

SPINAL CURVATURES: LORDOSIS, KYPHOSIS, AND SCOLIOSIS

The human spine normally curves to aid in stability or balance and to assist in absorbing shock during movement. These gentle curves can be seen from the side or lateral view of the spine. When viewed from the back, the spine should run straight down the middle of the back.

When there are abnormalities or changes in the natural spinal curvature, these abnormalities are named with the following conditions and include the following symptoms.

LORDOSIS

Some lordosis is normal in the lower portion or, lumbar section, of the human spine. A decreased or exaggerated amount of lordosis that is causing spinal instability is a condition that may affect some patients.

Symptoms of Lordosis include:

- Appearance of sway back where the lower back region has a pronounced curve and looks hollow with a pronounced buttock area
- Difficulty with movement in certain directions
- Low back pain



KYPHOSIS

This condition is diagnosed when the patient has a rounded upper back and the spine is bent over or curved more than 50 degrees.

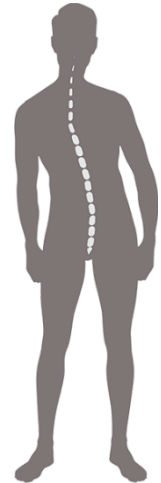
Symptoms of Kyphosis include:

- Curved or hunched upper back
- Patient's head that leans forward
- May have upper back pain
- Experiences upper back discomfort after movement or exercise



SCOLIOSIS

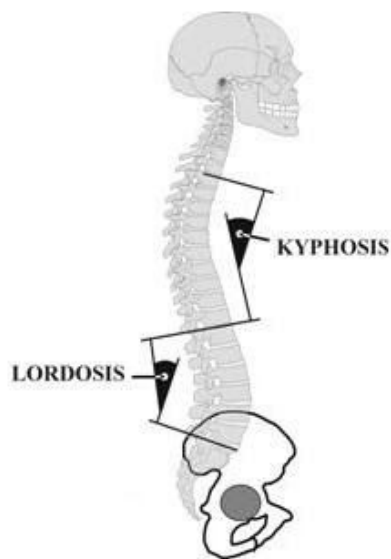
The most common of the three curvatures. This condition is diagnosed when the spine looks like a “s” or “c” from the back. The spine is not straight up and down but has a curve or two running side-to-side.



Sagittal Balance

Definition

- Sagittal= front-to-back direction (sagittal plane)
- Imbalance= Lack of harmony or balance



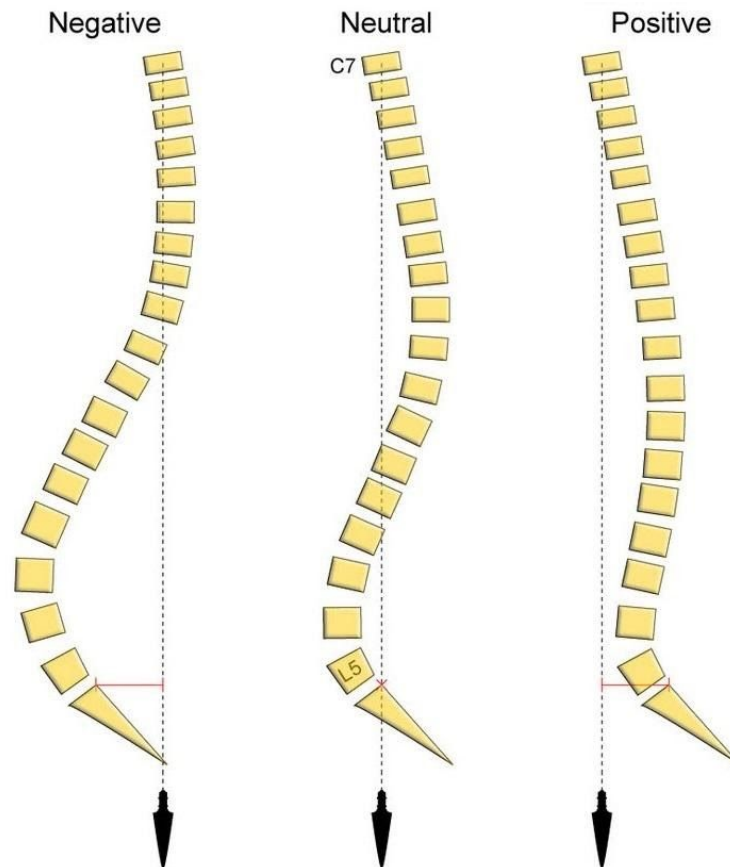
Etiology

- Excessive lordosis (backwards lean) or kyphosis (forward lean)
- Traumatic injury
- Previous spinal fusion that disrupted sagittal balance

Effects

- Low back pain
- Difficulty walking
- Inability to look straight ahead when upright

The most ergonomic and natural posture is to maintain neutral balance, with the head positioned over the shoulders and pelvis. To ensure this the sagittal vertical axis offset is an effective measurement. This is performed by drawing an imaginary plumb line vertically from the 7th cervical vertebra straight down to the floor that represents the natural pull of gravity and is perpendicular to the ground. The spine is considered neutral or balanced when this line intersects on or near the top back corner of the 1st sacral vertebra. Depending on where this plumb line falls the spine can be negative (leaning backwards) or positive (leaning too far forwards) balance.





Images showing adult degenerative scoliosis in the lumbar spine and sagittal imbalance.

Pediatric versus adult scoliosis

When the condition starts in childhood it is most commonly associated with a sideways curvature of the spine. Adolescent idiopathic scoliosis is the most frequent etiology associated with scoliosis in the pre-adult population. Instead of growing in a straight vertical line, the spine grows unevenly developing a side-to-side curvature like an elongated “S” shape.

It also tends to twist or rotate. Scoliosis affects around 2% of the pediatric population and can develop at any age, but most often occurs during adolescence. This is a time when children

typically experience a growth spurt, and their spine develops the abnormal curve of scoliosis. The curvature might remain stable or continue to worsen as your child grows. Severe spinal curvature tends to affect girls more than boys.

However, when scoliosis occurs later in life it is due to asymmetric degeneration in the discs and facet joints placing an asymmetric load on the spine and results in a loss of normal spine curvature leading to a loss of ergonomic posture. This is also referred to as adult degenerative scoliosis (ADS) or adult spinal deformity (ASD). Adult degenerative scoliosis effects up to 40% of the adult population greater than 60 years of age.

This abnormal new positioning of the head relative to the pelvis results in compensation mechanisms in other areas of our body such as the muscles in our back, the pelvis, and the legs all working together to restore a healthy center of gravity. These compensation mechanisms can elicit pain and continue to progress where the combined cascade of events results in significant pain, disability, and lack of mobility.

Etiology of scoliosis in children and adults?

The exact causes of scoliosis aren't always clear. Currently, researchers haven't found a genetic cause for scoliosis, although having a close family member with scoliosis does increase a child's risk of developing the disease. Over 60% of all scoliosis cases in children are idiopathic, which means there's no known cause.

Adult degenerative scoliosis in adults can develop because of disc deterioration or facet joint arthritis. However, anybody in the adult population with pronounced degenerative changes in their spinal architecture may be prone to developing ADS. Other risk factors include: osteoporosis, prior spine surgeries, degenerative disc disease, arthritis, spondylolisthesis, untreated scoliosis in childhood, or compression fractures.

Symptoms of scoliosis in children

Although scoliosis often doesn't cause pain in children there are other associated symptoms such as:

- Uneven shoulders or shoulder blades causing one to sit higher than the other
- Uneven rib cage or hips causing one to sit higher than the other
- Misaligned head or neck that may not be centered over the spine
- Patient's body may lean to one side
- May experience back pain

Symptoms of scoliosis in adults

Unlike in children, the main symptom of adult degenerative scoliosis is back pain. The pain results from degenerative changes in the lumbar discs, facet joints, and progression of the scoliosis. In addition, there is spine stiffness and muscle fatigue caused by an imbalance of the spine. Leg pain is a common symptom, presenting as intermittent claudication or radiating pain caused by spinal stenosis. Patients may also experience neurological symptoms.

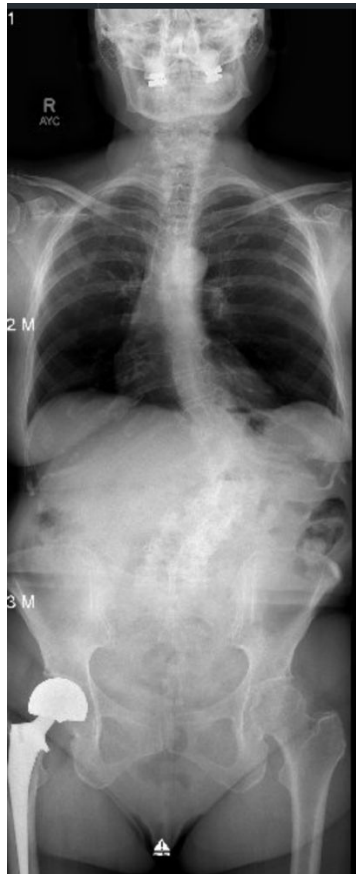


Image showing progression of lumbar adult degenerative scoliosis resulting in nerve compression.

Diagnosis

A thorough history of the patient's chronology of symptoms is performed. A detailed physical examination along with analysis of standing, sitting and walking posture is evaluated. Analysis of imaging is crucial, consisting of standing full body x-rays, magnetic resonance imaging (MRI) and computed tomography (CT) films. We utilize advanced modeling software along with 3D

augmented reality (see film below) to analyze the spine, diagnose the problems causing symptoms and if necessary, plan the appropriate surgery.

How is scoliosis treated in children?

Most cases of idiopathic scoliosis in children are treatable with nonsurgical methods. Children with a mild curvature of between 10 and 25 degrees need regular monitoring. Measurements of the degree of curvature show whether the scoliosis is worsening and requires further treatment. If your child's spinal curvature is increasing, or if it's between 25 and 40 degrees, they would benefit from bracing or undergoing a specialized form of physical therapy called the Schroth Method. Advances in 3D imaging and manufacturing technologies mean you can have custom braces made to your child's exact requirements.

For more severe cases of scoliosis, or where the curvature is putting pressure on the internal organs, surgery can be performed to straighten and stabilize the spine.

How is scoliosis treated in adults?

Just as in children, the initial treatment options for adult degenerative scoliosis are non-surgical and include:

- 1) Bracing
- 2) Physical therapy/exercise to strengthen core musculature
- 3) Pain Management either through medications or injections

If these treatments are ineffective in alleviating the symptoms then surgery can be considered. Surgery is also needed for patients whose curves are progressing over time or have curvatures leading to nerve compression causing symptoms such as numbness, weakness, or pain. Goals of surgery are to relieve pain and other associated symptoms along with preventing the deformity from worsening in the future. There are various approaches to surgically treat adult degenerative scoliosis.

Before deciding on the best surgical approach the patient's diagnostic imaging studies and clinical examination is reviewed multiple times to formulate the appropriate surgical plan. New technologies consisting of pre-operative simulations (see images below), robotic navigation guidance, intra-operative imaging have allowed for these surgeries to be more effective, safer and provided for improved outcomes. In addition, at our clinic we utilize virtual reality planning (see film below) and augmented reality guidance during surgery which helps to ensure the best possible approach and procedure is selected and performed for each patient.

The surgical treatment of adult degenerative scoliosis is accomplished through realigning the spine to the most natural shape tailored for each patient, resorting their natural center of gravity

and treating the pain along with the other associated symptoms. This can be performed through various techniques some of which may include decompression, osteotomies (removal of bone), instrumentation and fusion. Sometimes minimally invasive surgical options are available.

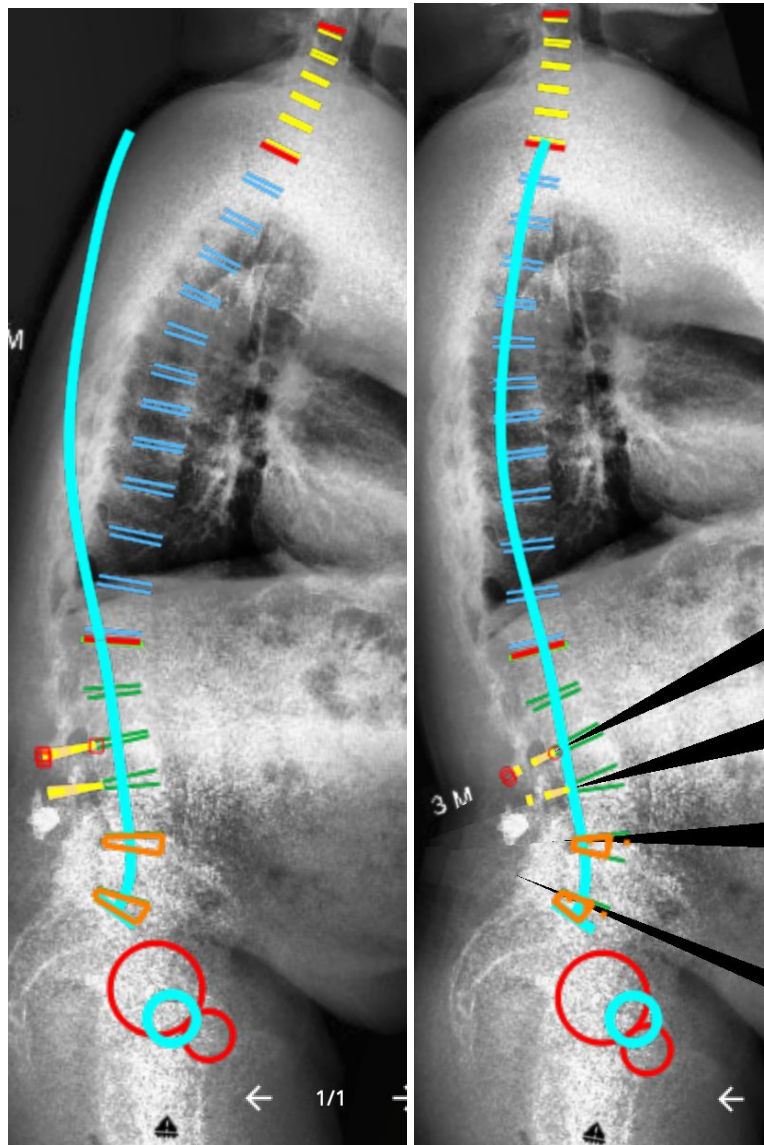


Image to the left shows pre-operative x-rays of a patient's spine deformity from adult degenerative scoliosis where the spine is not in the correct alignment and therefore resulting in significant pain and a decrease in global function by the patient. The turquoise line represents the proper alignment the patient's spine should be in. The image to the right shows an operative simulation what type of surgery is required to restore the proper alignment of the spine and alleviate the patient's symptoms.

Please view film in Scoliosis section



Augmented reality showing a patient's deformity in 360 degrees allowing for optimal surgical planning.