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Review Article

Selection of fusion levels in adults with spinal deformity: an update

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Abstract

BACKGROUND CONTEXT: Adult spinal deformity (ASD) is commonly associated with disability and represents a challenging condition for physicians. Although surgical management has been reported as superior to conservative care, the choice of patient-specific optimal strategy has been poorly defined. A key question remains selection of fusion levels as this implies careful balance of risks and benefits.

PURPOSE: The aim of this review is to propose an update on current knowledge related to optimal fusion levels in the surgical treatment of ASD.

STUDY DESIGN: Literature review.

METHODS: Based on a comprehensive literature search, recent studies focusing on the management of ASD were reviewed to establish current concepts on fusion levels in the management of symptomatic ASD.

RESULTS: Despite numerous published studies, the management of ASD and specifically optimal fusion levels is incompletely defined. Described approaches carry benefits and risks. However, the need for detailed analysis and preoperative planning is confirmed as a prerequisite to obtaining realignment objectives and good outcomes.

CONCLUSIONS: The treatment of ASD is emerging as an important health-care issue of the 21st century because of prevalence and cost. Despite technical advances related to ASD surgery, complication rates remain elevated, particularly in the older population. Recent research, mostly driven by outcome measures, has improved our understanding of optimal treatment approaches to ASD. The development of a widely accepted classification system will help to share knowledge and improve our ability to treat these complex patients.

Keywords: Spinal deformity; Surgery; Outcomes; Review; Level of fusion

Introduction

Adult spinal deformities (ASDs) are complex pathologies associated with a broad range of clinical and radiological presentation. Precise prevalence is difficult to evaluate but has been reported to be as high as 60% in the general population older than 60 years [1]. Numerous studies have reported radiological and clinical outcomes related to ASD surgery, but clear therapeutic consensus is still not available. From previous results, however, it is possible to elaborate some algorithms for the management of ASD patients. According to some authors [2], therapeutic strategy for adult patients should be based on both clinical and radiographic evaluation (pain and disability). This differs from treatment for adolescent deformities where radiological findings typically guide treatment. Positive impact of ASD surgery outcomes has also been reported with an

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improvement of back and leg pain at 2-year follow-up when compared with nonoperative strategies [3,4].

When a surgical treatment is indicated, one of the areas of ongoing debate remains the selection of end levels relating to fusion and instrumentation. At the distal end of the construct, although preserving levels will preserve mobility, it can also increase the risk for postoperative complications and revision surgeries. In addition to the concerns of distal fusion level, proximal extent of the fusion also requires specific attention because of the risks of instrumentation failure and proximal junctional kyphosis (PJK).

The aim of this work is to propose an update on the decision-making process for selection of fusion levels for ASD patients.

Radiographic evaluation of an ASD patient

To precisely evaluate a spinal deformity patient, satisfactory radiographs are needed. Standard imaging consists of 36" full-cassette standing anteroposterior (AP) and lateral free-standing radiographs. Although complementary examinations, such as AP and lateral bending films, can sometimes be useful, specific attention must be paid to these two standard views to have a precise evaluation of spine alignment. Arms positioning must be taken into account according to the fact that different positions or holding a support can lead to significant underestimation of sagittal alignment [5,6]. Based on the study of Vedantam et al. [6], positioning the arms with 30° shoulder flexion has the less impact of sagittal alignment.

With the relationship between the spine and pelvis being of paramount importance in the workup of these patients, ideal AP and lateral views must include visualization from the external auditory canal to the femoral heads.

Coronal plane deformity

Radiographic characterization of ASD patient in the coronal plane is usually extrapolated from the Lenke Classification system for adolescent idiopathic scoliosis (AIS) [7]. However, this classification system is not reliable for adults because of differences in deformity patterns between adolescent and adults. Although ASD evaluation must take into account global alignment, pelvic compensation (pelvic tilt [PT]), and focal issues (stenosis, subluxation, and degeneration), AIS does not bear these hallmarks, and therefore, the Lenke Classification does not consider them.

Global coronal alignment of the spine is assessed on the AP view by measuring the offset of the head in relation to the center sacral vertical line. In general, offsets of less than 5 cm are deemed normal, with greater offsets defining coronal malalignment. Specific evaluation points can also be visible at the extreme ends of the deformity:

- At the upper end, the clavicle angle [8], defined as the angle between a line joining the two clavicles and the horizontal, can be measured and will reflect shoulder asymmetry.
- At the caudal end, pelvic obliquity and oblique takeoff of L5 can be measured (in the absence of lower limb discrepancy) and are often involved in the decision to include the L5–S1 disc in the fusion.

Sagittal plane deformity

The importance of the sagittal plane evaluation has been increasingly recognized in the last decade. Classical parameters can be measured on a lateral X-ray, such as thoracic kyphosis (TK) from T4 to T12 and lumbar lordosis (LL) from L1 to S1. Different plumb lines and offsets have been described [9,10] in an effort to evaluate the global alignment (Fig. 1).

- The sagittal C7 plumb line and the sagittal vertical axis (SVA) defined as the horizontal offset from the centroid of C7 to the posterosuperior corner of S1.
- T1 and T9 spinopelvic parameters defined as the angle between the vertical plumb line and the line joining the center of the femoral axis to the center of the vertebral body (T1 or T9).

Furthermore, it is now established that radiographic evaluation of the spine must include the pelvis. The pelvis, as described by Dubousset [11], is a "pelvic vertebra," linking and interacting with the spine and lower limbs. Three main pelvic sagittal parameters have been described by Duval-Beaupere et al. [12,13] including pelvic incidence (PI), PT, and sacral slope (SS) (Fig. 2).

Pelvic incidence is a relatively constant morphologic parameter changing little throughout adulthood in a subject, whereas PT and SS vary according to pelvic position. These three pelvic parameters are interrelated by the equation PI=PT+SS. Variations of PT and SS are commonly reported as compensatory mechanisms in the setting of spinal malalignment and aging, acting as through a chain of correlation with other sagittal parameters (Fig. 3). For example, during the aging process, an increase of TK is commonly noticed, leading to a trend to pelvic retroversion (increased PT), loss of LL, and finally increased SVA. Mean normative values of radiographic spinopelvic parameters [13–18] have been reported as follows: 43° for TK, 60° for LL, 52° for PI, 12° for PT, and 40° for SS (Table 1).

Sagittal plane variations are frequently noted and considered as compensatory mechanisms to maintain satisfactory global alignment regarding the gravity line. This sagittal malalignment has also been correlated to self-related pain and disability. In addition to global spinopelvic parameters, Schwab et al. [19,20] have reported that intervertebral subluxation and loss of lordosis were associated with poorer health-related quality of life (HRQOL) scores. These results correspond with the study of Glassman et al. [21], which reviewed 352 patients for whom an increased