progress. Large-magnitude curves continue to

progress by about 0.5 to 2 degrees per year, even after skeletal maturity.^{10,11} The primary medical concern with further curve progression into adulthood is that pulmonary function can be affected in curves greater than 80 degrees. Adults with these severe curve magnitudes do have slightly higher rates of reported back pain and associated disability.

Surgery involves the use of metal screws that are inserted into the bones of the spine and then connected to strong metal rods that help hold the spine in a corrected position. The surgeon will correct the spinal alignment to an optimal position, often resulting in a 1- to 2-inch increase in height for the patient. The surgical procedure also involves techniques that help stimulate fusion of the bones of the spine. Typically, 6 to 18 months following posterior spinal fusion (PSF), the bones of the spine involved with the surgery will have fused into one long bone that will maintain the corrected position.

Post-operative protocols vary. At Dayton Children's, patients may begin physical therapy and return to school within three to four weeks. Under the guidance of experienced staff, they can begin



figure 2a. Mandy Duman, DPT demonstrates an example of a full-time brace.

low-impact sporting activities such as biking at four months, and then full athletic activity after six months.

scoliosis and exercise

Physical therapists have long known the benefits of exercise. Improving flexibility, strength, coordination, balance and aesthetics while also reducing pain are both short- and long-term patient goals. Our European colleagues have embraced the concept of Physiotherapeutic Scoliosis-Specific Exercises (PSSE) as an essential part of the treatment of AIS. The United States has been slow to adopt this approach as physical therapists require specialized training to effectively evaluate and treat scoliosis.

There are several different exercise protocols that have been utilized in the treatment of scoliosis including Schroth, Scientific Exercise Approach to Scoliosis (SEAS) and Pilates exercise (PE). A systematic review performed



figure 2b. Here she demonstrates an example of a nighttime brace designed to be worn lying down.

in 2014 demonstrated that PE was effective in reducing low back pain in addition to demonstrating improved flexibility, dynamic balance and enhanced muscular endurance.¹²

Scolio-Pilates® is a specialized treatment approach developed by Karena Thek, who lectures internationally on the topic and has developed a comprehensive exercise program that incorporates many of the principles of exercise and scolio-

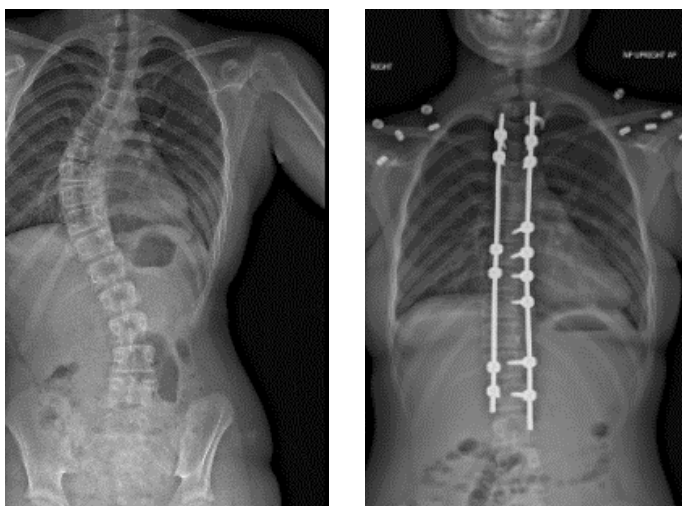


figure 3. Pre-operative scoliosis curve and the correction obtained post-operatively with the rods and instruments used to hold the correction.

sis that have emerged recently from Europe and the Society on Scoliosis Orthopaedic Rehabilitation and Treatment (SOSORT) consortium.¹³ Dayton Children's is the first hospital to receive training and adapt a specialized treatment approach for all scoliosis patients. The team of orthopaedic rehabilitation therapists received training last summer in this approach with three of the physical therapists currently involved in case studies and further intensive training. PSSE are not traditionally part of the physical therapy undergraduate or graduate curriculum and the approach requires specialized training to be used effectively. Several studies from Europe, with level I evidence, support exercise as playing an important role in the conservative treatment of AIS.¹⁴

AIS can be challenging to assess and treat from a physical therapist's perspective and requires close communication between the spine specialist and therapist. Unlike most of the conditions that therapists treat that are two-dimensional, scoliosis occurs in a three-dimensional framework involving the coronal, sagittal and horizontal planes. The physical therapist works closely with the growing adolescent to improve their proprioception, aesthetics and core strength.

While the level of evidence for conservative treatment of AIS is not high due to lack of randomized control trials and strong outcome measures,¹⁵ there are many benefits to the use of scoliosis-specific exercise. Many patients are currently not receiving any treatment as they fall under the "wait and see" cate-



figure 4. Scolio-Pilates approach using reformer.



figure 5. Scolio-Pilates approach using wedge.

gory, but would benefit from postural retraining, core strengthening, breathing education and relief as needed. Since beginning the Scolio-Pilates® program at Dayton Children's in September 2017, over 200 patients have used this approach. The goal is to provide every patient with optimal care and support with our comprehensive ap-

proach to scoliosis. A new orthopaedic/rehabilitation office in Troy will open in 2018.

The Scolio-Pilates® program is a three-dimensional exercise program, tailored to the individual and their specific spinal curve, as a proactive treatment during observation and bracing phases. Exercises focus on



figure 6. Scolio-Pilates approach – side lying exercises.

spinal elongation with postural control, corrective breathing techniques, corrective spinal positioning toward neutral, and strengthening within those corrective positions. Patients work directly with physical therapists throughout the program, starting off weekly, then progressing

to monthly maintenance as they are being monitored by orthopaedic surgeons. Benefits may include improved postural awareness, pain reduction, improved tissue symmetry, improved endurance and activity tolerance, increased strength and mobility, and improved breathing capacity.¹⁴

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figure 7. Scolio-Pilates approach using wall bars.

The goal is to establish independence with the patient, so that they may perform these postural corrections throughout their day,

every day. Over time, they will be able to maintain their own spine neutral in static and dynamic positions.



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Ann Smith, DPT, MS, PCS, is director of occupational and physical therapy at Dayton Children's. Ann received her degree in physical therapy from Northwestern University, a master's degree from Troy State University in management, and a Doctor of Physical Therapy degree in pediatric therapy from Rocky Mountain University. She completed a fellowship in developmental medicine from Georgetown University and is board certified in both pediatric and orthopaedic physical therapy. Ann served 23 years in the Air Force and served as the consultant for pediatric therapy.

CME questions

4. Bracing is typically used when an adolescent presents with significant growth remaining and a Cobb angle:

- a. <10 degrees
- b. 10 to 20 degrees
- c. 25 to 30 degrees
- d. > 50 degrees

5. Orthopaedic surgeons estimate pubertal growth velocity curve using:

- a. Risser staging of the Iliac crest
- b. Closure of the triradiate cartilage in the pelvis
- c. Bone-age hand X-rays
- d. All of the above

6. Patients typically return to school/activities of daily living (ADLs) and begin physical therapy _____ following posterior spinal fusion:

- a. 2 weeks
- b. 4 weeks
- c. 8 weeks
- d. 6 months

7. Physiotherapeutic-Scoliosis Specific Exercises (PSSE) play an important role in the conservative management of scoliosis and are supported with level 1 evidence:

- a. True
- b. False

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