The Journal of Turkish Spinal Surgery 2003; 14 (1-2): 27-30

NEW CLASSIFICATION SYSTEM IN AIS: IMPACT ON SURGERY

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AIS CURVE CLASSIFICATION

The King classification system has remained the principle means of classifying thoracic adolescent idiopathic scoliosis (AIS). Despite marked changes in the three-dimensional preoperative assessment and the use of segmental spinal instrumentation in the last decade, this coronal plane only system has prevailed, but has shortcomings. It is not comprehensive, uniplaner, and reliability of the system is suspect. As a direct reflection of a multi-center scoliosis group (Harms Scoliosis Study Group), difficulty with reproducible idiopathic scoliosis curve classification, a new system has been developed. Six goals in formulating this surgical system were specific from the outset: 1) to be comprehensive with all types of AIS curves classified; 2) to be two-dimensional with applicability to three-dimensional assessment; 3) to be treatment based; 4) to separate out specific curve types by objective radiographic criteria; 5) to be highly reliable; 6) to be logical, easily understood, and useful to scoliosis surgeons.

There are three components to this new curve classification system: curve type, lumbar spine modifier, and a sagittal thoracic modifier. Each of these three components should be identified separately, then combined together to create the complete classification.

Classification begins by reviewing the long cassette upright PA and lateral radiographs as well as right and left side bending radiographs. The spinal columns are divided into three regions: proximal thoracic (PT), main thoracic (MT), and thoracolumbar/lumbar (TL/L). one must also keep in mind the regional apices of curve designation with a main thoracic apex being located between the body of T2 inclusive to the T11-T12 disc; thoracolumbar curves having apices from the body of T12 to the body of L1 including the T12-L1 disc; and lumbar curves having apices extending from the L1-L2 disc to the body of L4 inclusive.

CURVE TYPES 1-6

Regional curves are separated into major (largest Cobb) and minor curves. Specific objective criteria in the coronal and sagittal planes determine whether the minor curves are structural or non-structural. Structural criteria in the coronal plane include inflexibility on side bending > 25; in the sagittal plane proximal thoracic (T1-T5) and thoracolumbar (T10-L2) kyphosis > +20; and in the axial plane residual apical lumbar rotation on side bending > Nash-Moe grade I. Thus, each region of the spine, the PT, MT, TL/L, is either designated as structural or non-

structural based on these criteria. The largest Cobb measurement is considered the major curve and thus is always structural in these operative cases. A template can thus be created whereby six curve types are designated: Type 1-Main Thoracic; Type 2-Double Thoracic; Type 3-Double Major; Type 4- Triple Major; Type 5-Thoracolumbar/lumbar; and Type 6- Thoracolumbar/lumbar-Main Thoracic.

These curve type designations are treatment-based, for by and large the regions of the spine that are designated structural will require instrumentation and fusion, while those non-structural regions will not. Thus, although not directly providing fusion levels, the curve type designation does implicate appropriate regions of the spine to be included in the instrumentation and fusion, and those regions, which should be left unfused.

LUMBAR SPINE MODIFIER

The lumbar spine is a mobile region of the spine and serves as the foundation of the spine and pelvis. The degree of lumbar deformity is an important determinant of spinal balance and success with scoliosis instrumentation and fusion. Therefore, we have included a lumbar spine modifier to classify the severity of the lumbar deformity in each scoliosis curve and to complement the specific curve type.

Lumbar spine modifiers, A, B, and C, are based on the relationship of the center sacral vertical line (CSVL) to the lumbar spine on long cassette upright radiographs. For the lumbar spine modifier A, the CSVL lies between the lumbar pedicles up to the stable vertebra. The curve must have thoracic apex (curve type 1-4), which excludes any thoracolumbar or lumbar curves (types 5 and 6).

For lumbar modifier B, a major thoracic curve also exists, but the CSVL falls on the apex of the lumbar spine between the medial border of the lumbar convave pedicle and the concave lateral margin of the apical vertebral body or bodies (if the apex is a disc) because of the lateral deviation from the midline of the lumbar spine.

And for the lumbar modifier C, the CSVL falls completely medial to the concave lateral aspect of the thoracolumbar/lumbar apical vertebral body or bodies (if the apex is a disc). Thus, lumbar modifier C my exist with any o fthe curve types 1-6 with curve types 5 and 6 always having lumbar curve madifier C because of the necessary deviation from the midline of the apex of the major thoracolumbar/lumbar curve for the curve type 5 and 6 designation.

SAGITTAL THORACIC MODIFIER (-,. N, +)

Thoracic sagittal alignment is crucial in the formation of scoliosis, the preoperative assessment of surgical indications, the specific operative approach, and instrumentation techniques utilized to correct the scoliosis. Currently, instrumentation techniques are often principally guided by the thoracic sagittal profile in order to optimize sagittal alignment during concomitant scoliosis correction. For these reasons, we have devised a simple thoracic sagittal modifier to complement the six curve types and three lumbar spine modifiers presented.

The sagittal thoracic modifier is based on the upright lateral radiograph and measured from the superior endplate of T5 to the inferior endplate of T12 (T5-T12). When this measurement is <+10, the sagittal modifier is designated as a “-” or hypokyphosis; when the measurement is between +10° to +40°, it is designated as “N” or normal kyphosis; and for measurements greater than +40°, the designation is “+” or hyperkyphosis.

COMPLETE CURVE CLASSIFICATION

Complete curve classification thus combines the specific curve type 1-6 along with the lumbar spine modifier (A, B, C) and the sagittal thoracic modifier (-, N, or +) to from the specific curve classification (for example 1A-, 1AN, 1A+, 1B-...., 6CN, 6C+). A one-page information sheet has been developed to provide all the necessary requirements for proper curve classification, and a one-page schematic highlights the coronal differences between the six curve types and the three lumbar modifiers.

IMPLICATIONS OF CLASSIFICATION ON OPERATIVE TREATMENT

One of the main goals of this new classification system was to make it treatment based. In evaluating the three components of curve type, lumbar spine modifier, sagittal thoracic modifier, the treatment based implications are highlighted.

By designating specific curve type 1-6, the regions of the spine that are structural and shouhld be considered included in the instrumentation and fusion are quite evident. Specifically, for curve type 1 (main thoracic-MT) the MT curve will be fused; in curve type 2 (double thoracic-DT), both the PT and MT curves will be fused; and type 3 (double major-DM), the MT and TL/L curves will be fused; in type 4 (triple major-TM) all three curves, PT, MT, and TL/L will be fused; in type 5 (thoracolumbar/lumbar-TL/L), only the TL/L curve will be fused; and type 6 (thoracolumbar/lumbar-main thoracic-TL/L-MT) both the MT and TL/L curves will be fused.

Surgical implications for the lumbar modifiers A, B, and C are also evident. For lumbar modifiers A and B, it is anticipated that the lumbar spine will not require fusion. One exception to this is if a thoracolumbar junctional kyphosis exists in the sagittal plane (T10-L2>+20°) requiring inclusion of this region in the instrumentation and fusion of the main thoracic curve above. Also, for those main thoracic curves that are quite large (>+75°), often the thoracolumbar/lumbar coronal plane is structural in and of itself because of the large compensatory thoracolumbar/lumbar Cobb measurement (e.g. curve types 3A and 3B, as well as 4A and 4B).

Lumbar modifier C may or may not require the lumbar curve to be included in the instrumentation and fusion of a main thoracic curve. For those with a Mt 1C (main thoracic) curve, the goal is to perform selective thoracic fusion to leave the lumbar spine mobile to accommodate and balance if possible. This is in distinction to a 3C (true double major) curve pattern where invariably the lumbar spine will be included in the instrumentation and fusion of the main thoracic region. Occasionally, there is a fine line between the 1C and 3C curve patterns, and ratio criteria of thoracic to lumbar (T:L) Cobb measurements, apical translations, and apical rotations that will be required in addition to the structural criteria as listed for this classification system. Lastly, it is important to evaluate the clinical appearance of the patient when separating out a true (3C) versus false (1C) double major curve pattern. If there is a marked discrepancy between the thoracic (greater) and lumbar (lesser) cosmetic appearance, often a selective thoracic fusion can be successfully performed. When the thoracic and lumbar cosmetic appearance is equal, this usually indicates a true double major curve pattern that will require both curves to be instrumented and fused.

For type 5 and 6 curves of the C modifier, the thoracolumbar/lumbar curve will always be included in the instrumentation and fusion. Most type 6 (TL/L-MT) curves will also require the main thoracic curve to be fused as well.

The treatment implications of the sagittal thoracic modifier are also quite important. For a hypokyphotic sagittal modifier (-), the goal of instrumentation and fusion of the thoracic region is to improve thoracic kyphosis either with posterior or more recently, anterior instrumentation techniques. For a normal (N) sagittal modifier, the goal is to maintain normalized thoracic sagittal alignment. For a hyperkyphotic (+) sagittal modifier, the goal is to reduce thoracic kyphosis into the normal range. This will usually require instrumentation and fusion from a posterior route with convex compression forces applied prior to any concave distraction forces.

Thus, all components of this triad classification system produce treatment implications of either regions of the spine to be fused, as well specific techniques to optimize coronal and sagittal curve correction and balance.