Scoliosis Research Society defined scoliosis deformity as a lateral curvature of the spine on a radiograph of the spine taken in standing position. The degree of the curve is measured as the angle between the most inclined vertebral end-plates at each end of the curve (the Cobb angle). There are many causes of scoliosis deformity. It can be structural due to spinal pathologies or non-structural as a result of other skeletal abnormalities, for example leg-length discrepancy and pelvic obliquity. Scoliosis with Cobb angle more than 10°, associated with vertebral rotational deformity, is regarded as structural scoliosis. Many conditions can lead to structural scoliosis deformity: neuromuscular diseases like cerebral palsy and polio; myelitis causing neuromuscular scoliosis; congenital vertebral abnormalities including hemi-vertebra and unsegmented bar causing congenital scoliosis; syndromal disorders like Marfan syndrome and neurofibromatosis that lead to syndromal scoliosis. Idiopathic scoliosis is a diagnosis of exclusion that can only be made after other causes of scoliosis deformity have been excluded. It is the most common type of spinal deformity and accounts for about 75% of patients with scoliosis. This article focuses on classifications of adolescent idiopathic scoliosis and their clinical applications.

**Classification systems**

What are the aims for classifying idiopathic scoliosis? First, it should categorise the disease into different patterns to help communication; secondly, it should guide us in managing the disease; thirdly, it should help us to prognosticate the outcome. Classically, idiopathic scoliosis can be sub-classified based on the patient’s age at onset of the disease: infantile (≤ three years), juvenile (four to nine years) and adolescent (ten years to maturity). These three sub-classifications correspond to the period of increased growth velocity of the spine which also coincides with times of maximal scoliosis progression. Various classification systems have been described for adolescent idiopathic scoliosis, however, there are still limitations in each system and room for further improvements.

**1. Ponseti Classification**

The initial attempt in classification of idiopathic scoliosis was made by Ponseti and Friedman in 1950, and divided cases into single-curve, double-curve, and triple-curve patterns. This early description of curve patterns included cervico-thoracic, thoracic, thoraco-lumbar, lumbar and combined double primary. The curve types were named after the location of the curve apex. Thoraco-lumbar curves had the apexes at T12 to L1, thoracic curves had the apexes above and lumbar curves have the apexes below these levels. They described the natural history of scoliosis based on curve type, suggesting that curve type and location correlate with the natural history and the curve pattern rarely changes as the curve grows. The double curves had a higher chance to progress than single curves, and thoraco-lumbar and lumbar curves had a higher chance to progress than thoracic curves. Although fundamental to classification, curve type and location alone do not capture the complexity necessary to formulate strategies for care, and further advancements aimed to address these deficiencies were made.

**2. King’s Classification**

Taking into consideration the curve pattern, magnitude and flexibility of the scoliosis deformity, King et al described their classification system in 1983, commonly known as the King’s classification system for adolescent idiopathic scoliosis (Fig. 1). It is useful for communication and helps in prognosticating the disease. It also provides some guidance about treatment strategy. If surgery is indicated, the authors propose fusion from one level above the upper end vertebra to the stable vertebra distally using the Harrington instrumentation. They also recommended selective thoracic fusion for King’s Type II curves. King’s classification was widely accepted and seemed to offer sound fusion guidelines when used with the Harrington distraction instrumentation; the standard idiopathic scoliosis instrumentation used in the early 1980s. However, the King classification is not comprehensive enough to include all scoliosis curve patterns, as double major and triple curves are not included. This classification system has also been challenged in that there was only fair to poor inter- and intra-observer reliability. Furthermore, selective thoracic fusion for all King’s II curves was found to have a high chance of post-operative lumbar decompensation when used with more modern instrumentation systems. Bridwell et al reviewed 31 patients suffering from King’s Type II adolescent idiopathic scoliosis treated with selective thoracic posterior spinal fusion using the Cotrel-Dubousset system with hooks and derotational maneuver in which 29% of patients developed coronal decompensation because the lumbar curve failed to match up with the good correction of the thoracic curve. Similarly, Lenke et al reviewed 50 King’s Type II curves treated with selective thoracic fusion with Cotrel-Dubousset instrumentation system, 26% of patients developed post-operative coronal decompensation.

**3. Lenke’s Classification**

In view of the incompleteness and low inter- and intra-observer reliability with the King classification, and high incidence of coronal decompensation with selective thoracic fusion for King’s Type II curves, Lenke et al proposed a new classification system to address these problems, commonly known as the Lenke classification. It is composed of three components: curve type (Type 1 to 6), a lumbar spine modifier (A, B or C) and a sagittal thoracic modifier (−, N or +). The six curve types have specific characteristics on coronal and sagittal radiographs that differentiate structural and non-structural
curves in the proximal thoracic, main thoracic, thoraco-lumbar and lumbar regions. The lumbar spine modifier is based on the relationship of the center sacral vertical line to the apex of the curve and the sagittal thoracic modifier is based on the sagittal curve measurement from the fifth to the twelfth thoracic level (Fig. 2). The authors proposed that only the structural curves should be fused if surgery is indicated. Studies showed that the Lenke classification has high inter-observer reliability in curve types (84%), lumbar modifier (86%) and sagittal thoracic modifier (90%). Lenke’s classification was also shown to have higher inter- (Kappa value = 0.92) and intra-observer error (Kappa value = 0.83) compared with King’s classification. Puno et al demonstrated good results following the surgical strategy proposed by Lenke’s classification. They compared patients with fusion levels according to the Lenke classification with those not according to the Lenke’s classification. They found that Lenke classification can produce shorter fusion in Lenke’s Type 1 and Type 5 curves, better shoulder balance in Lenke’s Type 2 curves and better trunk balance in Lenke’s Type 3 curves. Compared with King’s classification, Lenke’s classification is more comprehensive; it separates the King’s Type 2 curves to Lenke’s Type 1 and Type 3 curves and selective thoracic fusion is only indicated in Type 1 curves. It addresses the sagittal alignment which was not mentioned in the King classification. It has high inter- and intra-observer reliability and is useful for surgical planning. However, it does not take into consideration the rotational deformity which is an important element of the three-dimensional deformity of scoliosis. Another defect of this classification is that a ‘structural curve’ is defined as a curve which is greater than 25° on side bending. Conventionally a ‘structural curve’ is one that has a rotational component which distinguishes it from the absence of rotation in a ‘non-structural curve’ or a ‘postural scoliosis’. Flexibility of the curve should not be confused with the structural character of the curve.

4. PUMC (Peking Union Medical College) Classification

In addition to the deformity in the coronal and sagittal planes, scoliosis also has rotational deformity in the axial plane. A grading system for such rotational deformity was first described by Nash and Moe in 1969 (Fig. 3). Taking into consideration the rotational deformity of scoliosis, surgeons at the Peking Union Medical College in China proposed the PUMC classification in 2005. This classification is based on the location of the apexes, magnitude and flexibility of the scoliosis deformity, amount of apical vertebral rotation and presence of a thoraco-lumbar kyphosis. It defines stricter criteria for selective thoracic fusion for patients with double curve pattern with thoraco-lumbar or lumbar curves less than 45°, flexibility greater than 70% and apical vertebral rotation less than Nash and Moe Grade 2. The paper reviews 152 patients treated according to the PUMC classification. No patient developed truncal decompensation after surgery.

5. Three-dimensional Classification

Rotational deformity in scoliosis is getting more attention in recent years. It is of paramount importance in determining the structurality of the scoliosis deformity and guide on management. Poncet et al described three types of rotational malalignment in idiopathic scoliosis. In Type A curves, the maximum torsion is located in

*Fig. 1a* King’s type 1 curve: Thoracic and lumbar curve, the lumbar curve has higher magnitude and more rigid.
*Fig. 1b* King’s type 2 curve: Thoracic and lumbar curve, the thoracic curve has higher magnitude and more rigid.
*Fig. 1c* King’s type 3 curve: Single thoracic curve without lumbar curve
*Fig. 1d* King’s type 4 curve: Long thoracic curve with L4 tilted into the curve
*Fig. 1e* King’s type 5 curve: Double thoracic curve
the upper-end vertebrae (UEV) region, whereas in Types B and C curves, this occurs in both the UEV and lower-end vertebrae (LEV) regions. In Types A and C curves, the geometric torsion is unidirectional, whereas Type B curves are subjected to torsion in opposite directions. More recently, Sangole et al.\(^{18}\) showed that right-sided thoracic idiopathic scoliosis can be sub-classified into two groups with different rotational orientation in the plane of maximum curvature. Although clinical applications of these rotational deformity assessments are still under investigation, it is a direction for further improvement of classification systems for idiopathic scoliosis.

**Conclusion**

Classification can help to categorise idiopathic scoliosis for easier communication, prognosticate the disease and guide the treatment strategy. It has evolved over the past six decades from coronal curve pattern recognition by Ponseti and King, to Lenke’s classification with inclusion of flexibility and sagittal malalignment, to the PUMC classification with further inclusion of axial rotation. Recently, more detailed assessment of the rotational deformity enabled further sub-classification of the 3-D deformity which brings relevance to the three-dimensional correction in scoliosis management.\(^{17,19}\)

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