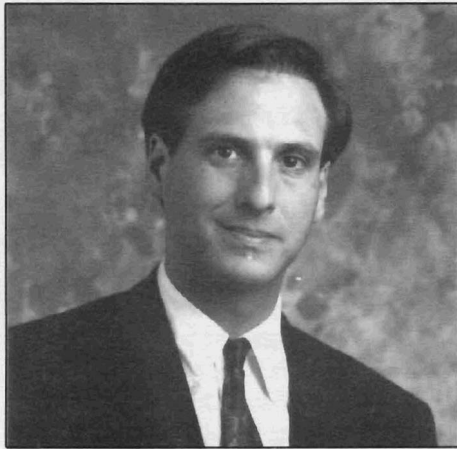


Sagittal Balance of the Spine and Flat Back Deformity



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When viewed from the side, the normal spine has three curves. The low back, or lumbar spine, is normally curved inward. The medical term for this sagittal alignment, or posture as seen from the side, is lordosis. When lordosis in the low back is increased it is commonly described as a sway-back. The normal neck or cervical spine should also be lordotic. In contrast, the thoracic spine, the portion of the spine to which the ribs attach, should be rounded outward, or kyphotic. Together, these three curves form an "S" shape which provides a spring like shock-absorbing function, reducing stress on the vertebral column when loaded with

weight. The three curves normally compensate for each other, resulting in balance in the sagittal plane (alignment of the spine when viewed from the side.) (Figure 1)

When the human spine is balanced in the sagittal plane, a line dropped straight down from the middle of the cervical spine should fall near the middle of the last lumbar vertebra. (Figure 2) When any one of the curves increases or decreases out of proportion to the other two, the spine is thrown out of balance. The term *flat back* refers to a relative decrease in lumbar lordosis causing the spine and head to be displaced forward. A line dropped down from the cervical spine of an individual with flat back will lie anterior to the last lumbar vertebra. This forward displacement is commonly called decompensation, because the sagittal curves are no longer compensating for each other. (Figure 3)

Flat back syndrome refers to the constellation of symptoms experienced by an individual whose spine is forward decompensated because of decreased lumbar lordosis. The most common clinical sign of this condition is a tendency to lean forward when walking or standing. Because it requires more energy to walk in a forward decompensated position, the body will tend to right itself. Low back, buttock and posterior thigh muscles are recruited to tilt the pelvis in an attempt to bring the body into better alignment. These muscles will commonly fatigue, causing aching and

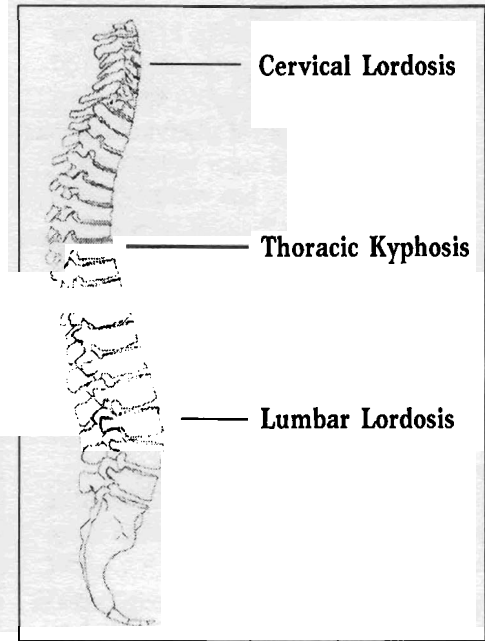


Figure 1

pain. Hip and knee flexion while standing and walking, is another mechanism for aligning the spine in patients with loss of lumbar lordosis. When hip flexion is used chronically to stand erect, a hip flexion contracture can result as the muscles in front of the hip shorten.

Interestingly enough, much of our awareness of flat back dates from our early experience with surgical instrumentation intended for the treatment of thoracolumbar scoliosis and degenerative spine disease. The Harrington rod and other similar devices produce correction of scoliotic deformities by

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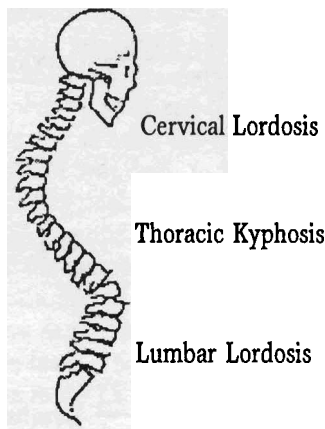


Figure 2:
Balanced Human Spine.

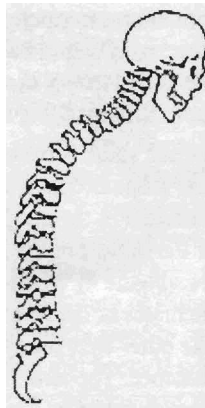


Figure 3:
Loss of lumbar lordosis results in forward decompensation of the spine.

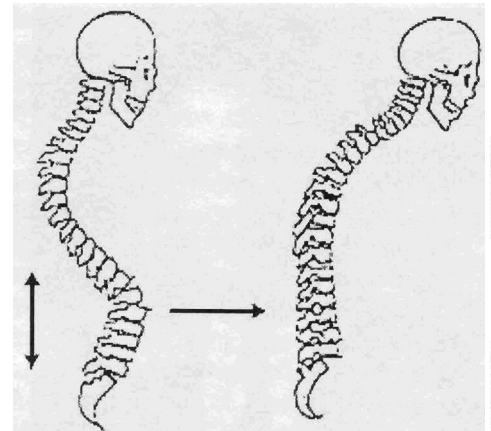


Figure 4:
Distraction forces in the lumbar spine produce flattening of lumbar lordosis and flat back.

utilizing distraction or lengthening forces in the concavity of the curve. Although the curve is straightened in the front view plane, the same distraction forces applied to the concavity of the curve in the side view plane produce straightening of the lumbar lordosis and forward decompensation of the spine. (Figure 4)

Although flat back syndrome was initially seen most commonly in patients with distraction-type instrumentation, loss of lumbar lordosis may occur in several other ways. During the aging process, for example, inter-vertebral disks lose water, degenerate and shrink; as the height of the spinal column shortens, lumbar lordosis may be lost. Compression fractures, most commonly caused by osteoporosis, can also flatten the curve of the lower spine and cause similar symptoms.

In many individuals, lack of lumbar lordosis does not produce symptoms. Those patients who are symptomatic however, can be treated. Most patients with symptomatic flat back should be treated initially with physical therapy. The emphasis of therapy should be on strengthening of the gluteal, low back, abdominal and hamstring musculature. Cardiovascular conditioning cannot be overemphasized as a method for improving pain tolerance.

Since symptoms are produced through abnormal mechanics of the spine, pelvis and upper legs, a brace intended to support a decompensated spine would have to cross each of these structures. Such braces are not usually effective. Similarly, trunk braces,

which also capture the leg are not well tolerated by most individuals. In general, bracing is not an option for painful flat back. When conservative methods fail and the patient is symptomatic to the point of being dysfunctional due to the pain, surgery is indicated.

Flat back occurs most commonly in patients who have had previous spinal

fusions. To recreate balance, it is necessary to break the fusion mass (osteotomy) and re-fuse the spine in a more balanced position. Particular techniques for osteotomy depend on considerations such as the cause of the flat back, the presence of residual scoliosis and a patient's general medical condition. While many osteotomies can be done through a posterior (back) approach only, others may require both a front and back surgery. (Figure 5 & 6)

The surgical treatment of flat back is typically demanding. Many patients have long standing disability which renders them in less than optimum condition for surgery. Most patients have had previous surgery leaving them with soft tissue and, in many cases, nerve scarring. For these reasons, surgical complications occur more frequently in these patients than those undergoing surgery for the first time.¹

Surgical treatment is normally less demanding in patients with small scoliotic curves, those with previous fusions for degenerative conditions or who have loss of lumbar lordosis due to inflammatory diseases such as

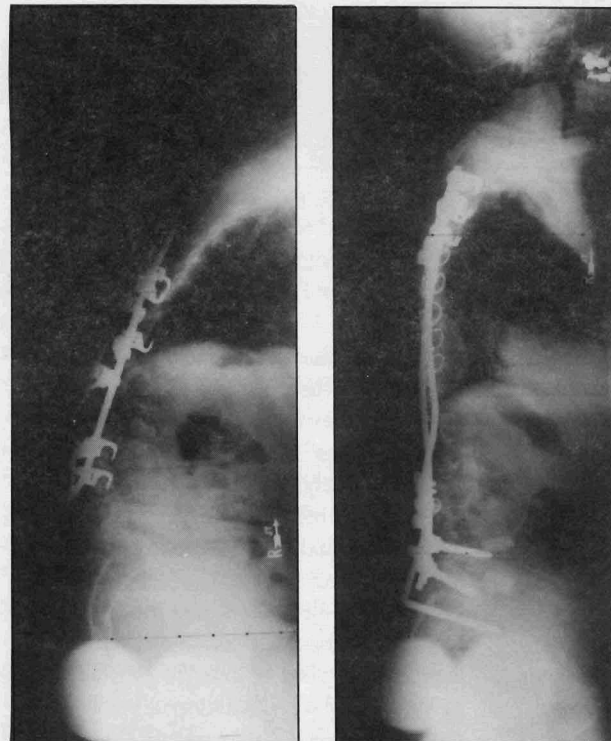


Figure 5: A 54-year-old female status post posterior spinal fusion for adult idiopathic scoliosis was left severely decompensated in both the frontal and sagittal plane. Reconstruction was necessary by anterior vertebral body resection followed by posterior osteotomy, re-alignment and instrumented fusion.

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ankylosing spondylitis.² Since these patients need correction only in the sagittal plane, it is usually possible to operate through one exposure from the back. At our center, we have been successful with an adaptation of the decancellation procedure described by Thomasen.³ In this procedure, an osteotomy is performed below the lowest most extent of the spinal cord, usually at the L3 level. At the L3 level, there are only nerve roots in the spinal canal and because they are more pliable, surgery is less risky than it is at higher levels where the spinal cord is less tolerant of movement and manipulation. The posterior bone at the L3 level is then completely removed and the spongy contents of the vertebra are loosened and extracted. Pressure on the pelvis causes the spine to crack, closing the osteotomy and producing increased lumbar lordosis. Fixation devices,

such as pedicle screws, rods and hooks are used to maintain correction. Bone graft is placed which ultimately heals, producing a new fusion at the osteotomy site. We have been successful in producing 20-40 degrees of correction using this method. (Figure 7)

In those patients who have combined deformities of scoliosis and lumbar flat back, or any other deformity which produces decompensation left or right of the middle of the pelvis, a three-dimensional correction is necessary to achieve spinal balance. Both anterior and posterior approaches are necessary in these patients. Discectomies or osteotomies in the front of the spine are performed at one or more levels, followed by standard osteotomies in the posterior spine. The instability that we can obtain by this type of circumferential surgery creates the opportunity to correct the spine both in the frontal and sagittal plane. A greater degree of correction can also be obtained from front and back surgery which may be necessary in any patient whose flat back requires more than 20-40 degrees of correction. Front and back

surgery is also augmented with spinal fixation devices, the placement of bone graft and in many cases the application of a brace postoperatively. At our Center, most front and back surgeries are performed under one anesthesia (same day), enabling us to mobilize patients quickly during the early postoperative period.

Many patients and their families ask "to what degree will the scoliotic curve be corrected by surgery?" However, the more important goal when contemplating scoliosis surgery is "will the progression of the curve be stopped and **will spinal balance be achieved with surgery?**" Spinal instrumentation is a powerful tool for the

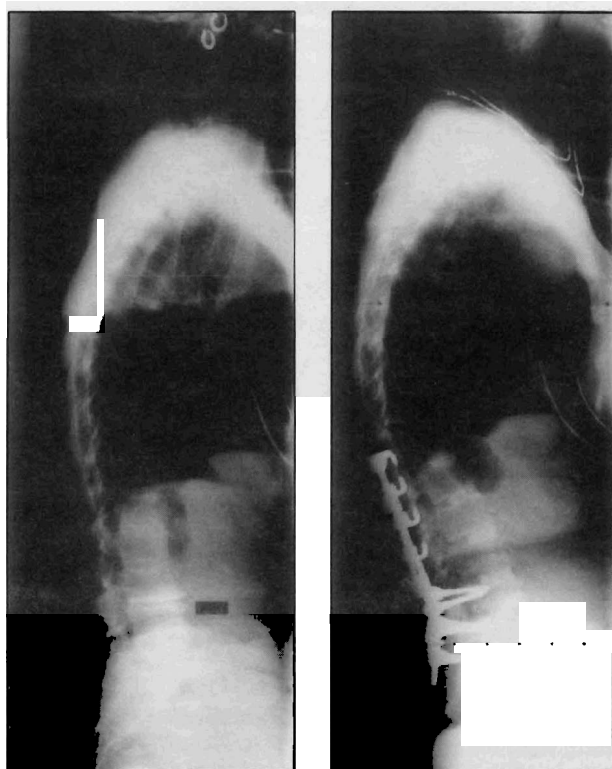


Figure 6: A 70-year-old female status post laminectomy and fusion in situ for degenerative scoliosis was left decompensated with low back and buttock pain. Anterior/Posterior reconstruction with re-creation of acceptable lumbar lordosis followed by posterior instrumentation and decompression resolved the patient's symptoms three months after surgery.

correction of spinal deformities, but it must be used with an appreciation for both frontal and sagittal plane alignment in the production of balance. Early use of these devices in the thoracolumbar spine considered only frontal plane deformity and in many individuals flat back was the result. Today, because of widespread attention to maintenance of lumbar lordosis by experienced spinal surgeons, the incidence of flat back is decreasing.

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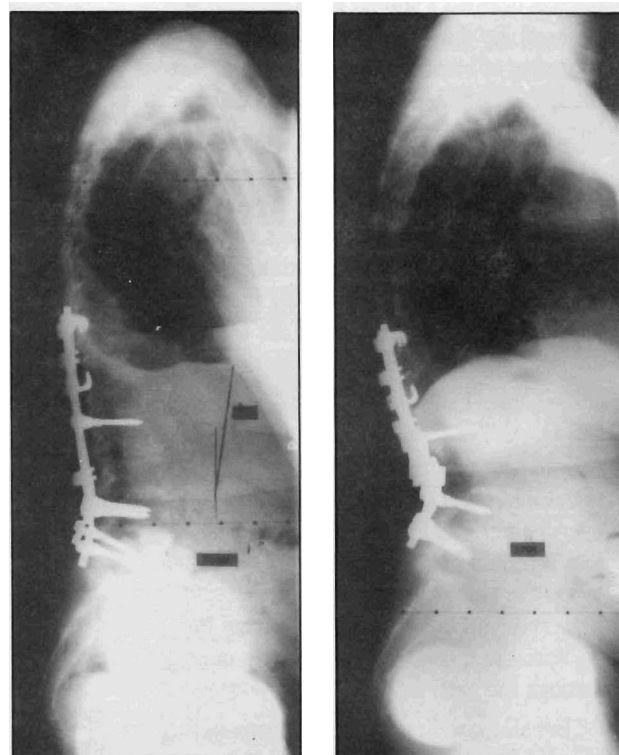


Figure 7: A 68-year-old female with symptomatic flat back status post instrumented fusion for lumbar scoliosis. Posterior decancellation, osteotomy and re-alignment of her instrumentation improved her sagittal alignment.