

Adolescent Scoliosis Classification and Treatment

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KEYWORDS

- Adolescent idiopathic scoliosis • Lenke classification • Scoliosis • Pediatric spine deformity
- Pedicle screws

KEY POINTS

- Adolescent idiopathic scoliosis (AIS) can be classified according to the Lenke classification system, which incorporates curve magnitude, flexibility, the lumbar modifier, and the sagittal plane.
- The Lenke classification serves as a guide with respect to level selection in patients with AIS.
- The widespread use of pedicle screws has resulted in most AIS being treated through a posterior approach.

INTRODUCTION

Adolescent idiopathic scoliosis (AIS) is a spinal condition causing deformity of the spine in 3 dimensions: the coronal, sagittal, and axial planes. AIS is defined as any curve equal to or greater than 10° in the coronal plane^{1,2} in patients 10 to 18 years old.³ It is a diagnosis of exclusion after congenital, neuromuscular, neural, or syndromic causes of scoliosis have been ruled out. Preoperative magnetic resonance imaging is useful for ruling out neural causes of scoliosis, such as syringomyelia or Chiari malformation, although its use as a preoperative screening tool is controversial.^{4,5} A genetic component has been described regarding the cause of AIS.^{6–11} With an incidence of 11% among first-degree relatives,¹² it is not uncommon for a health care provider to manage multiple members of a family with scoliosis.

AIS affects approximately 2% to 3% of the adolescent population, but fewer than 10% of patients with AIS need treatment.¹³ The higher the curve magnitude, the lower the prevalence and the higher the female/male ratio. Curves greater than 30° have a 0.1% to 0.3% prevalence and affect females 10 times more than males.¹⁴

For years, the King-Moe classification was the most widely used system for guiding treatment in AIS. Its shortcomings included classifying curves based only on the coronal plane and showing low interobserver reliability.¹⁵ Also, only variants of the thoracic curve were described, leaving some other curve types such as thoracolumbar or lumbar curves unable to be classified by this system. The Lenke classification¹⁶ addresses these shortcomings and is now considered the gold standard for classifying AIS and guiding treatment. In this article, the Lenke classification is used to describe the AIS types and the treatment options.

Treatment of scoliosis includes nonoperative management such as bracing of curves measuring 20° to 40° or progressing more than 5° per year. Larger curve magnitude, younger chronologic age, and Risser sign are associated with curve progression.¹⁷ The literature has shown bracing to be more effective in patients with earlier Risser scores (0–1) and open triradiate cartilages.^{18–20} The goal of bracing is to maintain curve magnitude throughout a patient's growth period, although conflicting evidence of its effectiveness have been reported.^{18,19}

No funding was received in support of this work.

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Neurosurg Clin N Am 24 (2013) 173–183

<http://dx.doi.org/10.1016/j.nec.2012.12.006>

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Surgery is indicated when a curve is progressive despite bracing and generally when the curve reaches 45° to 50°. The main goal is to stop the curve from progressing, leading to potentially severe complications from an untreated curve, including pulmonary function and back pain. Other goals driven by the patients themselves are improvement of cosmesis. Quality of life studies as measured by the SRS-22 (Scoliosis Research Society 22) questionnaire have shown that patients with AIS have lower self-image and are more self-conscious about their general appearance than the general population.^{21,22} This finding can be related to a shoulder imbalance, rib prominence, or trunk asymmetry. Thus, the psychological impact of the deformity must also be taken into account when considering surgery.

The goals of surgery are to restore coronal and sagittal balance, reduce the rib prominence, and achieve shoulder balance. However, another important goal is to leave as many unfused segments as possible to preserve motion in the lumbar spine. The specific treatment options are discussed further in this article.

Two approaches to AIS surgery exist: the anterior approach and the posterior approach; a combination of the 2 is also used. Some potential advantages to the anterior approach are saving fusion levels,^{23,24} decreased prominence of instrumentation, and decreased risk of crankshaft phenomenon in a skeletally immature adolescent.^{16,25} However, some studies have indicated morbidity related to decreased pulmonary function,^{26,27} which seems to improve at 2-year follow-up.²⁸ The anterior approach can be used to fuse simple thoracic curves and can also be used to perform anterior release and fusion combined with posterior spinal fusion in stiffer and larger (>90°) curves, although similar curve correction can be achieved in these larger curves by the posterior approach alone.²⁹

Since the development of pedicle screws, the posterior-only approach has become the mainstay of treatment of AIS. Pedicle screws provide a 3-column fixation that permits greater curve correction and improved derotation.³⁰ Even in the more severe (>90°) and stiffer curves, pedicle screw constructs with osteotomies render good correction,²⁹ thereby reducing the need for combined anterior and posterior approaches. The crankshaft phenomenon may also be reduced by using pedicle screws.³¹

However, pedicle screw placement has a learning curve, especially with the free hand technique.³² With surgeon experience, the accuracy of pedicle screw placement improves, and the medial breach rate decreases.^{33,34} Reported breach rates range

from 1.6% to as high as 58%.^{33–38} However, rates for neurologic and visceral injuries despite these breaches are low. Although hypokyphosis has been observed with posterior-only pedicle screw constructs,^{39,40} long-term follow-up has shown good maintenance of correction and coronal and sagittal alignment.^{31,41}

LENKE CLASSIFICATION

Overview

The Lenke classification for AIS was developed as a tool to help surgeons classify curve types and guide them in operative treatment.¹⁶ The curve type (the major curve), lumbar modifier (A, B, and C, depending on the location of the center sacral vertical line [CSVL] in relation to the apical lumbar vertebra), and the sagittal profile (–, N, +) is used to determine a specific curve pattern. Although there are 6 Lenke curve types, a total of 42 curve patterns can be observed.

The basis of surgical treatment is to fuse only the structural curves. The curve with the largest Cobb magnitude is defined as the major curve, which, by definition, is structural. Curves with lesser magnitude (minor curves) can be structural or nonstructural, depending on the degree of their flexibility seen on bending films. Generally, minor curves are not considered part of the arthrodesis if they bend out to less than 25°. Focal kyphosis is also a criterion for considering a curve to be structural.

The Lenke classification differentiates King-Moe type 2 curves into Lenke types 1 and 3, helping surgeons select which curves are amenable to selective fusions (Lenke type 1) and those that require an extended fusion in the lumbar spine (Lenke type 3). Unlike the King-Moe classification, which considers only the coronal plane, the Lenke classification accounts for both coronal and sagittal planes and has been shown to have good interobserver reliability. However, the axial plane (a reflection of vertebral body rotation) is still not included in the Lenke classification. Moreover, some curve types such as curves with C lumbar modifiers are subject to controversy regarding selective versus nonselective fusion. The following section on the specific Lenke curve types includes some of the controversies and current recommendations for treatment.

Treatment of Lenke Curve Types

Lenke 1: single thoracic curve

For single thoracic curves (**Fig. 1**), it is generally accepted to perform selective fusions of the main thoracic curve, unless there is a kyphosis of more than 20° in the thoracolumbar area, in which case, the lumbar curve is also included in the

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