



DECISION MAKING FOR SURGERY IN ADULT SCOLIOSIS REVIEW OF THE CURRENT LITERATURE

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ABSTRACT

Adult spinal deformity is a challenging condition in spine surgery. Adult scoliosis (AS) is an important health issue with potential to cause severe surgical adverse ramifications in aging population. Deciding who is going under the knife is still a debatable issue with no clear algorithm. This review of the recent literature is representative of the results of modern intervention methods and it references to competent authorities aiming to help clinicians to supply a guideline for surgical decision making in AS. A search in the National Library of Medicine (PubMed) database using keywords AS was performed. Our search yielded 4247 articles published between January 2005 and March 2019. When added the "surgical decision", it accounted for 105 articles. For the literature review, of papers, especially focusing on surgical decision-making, 27 were selected as guiding articles.

Non-surgical interventions for symptomatic AS cases lack a high level of evidence. Successful results were reported for local decompression, limited short segment fusion, and deformity correction with long segment fusion surgeries for selected cases. Leading factors for surgery seems to be a symptomatic case with a functional problem (primarily painful radiculopathy), self-image problems, a higher curve, and recently with an extra emphasis on sagittal malalignment. Patient's expectations, pain intensity, functional status, perception of self-image and medical risk stratification, surgeon's experience, and contentment will shape the strategy needed for decision-making for surgery and whether to address either a focal pathology or comprehensive deformity correction. Every case has to be managed according to its own characteristics.

Keywords: Adult scoliosis, degenerative, idiopathic, decision-making process, surgical indication, spine surgery

INTRODUCTION

Adult scoliosis (AS) is a term to define a lateral curvature of the spine more than 10 degrees of Cobb curve with accompanying vertebral axial rotation in a skeletally mature spine^(47,13). The incidence of AS is approximately 1.4-32%, and as high as 68% in patients over 60 years of age in a healthy adult population⁽⁷⁴⁾ and it is rising in conjunction with the aging population. Young patients with scoliosis almost always have a self-image complaint when they have been first seen in the clinic. However, patients with AS, in addition to deformity and cosmesis, mostly have a complaint like pain, neurological deficits, and psychosocial concerns namely "disability". Two main types of AS are idiopathic and degenerative subtypes. Idiopathic form is a continuation of an infantile or adolescent onset diagnosis whereas degenerative or so-called "de novo scoliosis" is believed to develop through asymmetric disk space collapse and facet degeneration with subsequent lateral and/or rotatory listhesis⁽⁷⁾. Differentiation of adult degenerative scoliosis from idiopathic counterpart can be somewhat confusing because of the complexity of the disease process and difficulties in the description and classification of the deformity. Sometimes it is very challenging to discriminate degenerative scoliosis just

by inspecting the X-ray images. Even so, there are some clues for radiological differentiation. For idiopathic AS, deterministic factors are younger age, larger Cobb angled curves (>40°), an obvious compensatory curve, and a rotatory deformity along the whole curve. On the other hand, degenerative cases have an older age (>50), lesser curve size (<40° Cobb angle), a rotatory deformity at the apex, and a higher incidence of spinal stenosis, lateral vertebral subluxation of vertebral body, and sagittal imbalance (Figure 1)^(7,10,17,36,67). The ideal treatment of AS has not yet been identified; both surgeons and clinicians face multiple challenges, including non-surgical and surgical treatment. For surgical treatment; choosing the included segments, preserving lower lumbar vertebrae and pelvis, setting ideal sagittal and coronal alignment, the ideal age, timing for surgery, and maybe still some cosmetic issues as in AIS should be concerned. In addition, deciding whether to go for surgery or to perform which surgical intervention (local decompression, short segment fusion or longer fusions) is limited to "expert opinion or surgeon's personal bias in the facility which they were educated". However, patients with AS constitute a heterogeneous population with a clinical complaint and additional degenerative changes, thus, it is difficult to compare the outcomes of different management strategies in meaningful

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numbers of patients. In addition, there is still a lack of outcome assessment tools for this complex group of patients. The factors affecting the surgical decision in the literature are mainly from “what we did and succeeded or failed” inferences. These mainly focus on patient-reported outcome measurements (PROMs) and complication rates. If one surgery has a significant improvement in health-related quality of life (HRQoL) and with a low complication rate on a similar group of AS patients, then it is logical to choose more patients in the same condition, who are waiting for a decision to be made. Through the past two decades, understanding the importance of the restoration of normal sagittal alignment is one of the fundamental goals in deformity correction surgery, and rod pre-contouring is a standard procedure in almost all modern correction techniques for sagittal alignment control. However, defining ideal sagittal shape and alignment for the surgically corrected spine is still a debatable topic today^(26,27,49,71). AS was found to have a devastating effect on HRQoL in several studies^(5,61), like the Short Form-36 Physical Component Score values for this cohort were similar to the values reported by patients with chronic heart disease, and the disease impact of large sagittal malalignment (sagittal vertical axis >10 cm) was greater than that reported by patients with limited vision and patients with limited use of arms and legs. A reputable classification system for AS should be that it distinguishes between clinically significant groups of cases with the disease, it is easy to apply in clinical settings, it is reproducible over time and among observers, it guides the surgical treatment, and it predicts outcomes. Ad hoc, first, King and Lenke classifications took place for adolescent scoliosis in 1983 and 2001, respectively, and then the need for more comprehensive definitions arose

for AS. The Simmons classification system⁽⁵⁵⁾, Aebi⁽¹⁾, Scoliosis Research Society⁽⁴⁾ and the SRS-Schwab Adult Spinal Deformity Classification⁽⁶⁾ have emerged for these needs. One put effort to cover others’ inadequacy, mainly focusing not only the coronal deformity but also the sagittal alignment and the disabled state of the patient. The simple pathogenesis-based approach of Aebi⁽¹⁾, the strong clinical relevance of the Schwab approach, and the richly descriptive SRS systems all gained popularity. Moreover, the ideal classification system for AS continues to be re-evaluated by researchers. Many groups continue to devise classification systems as both surgical techniques and the understanding of scoliosis are refined. During the past decade, advancements in surgical techniques, instrumentation, supported with the multidisciplinary advance in anesthesia, radiology, and understanding the importance of sagittal global alignment and its proportions have changed the management of adult spinal deformity surgery and led to improved long-term outcomes. Therefore, this study focuses on the current literature for reliable and valid information.

MATERIALS AND METHODS

A search in the National Library of Medicine (PubMed) database using the keywords ‘AS’ has yielded 4247 articles published between January 2005 and March 2019. When added the “decision”, it accounted for 105 articles. All information on outcome measures was extracted. Referenced clinical studies were retained in full text analyzed. We assessed the quality of each study based on following criteria: minimal number of patients, construct validity, internal consistency, criterion validity, reproducibility, responsiveness, up-to-dateness, and interpretability. As a result, 27 papers, especially focusing on surgical decision-making, were selected for the review (Figure 2) (Table 1).

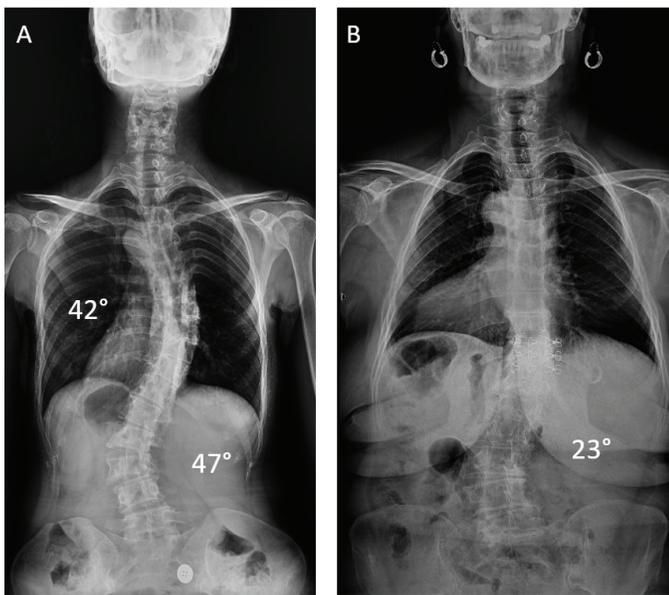


Figure 1. Case examples for 37 years old patient with idiopathic (A) and a 67 years old patient with degenerative adult scoliosis. Note the lesser curve size and absence of compensatory curve in (B)

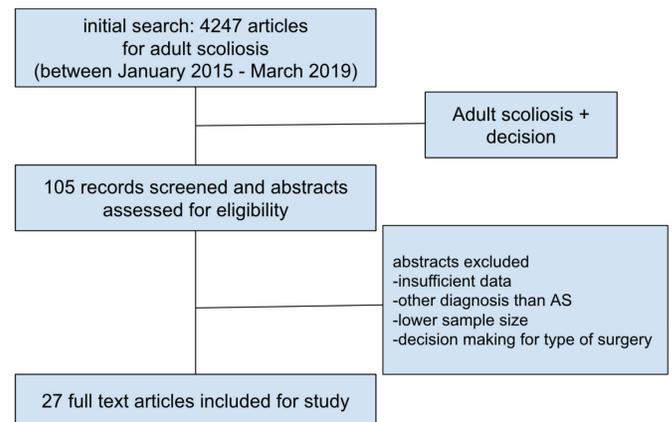


Figure 2. Flowchart of the study selection process

DISCUSSION

The PROMs, the intensity of symptoms, patient demographics, accompanying co-morbidities, coronal deformity and imbalance,

Table 1. Papers and remarks related to decision making for surgery in adult scoliosis

Publish year	Author	Study design	Cobb curve	Remarks
2006	Glassman et al. ⁽²¹⁾	RP	>30°	Sagittal plane deformity, worse PROMs more in surgical groups
2007	Glassman et al. ⁽²⁴⁾	RP	>30°	Nonsurgical patients had greater preoperative medical risk factors. Surgical patients had more frequent leg pain, a higher mean level of daily back pain, and more frequent moderate-to-severe back pain
2008	Smith et al. ⁽⁵⁷⁾	RP	>20°	Development of neurological symptoms and/or deficits is strongly associated with the decision to pursue operative treatment
2009	Pekmezci et al. ⁽³⁹⁾	R	>30°	BMI, comorbidity scores, back pain, and leg pain incidence, and severity were similar among operative or nonoperative groups. Functional limitations are more important than pain for adult deformity patients when deciding for operative or nonoperative treatment
2009	Smith et al. ⁽⁵⁸⁾	RP	>10°	Compared to nonoperative treatment, surgery can offer significant improvement of back pain for adults with scoliosis
2009	Smith et al. ⁽⁵⁹⁾	RP	>10°	Surgical treatment has the potential to provide significant improvement of leg pain in adults with scoliosis
2009	Wood et al. ⁽⁶⁷⁾	R	>30°	Patients treated operatively reported significantly less pain and better health-related quality of life, self-image, mental health, and global restoration. Preoperative radiographic parameters were not determined to be a significant factor for predicting whether an operative or nonoperative treatment course was chosen
2009	Bridwell et al. ⁽⁸⁾	P	>30°	Common nonoperative treatments do not change the HRQoL in patients with ASLS at 2-year follow-up. However, operative treatment does significantly improve HRQoL
2009	Bess et al. ⁽⁵⁾	R	>20°	Counter to previous reports, age, comorbidities, and sagittal balance did not influence treatment modality for AS. Operative treatment of younger adults with scoliosis was driven by coronal deformity. Operative treatment of older adults with scoliosis was driven by pain and disability, independent of radiographic deformity
2010	Fu et al. ⁽²⁰⁾	PR	>20°	Operative intervention group reported worse health, greater disability and had a higher level of comorbidity. Relative contraindications to surgery; age greater than 75 years and a Charlson Comorbidity Index score greater than 5 are used as discouraging criteria
2011	Smith et al. ⁽⁶¹⁾	PR	>30°	Elderly, despite facing the greatest risk of complications, may stand to gain a disproportionately greater improvement in disability and pain with surgery
2011	Kotwal et al. ⁽³⁰⁾	Review	-	The presence of lateral listhesis, spondylolisthesis, and sagittal or coronal decompensation, despite a low Cobb angle, is believed to be more important in decision-making
2012	Lonergan et al. ⁽³³⁾	R	-	Age alone should not be the deciding factor or a contraindication for patients in their 8 th decade of life who are incapacitated by their painful spinal deformity
2014	Cho et al. ⁽¹⁰⁾	Review	-	Short fusion is indicated in cases with less Cobb angle, minimal rotational deformity, and no coronal and sagittal imbalance. Long fusion is indicated in cases of severe Cobb angle and coronal and sagittal imbalance
2015	Sciubba et al. ⁽⁵⁰⁾	PR	>20°	Surgery provides significant improvements in pain and disability in patients aged >75
2015	Scheer et al. ⁽⁴⁴⁾	PR	>20°	Surgical management resulted in significantly greater improvement in both back and leg pain severity than nonsurgical management. Moreover, patients whose ASD was managed nonsurgically were more likely to experience no improvement or worsening of their pain
2015	Smith et al. ⁽⁵⁸⁾	P	>20°	Operative treatment for ASD can provide significant improvement of HRQoL at a minimum 2-year follow-up. In contrast, nonoperative treatment on average maintains presenting levels of pain and disability



2016	Parent et al. ⁽³⁸⁾	P	>30°	Patients with worse PROs, more back pain, more back and leg pain with ambulation, and larger lumbar Cobb angles are more inclined to select surgical over nonsurgical management
2016	Shaw et al. ⁽⁵³⁾	Review	-	Patients experiencing complications are significantly older and there is a progressive increase in complication rates with each decade of life
2016	Graham et al. ⁽⁴²⁾	Review	-	Both objective radicular weakness and neurogenic claudication are essentially predictive of a patient with adult spinal deformity choosing to undergo surgery
2016	Pizones et al. ⁽⁴⁰⁾	PR	>20°	Clinical symptoms, particularly function impairment, motivated patients to undergo surgery. Neither demographic nor radiographic parameters influenced decision-making about surgery
2016	Christiansen et al. ⁽¹²⁾	Review	-	Although more likely to experience complications, the older and more disabled patients may actually stand to gain the most from surgical intervention
2017	Teles et al. ⁽⁶³⁾	Review	-	No randomized controlled trial was identified in our search to support the long-term value of current nonsurgical therapeutic options
2017	Faraj et al. ⁽¹⁸⁾	R	>10°-55°	No significant difference in functional outcome was found between surgical and nonsurgical groups after a mean follow-up of 10 years. Certain patients can benefit from nonsurgical management after long periods of time
2018	Fujishiro et al. ⁽²²⁾	PR	>20°	Aside from the HRQoL measures and coronal deformity, sagittal parameters were identified as a significant factor
2019	Lonner et al. ⁽⁵⁴⁾	Research support	>40°	The adult scoliosis patient begins with worse QoL and improves to a greater extent in most domains than their adolescent counterpart
2019	Fujishiro et al. ⁽²¹⁾	PR	>20°	The first algorithm to guide the decision-making process for the ASD population and could be one of the indices for aiding the selection of treatment for ASD

RP: Retrospective review of prospectively collected data; R: Retrospective study, P: Prospective study, AS: Adult scoliosis, PROM: Patient-reported outcome measure, HRQoL: Health-related quality of life, BMI: Body mass index, ASD: Adult spinal deformity, ASLS: Adult symptomatic lumbar scoliosis

and sagittal malalignment all have a part in decision-making to pursue surgery for AS patients. Most studies have examined the factors influencing decision-making in AS by questioning the distinguishing determinant factors among surgical and nonsurgical cases.

Conservative Treatment

Initial management of symptomatic AS, without progressive neurologic deficit, basically comprises non-surgical treatments in order to avoid the inherent morbidity of extensive surgeries. However, nonsurgical modalities play a little role in ASD and there is a lack of evidence in the literature and most of the existing evidence is derived from observational studies with a high risk of bias^(16,41,58,63,). On the contrary, there is literature evidence of supporting conservative interventions for selected cases. Non-operative methods should be tried first and all means be consumed before the talk of surgery^(32,50,56). Conservative treatment includes aerobic exercise, aquatics/pool therapy, strength training, stretching exercises, postural training, body mechanics physical agents methods, analgesics, nonsteroidal anti-inflammatory drugs, narcotics, pain management, epidural blocks, facet or nerve root injections, bracing, bed rest, weight loss programs or “no treatment”. On the other hand, there is the option of “surgical treatment” with up to 80% (9.52%-81.52%) complication rates and more than 50% re-operation rate, reported in several papers^(8,9,63,68). Teles et al.⁽⁶²⁾ reported postoperative radiological (7 main categories) and instrument-related (7 main categories) complications and Christiansen et

al.⁽¹²⁾ modified their work and stated 46 major and 41 minor complications under 10 main categories (infection, implant-related, neurological, cardiopulmonary, gastrointestinal, radiographic, renal, wound problems, operative, and vascular). Surgery may be considered if patients have inadequate improvement with nonoperative measures. Thus, researchers sought for the answer to the question: “why all these patients still choose the operative treatment, despite this much complication rate?”

Why Surgery?

Answers to this question were given by several studies in the scope of risks and benefits. Smith et al.⁽⁵⁸⁾ compared propensity-matched 286 operative and 403 nonoperative patients and reported that 71.5% of operative patients had at least 1 complication, and reported still significant improvements in HQRoL measurements. Bridwell et al.⁽⁸⁾ revealed 31 complications among 85 operated patients and still reported improvements in all HRQoL parameters. Zimmerman et al.⁽⁷³⁾ also stated that in spite of high complication rates (49%), patients benefited from surgery. Trommell et al.⁽⁶⁴⁾ grouped patients in three categories as decompression only, decompression with limited fusion and long fusion and they concluded similar inference with prementioned studies in improvements in PROMs contrast to complications. First three studies also emphasized little or no change in PROMs in non-operative groups in the follow-up. Moreover, Smith et al.^(57,60) reported in two different studies that despite having started with significantly greater leg, back pain

and disability, surgically treated patients at 2-year follow-up had significantly less pain and disability than nonoperatively treated patients who gained nearly no improvement. Surgery has been shown to be superior to non-operative treatment in AS patients with severe disability^(8,49,50).

Back Pain

Back pain is the most common symptom of AS and widely a subjective quality of life measure. It usually presents on the convex side of the curvature. It has been found that the prevalence of back pain in scoliotic adults is no higher than that in the normal population⁽²⁵⁾. Back or leg pain that is refractory to conservative measures is an indication for surgery. Ha et al.⁽²⁵⁾ found that low back pain was no more severe in patients manifesting with lumbar scoliosis than in nonscoliotic cases; however, a specific pain profile, notably a high frequency of cruralgia and inguinal pain, existed for scoliotic patients.

Radicular Pain (Neurological Symptoms and Deficit)

Spinal canal or concave side neuroforaminal stenosis related to either degenerative changes or the scoliotic curve itself can enhance severe enough to result in neurological deficits. Both objective radicular weakness and neurogenic claudication are essentially predictive of a patient with adult spinal deformity, choosing to undergo surgical intervention⁽⁵⁷⁾.

Plenty of reports have showed that the presence of leg pain is an independent predictor of a patient's preference for surgical over nonsurgical care^(23,39,57,73). Smith et al.⁽⁵⁷⁾ described a best-fit model for a surgery candidate as having 3 of these: severe radiculopathy, radicular weakness, and greater sagittal imbalance. They also excluded the severe back pain from their model.

Age

There is a clear connection between increasing age and higher rates of major short-term complications, a factor that ought to be taken into account during decision-making for treatment and patient counseling^(14,33,53). Older age was once reported to be a relative contraindication⁽²⁰⁾. However, in spite of higher complication rates, more recent studies are in favor of surgery because of its positive impact on PROMs^(50,64,74). Bess et al.⁽⁵⁾ in their study, stratified their patients into 3 groups (G1<50 years, G2=50-65 years, G3>65 years) and demonstrated larger curves in G1 and G2 versus G3, progressively worsening sagittal imbalance in older age groups, and worse HRQoL scores in G3 versus G1 and G2.

A very sophisticated study is from Lonner et al.⁽⁵⁴⁾ They matched 28 AS patients with 56 (1:2) AIS patient, estimating their natural history of curve progression as a future equivalence of AIS deformities. They found the adult counterparts having greater levels fused, longer operative time, and higher complication rates than the AIS counterpart. Therefore, they emphasized the negative effects of waiting for surgery.

Comorbidities

Fu et al.⁽²⁰⁾ suggested criteria for relative contraindications to surgery as; age greater than 75 years and a Charlson

Comorbidity Index score greater than five. In contrast, Seboaly et al.⁽⁵⁰⁾ reported that in elderly patients greater than 75 years of age, reconstructive surgery can provide significant improvements in pain and disability over a two-year period. The presence of comorbidities, like the age, was once perceived as a restrictive factor for surgical intervention. However, this does not necessarily result in poor outcomes in recent literature, and favorable outcomes are not without complications^(12,74). Somehow, higher risk subjects potentially have more to gain, even if they encounter complications^(12,50,61).

Extension of Surgery

While some authors favor the local decompression in selected cases^(64,73), others advise it should be avoided to protect further curve progression⁽¹⁰⁾. One important issue is that if a long segment fusion surgery is decided for an AS case, the sagittal profile must be corrected properly to avoid postoperative complications^(4,64,70). Based on this, in case of a patient with a severely disproportioned (SD) sagittal spine profile, if one cannot properly restore the sagittal alignment, it is better to do a focal solution or even no surgery.

Patient-reported Outcome Measurements

Several researchers have studied factors influencing decision-making in AS by examining the distinguishing factors between surgical and nonsurgical cases. These factors mainly include the PROMs, the intensity of symptoms, coronal and sagittal imbalance, comorbid state of the patient, and demographics for selecting surgical management and provide information on the decision-making process for the adult spinal deformity (ASD) population. Worse HRQoL scores [Oswestry Disability Index (ODI) >20, SRS <4] in surgically treated groups were reported to be prevalent than the nonsurgical comparisons^(8,20,22,38,39,50,57,74) and after the surgical recovery period passed, these measures were also reported to be improved significantly in surgery cohorts, while the nonsurgical group remained with no significant change^(8,50,74). Glassman et al.⁽²³⁾, in a database of 585 nonsurgical ASD patients, divided the group into high-symptom (335) and low-symptom (250) subgroups, based on age-adjusted ODI scores and found that the 2 groups differed significantly on all standardized patient-reported health status measures ($p<0.0001$). Patients in the low-symptom group (49% vs. 38%) had a primary diagnosis of adult idiopathic scoliosis (<0.01). In the same paper, they also compared 335 high-symptom patients with 476 surgical ASD cases and found a higher incidence of sagittal plane deformity in favor of the surgical group.

Lateral Listhesis and Rotatory Subluxation

Lumbar lateral listhesis is common in AS and it is reported in 13%-34% of cases and it is stated to be an important finding leading to radiculopathy ranging between 43 and 65%^(19,29). The incidence of back pain in patients with AS and rotatory subluxation has been reported as high as 80%⁽⁶⁵⁾. Rotatory subluxation seems to be the initial element of progression

for degenerative scoliosis, while it is the consequence of progression for idiopathic scoliosis⁽⁵⁶⁾.

Glassman et al.⁽²⁴⁾ and Wood et al.⁽⁶⁷⁾ found that the greater apical vertebral translation led to an increased likelihood of surgical treatment among radiological parameters. In contrast, Pizones et al.⁽⁴⁰⁾ found no differences between surgical and nonsurgical groups in terms of radiographic preoperative data, including Apical translation and lumbar rotatory subluxation. Ferrero et al.⁽¹⁹⁾ found a correlation between PROMs and rotatory subluxation as the number of level increase significantly correlated with ODI scores.

The Coronal Curve Imbalance

Sagittal analysis has been broadly outlined in the literature during the past decade, whereas coronal deformity (as it should be a straight line), took little attention. Not like AIS patients, flexibility is limited in AS cases. Coronal alignment seems to have limited influence on the intensity of pain and functional disability⁽⁴⁷⁾.

In the majority of studies, patients in the surgical groups have higher Cobb curve magnitudes than the nonsurgical comparison groups^(21,22,24,54). Glassman et al.⁽²⁴⁾ reported that a coronal shift greater than 4 cm was strongly correlated with a decreased HRQoL and even so they stated that the correction of coronal balance within 4 cm of neutral may not be as important a goal as restoration of appropriate sagittal alignment. The goal should be a balanced coronal spine, rather than zero straight one. The coronal plane does have an effect on the clinical picture and the postoperative failures but seems to have no statistically significant role in decision making^(11,37,51). A clinical note is that patients with a pre-operative trunk shifted to the convex side of the coronal curve are predisposed to having a post-operative coronal imbalance and should be carefully evaluated for decision-making^(37,69).

Sagittal Plane Deformity

In the last decade, spine literature has been reshaped by the “new understanding of sagittal plane analysis”. Significant correlations have been detected in ASD between sagittal lumbopelvic parameters and functional outcomes^(4,49,51,70). It has been shown in many studies now that positive sagittal balance is the radiographic parameter highly correlated with adverse health status measures, poor clinical outcomes, and also postoperative mechanical complications^(13,24,43,57,70). Glassman et al.⁽²³⁾ reported a greater percentage of conservative treatment patients with high symptoms had a diagnosis of sagittal plane deformity ($p < 0.01$) and afterward, compared those 335 high-symptom conservative treatment patients with 476 surgical ASD cases and found a higher incidence of sagittal plane deformity in this time in the surgical group. Schwab et al.⁽⁴⁴⁾ also demonstrated that patients with worse scores in back and leg pain presented greater improvements in HRQoL scores postoperatively. Sagittal parameters such as pelvic incidence/lumbar lordosis (PI-LL) mismatch⁽²¹⁾, relative LL⁽⁷¹⁾ or relative

spinopelvic alignment⁽⁷²⁾ are a strong indicator for pursuing surgical treatment.

Scoring Systems

Global Alignment and Proportion Score

The Global Alignment and Proportion (GAP) score is a new PI-based proportional method of analyzing the sagittal plane in patients undergoing surgery for adult spinal deformity. It can either be used for pre and postoperative sagittal analysis and surgical planning^(70,71,72). For the study⁽⁷⁰⁾, sixth week postoperative sagittal radiograms were evaluated. Adding the age factor as the co-morbidity state, GAP score falls into 3 categories as proportioned (0-2 points), moderately disproportioned (3-6 points), and severely disproportioned (7-13 points). Each category gives a prediction about mechanical complication occurrence. This revolutionary scoring system has also been validated^(2,27,70) and it is still a new concept having ongoing validations.

The Adult Spinal Deformity-Surgical Decision-making Score

In a very recent article on March 2019 on behalf of European Spine Study Group⁽²¹⁾, a total of 316 patients with ASD were analyzed to develop and internally validate a scoring system: the ASD surgical decision-making score, specific to the decision-making process for ASD patients younger than 40 years old. A 10-point scoring system was created from four variables: self-image score in the SRS-22 score, coronal Cobb angle, PI-LL mismatch, and relative spinopelvic alignment, and the surgical indication was graded into low (score 0-4), moderate (score 5-7), and high (score 8-10) surgical indication groups.

Surgical planning is mostly at the preference of the surgeon and also affected by whether the surgeon had a previous history of spinal surgery fellowship training or not⁽³⁾. Advancing literature supports the benefits of surgical treatment for selected ASD patients, further high-quality studies are required to compare operative and nonoperative treatment. It should be noted that one of the internal difficulties in the designs of these studies is the matter that AS patients referred to a spine surgeon might be more symptomatic and hence not representative of the population as a whole. A majority of AS patients may be treated by their primary care providers and never referred to a tertiary spine center. This may considerably alter the findings in most studies.

CONCLUSION

A considerable portion of the AS is asymptomatic and maybe never seen by a spine surgeon. Patients with debilitating symptoms, who are referred to the spine surgeons, are mainly decided to pursue surgery mostly influenced by; sagittal plane deformity, functional problems like radicular unbearable leg and lower back pain especially in walking, larger coronal curves, thereby clinical appearance, worse HRQoL measures, surgical indications among the physicians and assessment of medical risk factors. The radiological parameters especially in coronal

plane, as opposed to AIS, are not as effective as functional limitations and disability in AS for surgery decision-making. Despite high complication rates in adult spinal deformity surgery, benefits patients gain after the surgery outweigh the complication risk. Surgical treatment has the potential to provide significant improvement of leg and back pain in adults with scoliosis. Patients with functional disabilities have a higher tendency to surgical modalities. With the new attempts on classifications and scoring systems, by managing every case according to its own characteristics, surgeon's experience and contentment and the patient's expectations and medical risk stratification will shape the strategy needed to address the pathological processes in adult spinal deformity.

Peer-review: Internally peer-reviewed.

Financial Disclosure: The authors declared that this study received no financial support.

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