Patient-Specific Spinal Alignment and Adult Deformity Surgery: Are All Patient Deformities the Same?

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Adult spinal deformity is a complex pathologic process with many etiologies and several mechanisms of compensation. A complete understanding of patient-specific spinopelvic alignment is required to differentiate the origin of the deformity from postural compensatory mechanisms and, ultimately, to optimize surgical correction. Specific spinopelvic parameters have been shown to be invaluable in the evaluation and surgical treatment of adult spinal deformity.

X-ray radiography is the principal tool used in the diagnosis of spinal deformity. Global and regional imaging with anteroposterior and lateral views in the standing and unsupported position can assess the true magnitude of the deformity in the presence of axial loading. Spinal deformity and recruitment of compensatory mechanisms are best evaluated with full 36-inch cassettes or full-body imaging. For purposes of standardization and for optimal visualization of critical landmarks, the "clavicle position" should be utilized when the patient stands unsupported in a position of comfort, with elbows fully flexed and fingers placed at the supraclavicular fossa.

Computed tomography (CT) and magnetic resonance imaging (MRI) to assess for pseudarthrosis and neural compression are important standard components of the preoperative radiographic workup for adult spinal deformity. Baker et al demonstrated that lumbar MRI and CT have further utility in determining lumbar flexibility. A change in pelvic incidence (PI)-lumber lordosis (LL) mismatch identified on supine imaging can obviate the need for a more invasive three-column osteotomy.

The literature is replete with studies that demonstrate the negative health impact of sagittal spinal deformity. The sagittal vertical axis (SVA) has been widely used to quantify spinal malalignment, but the complexities of standing alignment cannot be described with this parameter alone. Researchers have demonstrated that the pelvis is a key component of the spinopelvic axis and an important regulator of standing alignment. The SVA should always be considered in tandem with the pelvic tilt—a measure of pelvic retroversion.

Another key parameter is PI, which does not change after skeletal maturity. PI has been described as useful for assessing pathologic changes to LL because PI is related to pelvic tilt and sacral slope (PI = PT + SS), and sacral slope is highly correlated with LL in asymptomatic well-aligned patients. Sagittal malalignment results in changes in pelvic version, but because PI is a static parameter related to LL, surgeons can utilize the PI-LL relationship to determine optimal sagittal correction.

Patients with sagittal spinal deformity utilize predictable compensatory responses to optimize their standing alignment depending on the magnitude of their deformities. A deformity localized to one or more spinal regions will lead to compensatory changes in adjacent regions, followed by compensatory changes in the pelvis and, finally, in the lower extremities.

Pelvic retroversion is a key compensatory mechanism in the modulation of standing alignment. When attempting to reposition the center of gravity of the body over the feet, a patient with spinal deformity will rotate the pelvis backward through the femoral heads to maintain economic standing posture. Pelvic retroversion is one of the first
mechanisms of compensation adopted by adult patients with spinal deformity. Furthermore, patients with poor motor strength, including frail and sacropenic elderly patients and those with neurodegenerative disorders such as Parkinson disease, cannot effectively tilt the pelvis, even in the presence of severe sagittal malalignment. Patients with a relatively small pelvic tilt often demonstrate greater levels of disability.

Pelvic retroversion is the most important compensatory mechanism to be considered in planning for surgical correction of sagittal malalignment. Failure to recognize increased pelvic tilt in a well-compensated lumbar flatback deformity or in a large sagittal deformity with increased SVA can lead to under correction, residual sagittal malalignment, and persistent pain and disability.

A novel measure of sagittal spinal alignment is the T1 pelvic angle (TPA), which accounts for sagittal inclination and pelvic tilt simultaneously. The TPA has been shown to correlate with health-related quality-of-life measures and is useful in perioperative planning because it is a direct measure of the geometry of spinal deformity separate from pelvic and lower extremity compensation (Figure 1). TPA can be measured on a full-length intraoperative radiograph to confirm appropriate deformity correction. Furthermore, the alignment goal for TPA can be deduced intuitively. This measure is the sum of T1 spinopelvic inclination and pelvic tilt, and surgical correction requires restoration of spinal inclination back to a neutral or slightly negative position and correction of the pelvic tilt to a normal range (15°–25°).

Using TPA, surgeons may optimize postoperative correction of the spine to fit the patient’s age. Recent work suggests that a TPA target of 10° to 15° is optimal for middle-aged patients (age 40–65), and a TPA target of 15° to 25° is favorable for elderly patients (age >65).

Adult spinal deformity is a complex pathologic process with many etiologies and several mechanisms of compensation. A complete understanding of spinopelvic alignment is required to differentiate the origin of deformity from its compensation and, ultimately, to optimize surgical correction. Compensatory mechanisms are activated in a predictable manner and progress to include pelvic and lower extremity mechanisms such as pelvic tilt and knee flexion as tolerated. Optimal correction can be determined on the basis of radiographic spinopelvic parameters such as PI, LL, PT, and TPA.

References