# (iii) Adult degenerative scoliosis

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## Abstract

In an ageing population adult degenerative scoliosis, a subset of adult scoliosis, is a growing problem. The spinal curves, unlike those of idiopathic scoliosis, are predominantly lumbar. Patients usually complain of axial pain, neurogenic claudication and radicular symptoms. Initial conservative management is indicated. If that fails, surgical treatment may be indicated, which requires careful patient selection, pre-operative assessment and pre-optimization to reduce the incidence of complications. Surgery is aimed at correcting the deformity, achieving adequate decompression, while obtaining solid spinal fusion and restoration of adequate coronal and sagittal balance.

**Keywords** complications; degenerative scoliosis; lumbar curves; posterior instrumentation; sagittal balance

## Definitions

Scoliosis is a complex three-dimensional rotational deformity affecting the spine in the coronal, sagittal, and axial planes. Treatment paradigms must address all three components.

Adult scoliosis, be it Adult Idiopathic Scoliosis (AIS) or Adult Degenerative Scoliosis (ADS) is a spinal deformity in a skeletally mature individual, with a curve measuring >10° measured by the Cobb method.[1] AIS arises as progression of infantile or adolescent idiopathic scoliosis, but ADS develops during adulthood due to the degeneration of spinal motion segments[2] and is termed degenerative scoliosis or de novo scoliosis. Occasionally the curve is compensatory or neuromuscular.

Degenerative scoliosis develops most frequently in the lumbar spine, where degenerative changes are most prevalent, whereas in neuromuscular and idiopathic scoliosis the major curve is usually in the thoracic or thoraco-lumbar spine.

Lumbar degenerative scoliosis is a rotational disorder that leads to hypo-lordosis associated with a relatively flexible thoracic compensatory curve of typically less than 30°. Common radiographic findings in this population include degenerative changes (most commonly at L5–S1) and rotary subluxation or lateral translation at L3–L4 and obliquity at L4–L5.[3]

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## Epidemiology & demographics

Reported prevalence of adult scoliosis ranges from 1 to 10%.[2] Such new-onset deformity is observed in more than 30% of elderly patients with no past history of spinal deformity. Degenerative scoliosis is typically diagnosed in patients older than 40 years, with a mean age of 70.5 years. They are lumbar curves measuring >10° with associated distal fractional curves. Although the curves are not associated with structural thoracic curves, compensatory thoracic curves can occur. As in AIS, curve prevalence in ADS is inversely proportional to curve magnitude. The prevalence of 10°, 10–20° and >20° curves is 64, 44, and 24%, respectively. These curves have roughly a 1:1 female/male ratio. An overall increase is seen due to the demographic shift towards an ageing society.[4]

## Clinical presentation & natural history

Symptoms of degenerative scoliosis are most frequently progressive back pain with radiculopathy and neurogenic claudication.[5] Ageing progressively affects all structures of the spinal unit, eventually leading to spondylolisthesis, spinal stenosis and scoliosis. Due to multiple degenerative pathologies, identifying the exact source of pain is difficult. Relationships between scoliotic pattern and patient symptoms are unclear, although speculations on such relationships are frequently made.[5–7] Pain at the convexity is caused by fatigue of the paraspinal muscles[5–8] or arises from the facet joints. Pain at the concavity of the curve is thought to be caused by destruction of the facet joints[8] and degenerative changes in disc spaces.[6,7] Radicular pain at the concavity can arise from narrowed foramina[5,8] or ruptured discs causing radiculopathy. Dynamic overstretch of a nerve root might also cause radicular pain on the convex side.[9]

One of the common syndromes is of spinal stenosis. Such symptoms in this group of patients are not relieved by leaning forward, as is seen in those with neurogenic claudication not associated with scoliosis. This distinction is important because the prognosis and treatment of ADS are different from those in patients with degenerative spinal stenosis.

Pulmonary compromise with severe thoracic scoliosis (curve >80°) is well recognized, due to loss of lung volumes and inability to expand the thorax with inspiration. This is a greater problem in patients with idiopathic scoliosis with progression in adult life, but is unusual in patients with degenerative scoliosis and lumbar curves.

ADS curves tend to progress 1–6° per year (average 3° per year).[10] Factors implicated in curve progression are osteopenia,[1,11] curves with Cobb angles >30°, an apical rotation greater than Grade II, a lateral listhesis >6 mm, and an inter-crest line through L-5.[10] Patient age and/or sex are not associated with curve progression in ADS.[12]

## Pathogenesis

Degenerative scoliosis is assumed to be caused by asymmetric disc degeneration and facet joint degeneration.[5,10,13,14] The onset is marked by disc degeneration.[10] This distinguishes degenerative scoliosis from other types of scoliosis, such as adolescent idiopathic scoliosis and scoliosis secondary to neuromuscular disease.

Vertebral rotation and lateral deviation of the spine are coupled phenomena, with the rotation of vertebral bodies directed into the convexity of the curve.[15] It has been shown that in the normal non-scoliotic spine there is a predominant left-sided rotation in the high thoracic vertebrae, and that the mid- and lower thoracic vertebrae are predominantly rotated to the right.[16] This rotational pattern in the normal spine corresponds with the predominance of right-sided thoracic and thoracolumbar curves in idiopathic and neuromuscular scoliosis.[16] However, lumbar vertebrae of the normal spine do not show a predominant rotation, but in idiopathic and neuromuscular scoliosis a left-sided compensatory curve is often seen at the lumbar level.[16] While in lumbar degenerative scoliosis, the scoliotic curve is lumbar, it tends to show the same predominant direction as the compensatory lumbar curve in idiopathic or neuromuscular scoliosis. The strong relationship between apical level and curve direction does indicate that in degenerative scoliosis the innate curvature of the spine plays a role in the direction of the curve.

In idiopathic scoliosis, it is believed that biomechanical factors play a role in the development and progression of the curvature. It is thought that a spine with scoliosis experiences greater loading on the concave side and that this asymmetrical loading leads to asymmetric growth and thus progression of the deformity. Similar processes may play a role in degenerative scoliosis; the greater loads on the concave side inducing degenerative changes resulting in further progression of the scoliosis. Such changes can be diverse, ranging from degenerative changes in the intervertebral discs to spondylolysis or frank spondylolisthesis, rotatory dislocations and destruction of facet joints, depending on the 'weakest link'. It is recognized that disc degeneration temporarily induces a segmental instability which makes the spinal construct more vulnerable to forces that increase a slight pre-existing rotatory pattern, such as Dorsally Directed Shear Loads (DDSL's).[16] Lumbar vertebrae are more subject to such loads which supports this hypothesis.

## Classification of adult degenerative scoliosis[17]

Most classification systems are for adolescent scoliosis and as yet there is no generally accepted classification system for adult degenerative scoliosis. The Lenke classification is widely accepted for adolescent scoliosis and has addressed all the drawbacks of previous classification systems. Recently described classifications of adult scoliosis offer specific advantages, for example, the simple pathogenesis-based system of Aebi, the strong clinical relevance of the Schwab system, and the richly descriptive Scoliosis Research Society (SRS) system.[17] We use the SRS system.

### SRS classification system (Table 1)

The SRS classification provides a framework for an evidence-based approach to the management of adult scoliosis patients.[18] This depends on standing full-length X-rays in the coronal and sagittal planes and is based on curve type and three modifiers as shown in table. Six major coronal curve types — as well as a single sagittal plane deformity that lacks any associated thoracic or lumbar coronal deformities that would meet requirements of a primary deformity — are distinguished.

**Scoliosis Research Society adult deformity classification**

**Primary curve types**
Single thoracic (ST)
Double thoracic (DT)
Double major (DM)
Triple major (TM)
Thoracolumbar (TL)
Lumbar "de novo"/idiopathic (L)
Primary sagittal plane deformity (SP)
**Adult spinal deformity modifiers: regional sagittal modifier (include only if outside normal ranges as listed)**
Proximal thoracic (T2—T5): $>+20^\circ$ (PT)
Main thoracic (T5—T12): $>+50^\circ$ (MT)
Thoracolumbar (T10—L2): $>+20^\circ$ (TL)
Lumbar (T12—S1): $\geq -40^\circ$ (L)
**Lumbar degenerative modifier (include only if present)**
Decreased disc height and facet arthropathy based on X-ray: include lowest involved level between L1 and S1 (DDD)
Listhesis (rotational, lateral antero, retro) >3 mm: include lowest level between L1 and L5 (LIS)
Junctional L5—S1 curve $>10^\circ$ (intersection angle superior endplates L5 and S1) (JCT)
**Global balance modifier (include only if imbalance present**
Sagittal C7 plumb >5 cm anterior or posterior to sacral promontory (SB)
Coronal C7 plumb >3 cm right or left of CSVL (CB)
**SRS definition of regions**
Thoracic: apex T2—T11—T12 disc
Thoracolumbar: apex T12—L1
Lumbar: apex L1—L2 disc—L4
**Criteria for specific major curve types**
Thoracic curves: (1) curve $>40^\circ$; (2) apical vertebral body lateral to C7 plumb line; (3) T1 rib or clavicle angle $>10^\circ$ upper thoracic curves
Thoracolumbar and lumbar curves: (1) curve $>30^\circ$; (2) apical vertebral body lateral to CSVL
Primary sagittal plane deformity: no major coronal curve

**Table 1**

Coronal curve classification is based on apex location, and criteria for specific major curve type are defined objectively. To be classified as a sagittal plane deformity, there must be a kyphosis present that meets the criteria under the regional sagittal modifier.

The SRS classification also includes three radiographic modifiers. A regional sagittal modifier was added in recognition of the impact that regional kyphosis or hypo-lordosis has on health status and surgical strategies. The sagittal modifier is included only if the curve lies outside of the designated normal range and separate modifiers are listed for each of the four regions of the spine.

Because degenerative changes of the lumbar spine are common in adults with scoliosis and because these changes are often the reason for clinical presentation, a lumbar degenerative modifier was added to the classification. This modifier is only