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The Scoliosis Research Society Classification for Adult Spinal Deformity

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Spinal deformity in the adult encompasses a broad spectrum of pathologic findings, including the adult sequelae of adolescent developmental deformity, de novo deformity attributable to age-related changes or systemic disease, and posttraumatic or postsurgical deformity. Deformity in the adult spine is common and has a significant and measurable impact on health-related quality of life [1,2]. The management of spinal deformity is characterized by significant variability. The presence of variable approaches to common clinical presentations is a clear indication of the absence of an evidence-based approach to care. The existing literature on adult spinal deformity offers little guidance regarding an evidence-based approach to care. Studies on the natural history of adult scoliosis reflect tremendous disparity in long-term follow-up of patients treated with nonoperative care [3–7]. Similarly, studies on the operative care of adult deformity reflect variability in surgical approaches and in outcomes [8–14]. A major limitation in the development of an evidence-based approach to nonoperative and operative care is that there is not a systematic categorization of adult deformity that enables an evaluation of cohorts that are homogeneous or a classification that permits comparison of similar disorders. The purpose of this article is to describe a preliminary classification of adult spinal deformity that may be useful in the development of an evidence-based approach to care.

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Distinction of adult deformity from adolescent idiopathic deformity

Existing classification systems for spinal deformity have significant limitations and do not include parameters that are important considerations in deformity of the adult spine. The King/Moe classification is an ordinal classification system for thoracic idiopathic scoliosis that was intended to provide guidance for treatment of thoracic deformity [15]. The authors demonstrated that the classification has significant value in determining the appropriate levels for fusion for thoracic deformities, and with the use of distraction instrumentation, the system led to a low rate of late decompensation and revision surgery. The classification has significant limitations, however, including in applicability to current segmental instrumentation systems [16], applicability to patients with lumbar deformity [17], and recognition of alignment and deformity in the sagittal plane [18–20]. The Lenke classification was developed by members of the Harms Study Group with the intent to be comprehensive and encompass all curve types, to be based on objective criteria for each curve type, to emphasize sagittal plane alignment, and to be easily understood and applied [21]. The Lenke classification provides a standardized and useful framework for the determining the extent of spinal arthrodesis in deformity [22,23]. Nevertheless, there is significant variability in the observed choice of levels by surgeons because of specific structural characteristics within the deformity and, most importantly, because of considerations that are apparent from the patient's clinical presentation and "override" radiographic

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considerations [24]. The Lenke classification has limited applicability in adult deformity because of the predominance of degenerative changes in the adult and the consideration of symptoms that drives decision making in the management of the adult spine.

The adult with spinal deformity presents with clinical symptoms and radiographic findings that are distinct from those of the adolescent with spinal deformity. Important differences between the adult and the adolescent with spinal deformity include the following:

- Patterns of deformity
- Degenerative changes within the curve
- Natural history of deformity progression
- Clinical symptoms at presentation

The goals of operative and nonoperative care and surgical strategies for achieving these goals of care can differ significantly between adolescent and adult patients. Specifically, in the adolescent, the goal of care is to prevent deformity progression and to limit the future consequences of spinal deformity. In the adult, the goal of care is to manage present symptoms and disability.

Deformity in the adult spine is frequently characterized by associated degenerative changes, including the following:

- Spinal stenosis
- Spondylolisthesis
- Rotational subluxation
- Lumbar hypolordosis
- Rigidity within the deformity

Degenerative changes in the adult spine are important considerations in surgical strategies, and recognition of these changes and their correlation with clinical symptoms is more important in decision making on levels for arthrodesis than the end vertebra or the neutral vertebra of a structural curve.

Value of a classification for adult spinal deformity

Classification systems are important and valuable to the physician who cares for patients with spinal disorders because they serve to characterize a disorder accurately, to guide treatment and decision making, and to form a basis for the uniform reporting of results of care that may lead to an evidence-based approach to care [25]. A classification system for spinal deformity has four main purposes:

1. Systematic categorization of similar disorders
2. Prognosis regarding natural history and outcomes of care
3. Correlation with health status or severity of deformity
4. Guidance for optimal care

Limited work has been reported in the area of adult deformity classification [26]. The recognition of symptomatic degenerative changes within the deformity, including stenosis, spondylolisthesis, and rotational subluxation, is critical for an effective classification system in the adult. Similarly, global imbalance of the spine in the sagittal and coronal planes is rare in adolescent idiopathic scoliosis but has an important impact on health status and treatment options in the adult patient [27]. Guidance on when to do more, less, or nothing at all can be useful for the surgeon who is considering a spectrum of options and strategies for care. The role of nonoperative care, decompression alone, limited stabilization, or long fusions has not been well defined and is likely to remain poorly defined in the absence of a valid classification system that can be used to categorize and to report outcomes on specific presentations of adult spinal deformity. An evidence-based approach to the management of adult spinal deformity requires a valid classification as a starting point. The Scoliosis Research Society (SRS) Classification for Adult Deformity is intended to be used by physicians to group patients with similar radiographic presentations and to facilitate useful multicenter collaborations and comparisons of similar cases.

Scoliosis Research Society adult deformity classification system

The proposed classification is based on standing full-length radiographs in the coronal and sagittal planes [28]. Global balance, regional deformity patterns, and focal degenerative changes within the deformity are the parameters considered in the classification. The classification also includes primary sagittal deformity, which is commonly related to degenerative disc disease; developmental pathologic change, including Scheuermann's kyphosis; trauma; primary myopathies; and osteoporosis in older adults. The proposed classification is illustrated in Table 1.

Major curve types

Six major coronal curves types are recognized (Figs. 1–3):

1. Single thoracic
2. Double thoracic

Table 1
Scoliosis Research Society Classification for Adult Deformity

Primary curve types	Scoliosis Research Society definition of regions	
Single thoracic (ST)	Thoracic	Apex T2-T11-T12 disc
Double thoracic (DT)	Thoracolumbar	Apex T12-L1
Double major (DM)	Lumbar	Apex L1-L2 disc to L4
Triple major (TM)		
Thoracolumbar (TL)		
Lumbar "de novo"/ idiopathic (L)		
Primary sagittal plane deformity (SP)		

Major curve types	Criteria
1. Thoracic curves	Curve $\geq 40^\circ$ Apical vertebral body lateral to C7 plumb line T1 rib or clavicle angle $\geq 10^\circ$ for upper thoracic curves
2. Thoracolumbar and lumbar curves	Curve $\geq 30^\circ$ Apical vertebral body lateral to center sacral vertical line
3. Primary sagittal plane deformity	No major coronal curve One or more regional sagittal measurements (proximal thoracic, main thoracic, thoracolumbar, or lumbar) outside normal range

3. Double major
4. Triple major
5. Thoracolumbar
6. Lumbar (idiopathic or "de novo")

The definitions described by the SRS [29] were used to establish the major curve types. Thoracic curves have an apex between the second thoracic vertebral body and the 11th and 12th thoracic discs. Thoracolumbar curves have an apex between the 12th thoracic vertebral body and the first lumbar vertebral body. Lumbar curves have an apex between the first and second lumbar discs and the fourth lumbar vertebral body.

Criteria for a structural thoracic curve include a magnitude of 40° or more, and the C7 sagittal plumb line must lie lateral to the apical vertebral body of the curve. The threshold of 40° was chosen to identify curves of significant magnitude to warrant consideration of extension of instrumentation and fusion. Upper thoracic curves are structural if the first thoracic rib or clavicular tilt is 5° or greater with the elevated side ipsilateral to the apex of the upper thoracic curve. Criteria for the thoracolumbar and lumbar curves include a curve magnitude of 30° or greater and a center sacral vertical line (CSVL) that passes lateral to the apical vertebral body of the curve. The lower threshold in magnitude for lumbar major curves is based on the conclusion that lumbar curves of smaller magnitude than thoracic curves would be significant in clinical presentation and in surgical planning.

In addition to the six major coronal deformities, there is a single sagittal plane deformity when there are no associated thoracic or lumbar coronal deformities that would meet the requirements of a primary coronal deformity. The criteria for a major sagittal deformity would include an increased kyphosis in one or more of the regional sagittal measurements listed in the section on the regional sagittal modifier. If regional sagittal deformity coexists with a structural coronal plane deformity, the curve is classified by the coronal plane of deformity and the sagittal contour is recognized as a modifier.

Sagittal modifiers

Deformity in the sagittal plane is an important consideration in adult scoliosis. Regional kyphosis or hypolordosis has a significant impact on health status and surgical strategies for deformity correction. A regional sagittal modifier has been included to describe excessive kyphosis in each of the four regions of the spine: proximal thoracic (T2-T5), main thoracic (T5-T12), thoracolumbar (T10-L2), and lumbar (T12-S1). The regional sagittal modifier is only listed if one or more regions are outside the proposed normal limits. A positive sagittal modifier for the proximal

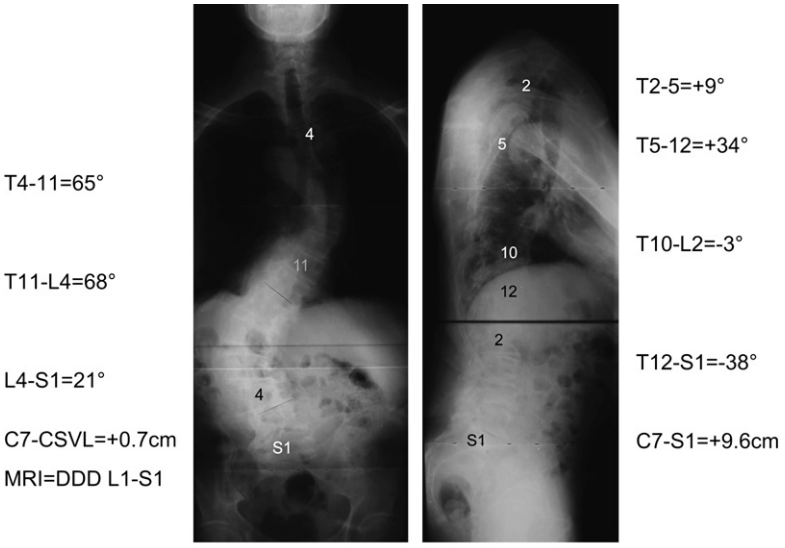

Fig. 1. Case 1: double major (DM) curve plus lumbar degenerative modifier at L5-S1, lumbar regional hypolordosis, and global sagittal malalignment.

thoracic (PT) region would include 20° or greater; for the main thoracic (MT) region, 50° or greater; for the thoracolumbar (TL) region, 20° or greater; and for the lumbar (L) region, −40° or greater.

Lumbar degenerative modifiers

Degenerative changes within the lumbar spine are characteristic of adult spinal deformity and are often the cause of presenting clinical

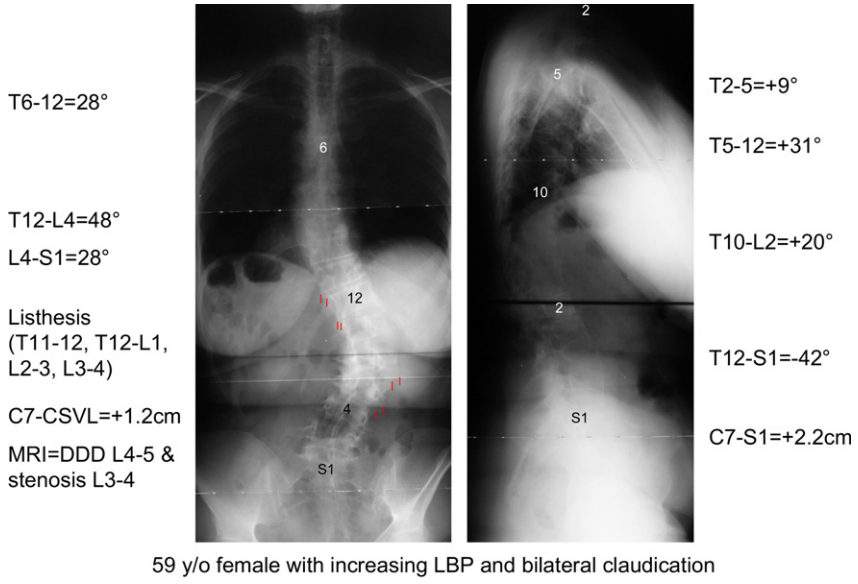

Fig. 2. Case 2: lumbar (L) curve plus degenerative lumbar modifier at L4-L5 with a healthy L5-S1 motion segment and thoracolumbar regional kyphosis.

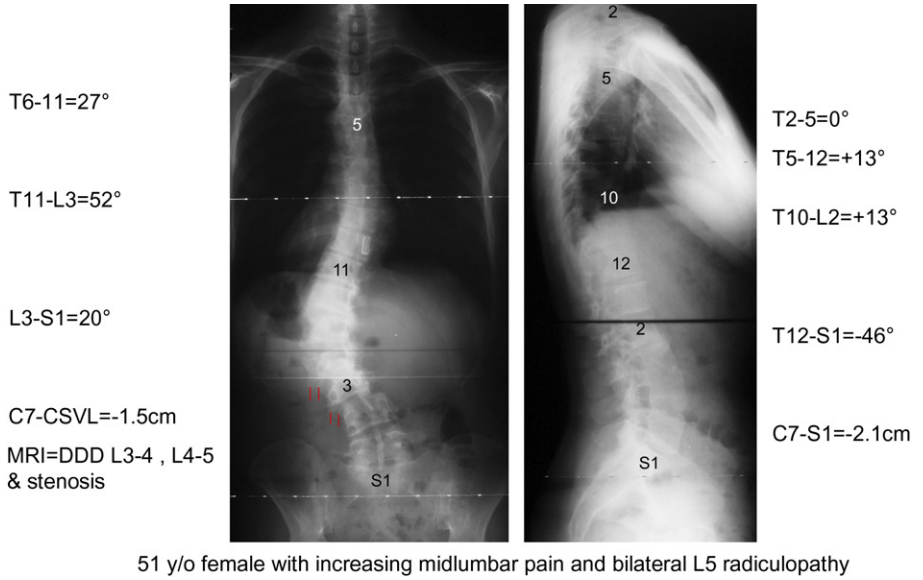

Fig. 3. Case 3: thoracolumbar curve with lumbar degenerative modifier at L4-L5 and normal regional and global sagittal alignment.

symptoms and an important consideration in treatment options. A degenerative lumbar modifier is intended to describe specific degenerative radiographic findings within the lumbar spine. This modifier recognizes radiographic evidence of disc narrowing, facet arthropathy, and degenerative spondylolisthesis or rotatory subluxation. The degenerative modifier is an important parameter in considering an end vertebra for instrumentation in the adult spine. Specifically, instrumentation and fusion generally are extended to include a symptomatic degenerative motion segment.

Global balance modifier

Global alignment of the spine describes the relation between C7 and the sacrum. Sagittal imbalance is significant if the C7 plumb line is 5 cm or greater anterior to the posterior margin of the sacrum. Coronal imbalance is significant and considered in the classification if the C7 plumb line is 3 cm or greater to either side of the CSVL.

Summary

The SRS adult deformity classification offers an important framework for the establishment of a comprehensive description of adult spinal deformity. The terminology and definitions adopted by the SRS were applied in categorization of apical level, and thus curve types. Further modifiers offer important descriptors relevant to surgical decision making. Adult spinal deformity is distinct from adolescent deformity because of the predominance of lumbar degenerative conditions, regional loss of sagittal alignment, and global imbalance in the sagittal and coronal planes in the adult spine. Therefore, a classification that is responsive to the specific pathologic findings of the adult spine is necessary to categorize deformity and guide treatment accurately.

The primary role of this classification system is to provide a taxonomy or framework for adult spinal deformity and to enable comparison of like cases between centers and inclusion of like cases in multicenter studies. The classification presented enables a precise definition of cohorts in prospective studies and permits comparison of similar cases within the cohort. A secondary role of the SRS adult deformity classification system is to provide guidance for optimal care and to contribute toward an evidence-based approach to the management of adult deformity. Operative and nonoperative management of adult deformity is characterized by significant variability. The use of a standard classification for adult deformity permits the investigation of specific curve patterns and coexisting radiographic changes. Recording outcomes for the management of specific adult spinal disorders can

provide an evidence-based approach to care and lead to better consensus in clinical practice patterns.

A limitation of the SRS adult deformity classification as it is presented here is that it does not encompass important clinical considerations, including presenting symptoms of the patient, age, and comorbidities (eg, osteoporosis, systemic disease). For example, the optimal evidence-based treatment for a patient with a lumbar major curve and lumbar degenerative stenosis at L3-L4 with no regional or global modifiers may be quite different from that of a patient who presents with isolated radicular pain or from that of a patient who presents with pain at the apex of the deformity and curve progression. The proposed system is designed to offer a valid radiographic classification for use in accurate and organized categorization of adults with deformity and to identify considerations that may guide surgical treatment. The classification may undergo further refinement in terms of clinical impact and treatment utility for operative and nonoperative patients.

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