Pain and Disability Determine Treatment Modality for Older Patients With Adult Scoliosis, While Deformity Guides Treatment for Younger Patients

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Study Design. Multi-center, retrospective review.

Objective. Identify age associated clinical and radiographic features correlating with AS treatment.

Summary of Background Data. Little information exists about factors determining treatment for adult scoliosis (AS). Existing studies have not evaluated age stratified differences.

Methods. Multicenter, retrospective review of 290 patients treated for AS. Patients divided into operative (OP) or nonoperative (NON), and age stratified into 3 groups (G1 = <50 years, G2 = 50–65 years, G3 = >65 years). Demographic and spino pelvic radiographic parameters evaluated. Health-related quality of life (HRQL) measures included SRS-22, Oswestry Disability Index (ODI), visual analog pain scale.

Results. Treatment groups (OP, n = 137; NON, n = 153) demonstrated similar age (OP = 52.7 years; NON = 55.5 years; P > 0.05) and cormorbidities. OP had larger thoracic curves than NON (OP = 51°, NON = 45°; P < 0.05). OP had worse HRQL scores than NON (SRS = 2.96 vs. 3.12, P < 0.05; ODI = 33.4 vs. 28.7, P < 0.05; visual analog pain scale = 6.9 vs. 5.6, P < 0.05, respectively). Age stratification of OP demonstrated larger curves in G1 and G2 versus G3, progressively worsening sagittal imbalance in older age groups, and worse HRQL scores in G3 versus G1 and G2. Age stratification of NON demonstrated worsening sagittal imbalance with age, however, other radiographic values and HRQL scores were similar between all NON age groups. Treatment stratification of age groups demonstrated G1-OP had greater deformity than G1-NON (mean thoracic curve: G1-OP = 53°, G1-NON = 43°; P < 0.05) but similar HRQL values. Whereas G2 and G3-OP had similar radiographic coronal and sagittal values as G2 and G3-NON, but worse HRQL scores.

Conclusion. Counter to previous reports, age, cormorbidities, and sagittal balance did not influence treatment modality for AS. Operative treatment for younger patients was driven by increased coronal plane deformity. Conversely, pain and disability mandated treatment for older patients, independent of radiographic measures. These findings suggest that AS patients do not become uniformly disabled with age, and that disability can not be solely predicted by radiographic findings. These data should be considered when considering treatment for AS.

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Management of adult spinal deformity is a growing challenge. Adults with scoliosis demonstrate greater functional limitations, greater daily analgesic use, and report worse health-related quality of life (HRQL) compared with adults without scoliosis.1–4 The symptoms and physiology in the adult patient with spinal deformity are more complex than for childhood spinal deformity. Treating physicians must relieve pain, restore spinal balance, and improve function, in a population with less physiologic reserve and less healing potential than children and adolescents with spinal deformity. Additionally, operative treatment of adult scoliosis (AS) is more expensive and is associated with higher complication rates than childhood scoliosis.5–12 Consequently, treatment indications for AS are often inconsistent and indistinct.13–15

Despite the existing volume of literature that describes surgical techniques for AS, little attention has been directed toward treatment decision-making for AS. Glassman et al recently published the results of an investigation that sought to delineate the distinguishing clinical and radiographic features between AS patients treated operatively (OP) or nonoperatively (NON).16 OP patients reported greater leg pain, higher mean levels of back pain, and worse SF-12 subscores than the NON cohort. OP also demonstrated larger main thoracic (MT) and thoracolumbar/lumbar (TL/L) curves than NON. Conversely, NON were older, had greater body mass index (BMI), and greater incidence of cardiac disease than OP. These data provide important information to help understand the distinguishing features that lead to a specific treatment modality for AS. However, the study evaluated a relatively young patient population (mean age 44 years), and did not include a subgroup analysis based on patient age. Increased patient age has been shown to be an inde-
ependent risk factor for surgical complications in AS.6,12,17 Consequently, patient age is likely a major factor when determining treatment modality for patients with AS. The purpose of this study is to evaluate the age stratified clinical and radiographic differences between patients treated OP versus NON for AS.

Materials and Methods

After obtaining approval from the Institutional Review Board at each participating institution, a multicenter, retrospective review of patients treated OP or NON for AS was initiated. Treatment was based on individual surgeon and patient preference. Uniform inclusion criteria at each study site included: patient age (>18 years), diagnosis of adult degenerative or adult idiopathic scoliosis, sciotic curve (>20°), and no prior surgical treatment for scoliosis. Exclusion criteria included: scoliosis etiology other than degenerative or idiopathic (e.g., neuromuscular, congenital, etc.), prior surgical treatment for scoliosis, primary sagittal plane deformities with scoliosis (<20°), and incomplete clinical and radiographic records. Patients were divided into operative (OP) or nonoperative (NON) treatment groups, and stratified into 3 age groups (G1 = <50 years, G2 = 50–65 years, G3 = >65 years).

Demographic evaluation included age, gender, medical comorbidities, and smoking status. All patients had 36° frontal and lateral radiographs. Radiographic evaluation included regional coronal plane measurements including: proximal thoracic, MT, TL/L, and lumbosacral curve measures, and coronal balance. Regional sagittal plane measurements included: thoracic kyphosis (Cobb angle superior endplate of T5 to inferior endplate of T12), thoracolumbar kyphosis (Cobb angle superior endplate of T10 to inferior endplate of L2), lumbar lordosis (Cobb angle superior endplate of T12 to superior endplate of S1), maximal kyphosis, and sagittal balance (distance C7 plumbline to posterior superior corner sacrum). Spinepelvic parameters included: pelvic tilt, pelvic incidence, and sacral slope. HRQL measures included: SRS-22, ODI, and visual analog pain scale (VAS).

Statistical analysis was preformed using SPSS version 16.0. Patients were stratified according to treatment (OP vs. NON) and age (G1 vs. G2 vs. G3). Group analysis (e.g., OP vs. NON) was performed using, Student t test, 2-factor ANOVA and Bonferroni post hoc test. Fisher exact test was used for categorical data. Age and treatment stratified subgroup analysis (e.g., G1 OP vs. G1 NON) was performed using 1-factor ANOVA and Bonferroni post hoc test. Fisher exact test was used for categorical data. P values <0.05 were designated as statistically significant.

Results

Two hundred ninety patients met inclusion criteria and formed the basis of this study. Average patient age was 54 years old (range, 19–90). Sixty-one percent of patients had minimum one medical comorbidity, 16% patients were smokers. Average MT curve was 48.2° (range, 20–132°) and average TL/L curve was 51.3° (range, 20–125°). Baseline HRQL measures were: SRS = 3.1 (range, 1.36–4.77), ODI = 30.8 (range, 0–80), and VAS = 6.2 (range, 0–10; Table 1).

OP (n = 137) and NON (n = 153) groups were similar for mean age, gender distribution, comorbidities, and nicotine use (Table 1). OP demonstrated larger MT curve size (51.2° vs. 45.3°; P < 0.05) and less lumbar lordosis (−43.0° vs. −47.8°; P < 0.05) than NON. All other radiographic parameters were similar. Comparison of HRQL measures demonstrated that OP had worse SRS-22 total score (2.95 vs. 3.12; P < 0.05), worse SRS self-image (2.56 vs. 2.83; P < 0.05), worse ODI (3.4 vs. 3.1; P < 0.05), and greater VAS pain measures (6.9 vs. 5.6; P < 0.05) than NON.

Stratification according to age demonstrated similar patient numbers in G1–G3 (Table 2). Older age groups had more medical comorbidities. Radiographic analysis demonstrated that G2 had larger MT curve than G3 (52.7° vs. 38.6°, respectively; P < 0.05), and G2 had larger TL/L curve than G1 and G3 (55.4° vs. 49.0° and 48.5°, respectively; P < 0.05). Older age groups demonstrated progres-
sively worsening spinal balance, coronal balance, and loss of lumbar lordosis. Older age groups also demonstrated progressively increased pelvic tilt and decreased sacral slope. HRQL analysis demonstrated worsening SRS-22 total score and SRS-22 function subscale score, and worsening ODI and VAS in older age groups.

Stratifying by age in the OP and NON treatment groups, demonstrated that comorbidities progressively increased in the older age groups for both OP and NON (Table 3). G1-OP and G2-OP had larger MT curves than G3-OP, and G2-OP had larger TL/L curves than G3-OP. NON demonstrated similar curve size in all age groups. Both OP and NON demonstrated reduced lumbar lordosis, increased sagittal imbalance, increased pelvic tilt, and decreased sacral slope in older age groups. Older OP groups had worse SRS-22 total and function scores, worse ODI, and worse VAS compared with younger OP. HRQL values were similar for all categories in NON groups with the exception that G3-NON had worse mean ODI score than G1-NON.

Comparing treatment modality within age groups (e.g., G1-OP vs. G1-NON), demonstrated similar patient numbers, age, demographics, and comorbidities in each group (Table 4). G1-OP had larger MT curves (53.0° vs. 43.0°; \( P < 0.05 \)) and larger TL/L curves (52.0° vs. 45.0°; \( P < 0.05 \)) than G1-NON. OP and NON within G2 and G3 demonstrated similar coronal and sagittal radiographic measures. Pelvic parameters were similar OP versus NON in all age groups. Older OP groups (G2 and G3) demonstrated worse ODI and VAS compared with NON. All OP and NON HRQL measures were similar in the youngest age group (G1). G3-OP demonstrated the worst SRS total score, SRS function, SRS pain, ODI, and VAS of all groups.

### Discussion

Patients with AS represent a heterogeneous patient population, with varying clinical presentations, varying treatment indications, and varying treatment outcomes. To better understand this patient population and the reasons for treatment discrepancy, we evaluated the age-based clinical and radiographic differences between patients treated operatively and nonoperatively for AS.

Similar to Glassman et al., we found that OP had larger thoracic curves and more pain than NON. Older OP patients in our study, however, demonstrated greater disability compared with NON, as SRS and ODI measures were worse in the OP group, whereas these values were similar between OP and NON in Glassman’s study. The reason for greater disability reported by patients in our study may be due to an older patient population compared with Glassman’s study (mean age 54 vs. 44 years, respectively). The younger OP versus NON groups in our study demonstrated no differences in HRQL measures, similarly, the younger patient population sampled by Glassman et al. was likely minimally disabled, thus a difference was not detected between OP versus NON.

We found that deformity and disability influence treatment modality. This is supported, in part, by the similar age and comorbidities between the OP and NON groups in this study. Compared with the findings by Glassman et al., the influence of age and comorbidities on treatment was likely less confounding in our study. This allowed more complex factors, including magnitude of deformity and amount of disability, to emerge as predominant factors that correlated with treatment, rather than simply age and comorbidities being the predominant decision-making factors. Furthermore, the homogeneity in age and medical comorbidities between OP and
NON groups further allowed distinguishing patient characteristics to appear when stratifying by age. OP treatment for younger patients in this study appeared to be motivated by deformity, as MT and TL/L curve magnitude was larger for the younger OP patients compared to NON. However, the differences in radiographic deformity became progressively less apparent in the older age groups, and, ultimately, no demonstrable radiographic differences were found between OP and NON in the oldest age group. Disability emerged as the predominant feature for the older patients treated operatively, as sagittal balance, distance C7 plumbline to center sacral vertebral line; Sagittal balance, distance C7 plumbline to posterior superior corner sacrum; SRS-22, Scoliosis Research Society Outcomes Score; P < 0.05, statistical significance; NS, not significant, P > 0.05.

<table>
<thead>
<tr>
<th>OP G1/G2/G3</th>
<th>NON G1/G2/G3</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total patients</td>
<td>55/52/24*</td>
<td>56/52/42</td>
</tr>
<tr>
<td>Age, years; mean</td>
<td>38<em>57/73</em></td>
<td>37<em>67/75</em></td>
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<td>Comorbidities, &gt;1; %</td>
<td>42<em>85/85</em></td>
<td>41<em>87/82</em></td>
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<td>Smoker; %</td>
<td>13/17/7</td>
<td>22/23/9*</td>
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<tr>
<td>MT curve, degrees; mean</td>
<td>53/52/54*</td>
<td>43/53/40</td>
</tr>
<tr>
<td>TL/L curve, degrees; mean</td>
<td>52/58/44*</td>
<td>45/53/51</td>
</tr>
<tr>
<td>Sagittal balance, cm; mean</td>
<td>1.5/2/3/0</td>
<td>1.4/2/5/6</td>
</tr>
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<td>Thoracic kyphosis, degrees; mean</td>
<td>29/23/23</td>
<td>25/23/21</td>
</tr>
<tr>
<td>Lumbar lordosis, degrees; mean</td>
<td>52*/57/33</td>
<td>55*/56/36</td>
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<tr>
<td>Sagittal balance, cm; mean</td>
<td>0.46*/2.6/6.4*</td>
<td>1.3/1.5/6.6*</td>
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<td>SRS-22 total; mean</td>
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<td>SRS-22 function; mean</td>
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<td>3.6/3/3.8</td>
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<td>ODI; mean</td>
<td>27*/28/49</td>
<td>25/24/36</td>
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<tr>
<td>VAS; mean</td>
<td>5.5*7/3.7/8</td>
<td>5.7/3.5/8</td>
</tr>
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G1 indicates age <50 yr; G2, age 50–65 yr; G3, age >65 yr; MT, main thoracic; Coronal balance, distance C7 plumbline to center sacral vertebral line; Sagittal balance, distance C7 plumbline to posterior superior corner sacrum; SRS-22, Scoliosis Research Society Outcomes Score; P < 0.05, statistical significance; NS, not significant, P > 0.05.

Our findings raise important issues surrounding AS treatment, namely, why some patients with AS become more disabled than others. Glassman et al reported that sagittal balance, rather than coronal balance and curve magnitude, is the radiographic feature that correlates most with disability and worse HRQL scores.13 We did find that lumbar lordosis decreased and sagittal imbalance increased with age. Disability also increased with age. However, when stratifying age groups by treatment, both OP and NON age groups demonstrated similar worsening of sagittal balance with increased age, but disability was increased only in the OP group. Similarly, when stratifying treatment groups by age, sagittal balance in the NON group worsened in a similar age related fashion as OP. However, disability values remained similar between all NON age groups, whereas disability worsened in OP. Clearly the factors that cause disability in adult deformity need to be further evaluated. Our results also indicate that curve magnitude does have an influence on treatment modality and that younger patients with larger curve magnitude were apt to have OP treatment. However, SRS self-image scores were inconsistent. Although, OP reported worse SRS self-image scores compared with NON and self-image scores were worse for G2-OP compared with G2-
NON, this relationship did not hold true when evaluating the 3 different age groups and when age stratifying treatment groups.

Limitations to this study include retrospective design and, thus, an inability to delineate the specific factors that determined treatment for each individual patient. Additionally, because the study was retrospective, we were unable to specify if the patient or the surgeon ultimately decided the treatment modality. We would assume that the decision was consensual, however, we can not comment if deformity or disability was the ultimate factor determining treatment for the patient or the surgeon. Further study is needed to compare patient versus surgeon perception on the specific factors that determine treatment modality.

**Conclusion**

In summary, age stratification of patients treated either OP or NON, demonstrated distinct differences between different age groups. Consistent with previous reports, it appears that patients treated OP have larger curve magnitude than those treated NON. However, this difference holds true only for younger patients, as there were no radiographic differences between OP and NON in the oldest age group. Conversely, disability appears to be the factor motivating treatment for older patients. Nonetheless, patients with scoliosis do not become uniformly disabled with age, and disability can not be predicted by radiographic findings, as we demonstrated that the oldest OP groups had worse HRQL measures than NON, despite similar radiographic measures. Further research is needed to delineate the factors that lead to disability in AS, as well as the specific factors that motivate treatment. However, we hope that our findings will aid in patient counseling and treatment decision-making, and will assist further research on the evaluation and treatment of adult spinal deformity.

**Key Points**

- Age, comorbidities, and sagittal balance did not influence treatment modality for adult scoliosis.

- 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.
- Adult scoliosis patients do not become uniformly disabled with age, and disability can not be solely predicted by radiographic findings.

**References**