Sagittal balance is a concept familiar to spine deformity surgeons. Postural imbalance with displacement of the patient’s center of gravity anteriorly to the sacrum due to spinal disease is biomechanically disadvantageous and may cause significant pain and ambulatory difficulty. The evaluation of patients with sagittal imbalance involves a careful assessment of the thoracic kyphosis, lumbar lordosis, and pelvic angulation. Surgical planning prior to operative treatment involves careful study to determine the correct location and amount of sagittal angulation that needs to be achieved to create neutral sagittal balance. Equally important is the preservation of neutral sagittal alignment in patients without sagittal imbalance who undergo fusion in which instrumentation is placed from the lumbosacral spine to the pelvis; these patients possess a minimal ability to compensate for any sagittal imbalance postoperatively.

Although there is a long history of the surgical treatment of sagittal-plane deformities and sagittal imbalance and the reasoning behind these tenets seems sound, the outcome-based evidence supporting the importance of C7–S1 balance is not strong. Additionally, the applicability of these concepts to degenerative and other nondeformity pathological entities has not been established. For example, should a patient with single-level stenosis but lumbar hypolordosis due to degenerative disc disease be considered for a multilevel instrumentation-augmented fusion to “correct” the lumbar sagittal contour? Should patients whose sagittal spinal contour is 1 or 2 standard deviations (SDs) outside of the age-specific norm or some other measure be considered patients suffering from spinal deformity? Should all lumbar decompressions be performed with instrumented fusions to maximize segmental lordosis and minimize the risk of developing sagittal imbalance? These provocative questions are not entirely implausible if the reasoning behind sagittal balance is extended to its logical extreme.

In their paper “Neutral upright sagittal spinal alignment from the occiput to the pelvis in asymptomatic adults: a review and resynthesis of the literature,” Kuntz and colleagues present the results of their review and analysis of neutral sagittal spinal alignment. Kuntz et al. distilled 12 previously published studies in which authors reported various measures of spinal alignment from the occiput to the pelvis. From these studies, they calculated pooled estimates of the mean value and the SD for 23 separate parameters of spinal alignment, and they present their findings in tabular form. Kuntz et al. conclude that, although regional kyphotic and lordotic angulation may vary widely, global spinal sagittal balance (measured by either the relationship of a C-2 or C-7 plumb line to the sacrum or by the angular displacement of T-1 or T-9 relative to the hip axis) is maintained within a relatively narrow range in asymptomatic adults.

Kuntz and associates’ efforts to evaluate and compile the results of the many studies on regional spinal alignment were substantial. Although there are no new data in their study, their pooled estimates of the population mean can yield more accurate results than the original individual studies if the study populations are relatively homogeneous. Furthermore, compiling the mean regional sagittal contour measurements into a single table enhances our understanding of the relationships between the regional curves that are important both for deformity correction and for the avoidance of iatrogenic deformity. In general, for example, patients with neutral sagittal spinal alignment have approximately 20° more lumbar lordosis than thoracic kyphosis. The study is limited, however, in that the data were obtained from different studies, in none of which did investigators examine global sagittal balance and all of the regional measurements from occiput to pelvis in individual patients.

As Kuntz and coworkers assert in their paper, “increasing emphasis is being placed on the preservation or restoration of neutral upright sagittal spinal balance. The regional and global alignment of the spine after fixation and fusion is increasingly recognized as a significant factor in postoperative clinical outcomes.” Although no data are presented to support their statement that awareness has been heightened, it is our perception, also, that sagittal balance is currently a topic of particular concern among spine surgeons. A PubMed title/abstract search for “sagittal balance” supports these impressions. Between 1993 and 2001, no more than six articles were found for each.
With Kuntz and coauthors’ publication of normal or average sagittal spinal measurements and with the concerns regarding the proper application of these concepts and measurements to clinical practice, it is worthwhile to examine the published evidence of an association between sagittal alignment and clinical outcome. The authors of several recent studies have examined this relationship in patients with spinal deformity and degenerative disease. A critical analysis of these papers may help the spine surgeon to evaluate the clinical importance of a deviation of either overall sagittal balance or segmental alignment from normative population data.

Glassman et al. have reported the results of a prospective multicenter observational study of 298 patients with adult scoliosis. Their key conclusion was that “Positive sagittal balance predicts clinical symptoms in adult spinal deformity.” Although there are some data in that report that support their finding, their results are neither as clear cut nor compelling as that statement implies. The authors divided the patients into two groups based on sagittal balance: negative (patients with a C-7 plumb line posterior to the posterosuperior margin of the S-1 endplate) and neutral or positive (patients with a C-7 plumb line through or anterior to the posterosuperior margin of the S-1 endplate). Based on this dichotomous classification, they found that, at a probability value of less than 0.05, neutral or positive sagittal balance was associated with greater pain, worse function, worse self-image, and poorer social function, as measured by the Scoliosis Research Society–22 (SRS-22), Short Form–12 (SF-12), and Oswestry Disability Index (ODI) instruments, compared with negative sagittal balance.

Closner examination reveals, however, that the magnitude of difference in outcome instrument scores is, in several cases, quite small, particularly among patients who have not undergone prior surgery. The mean ODI scores in the two groups among patients without a history of surgery differ by nine points, just below the Food and Drug Administration threshold of 10 points for a minimal clinically significant difference. The differences in SRS-22 scores between the negative sagittal balance group and the neutral/positive group range from 0.2 (self-image) to 0.5 (function). These values are likely at or less than the threshold of a minimal clinically significant difference. The differences in mean SF-12 subscale scores range from 11 (social function) to 23 (function). The significance of these differences is difficult to determine as the developers of that instrument have recommended against using the subscale scores because their instability. The differences among patients with a history of surgery were generally of larger magnitude but, with the exception of the ODI scores, very close to the threshold of a minimal clinically important difference.

Analyzing sagittal balance as a dichotomous variable also potentially limits the strength of the authors’ findings, particularly because patients with neutral sagittal balance are included with those with positive sagittal balance in each subgroup. The strongest evidence in favor of a relationship between sagittal balance and clinical symptoms would be derived from a study involving a large-magni-
association. Additionally, there was no correlation between the overall lumbar lordosis, the L-1 plumb line, or the magnitude of spondylolisthesis as independent variables and outcome. In addition to the aforementioned limitations of correlation analysis techniques, the results of these two papers seem to support the conclusion that more lumbar lordosis is always better, regardless of the initial alignment.

Intuitively, neutral sagittal balance should be associated with less pain and better function than positive sagittal imbalance. Particularly among patients who have previously undergone surgery and those with posttraumatic or ankylosis deformity, sagittal imbalance may be a major source of pain and disability. In some cases it may be the primary spinal disorder. Treating these patients effectively requires the appropriate correction of the spinal deformity and restoration of functional spinal alignment. Additionally, preventing iatrogenic sagittal-plane deformity should be a key objective for every surgeon who performs spinal arthrodesis. We must be careful, nevertheless, not to approach the spine as a trigonometry problem and extrapolate associations between radiographic measurements and clinical outcomes without evidentiary support. Spine surgeons have accepted at face value the importance of sagittal alignment and the restoration of sagittal contour. Although these beliefs are widely held and a few studies seem to support the existence of a relationship between sagittal balance and clinical outcome, a review of the literature shows that our data lag far behind our logic. In this light, the present paper by Kuntz et al. represents an important incremental step in our understanding of spinal disorders, but the reported mean values should be interpreted as population parameters, not as measurements from an ideal template to be applied indiscriminately to patients.

References

RESPONSE: We would like to thank Drs. Angevine and McCormick for providing this important perspective. The evaluation of patients is multifactorial including a history, physical examination, and imaging as well as laboratory investigations. Sagittal spinal alignment is one important aspect in the evaluation of patients with spinal disorders.

As residents, fellows, and young surgeons, we were too often myopic as we evaluated patients with spinal disease, focusing on the local spinal disease and overlooking the remainder of the axial skeleton. This myopic view resulted in patients needing further surgery to restore neutral upright spinal alignment. Our manuscript and future research are directed at better understanding regional and global spinal alignment.

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