ORIGINAL ARTICLE

Acta Orthop Traumatol Turc 2016;50(1):57–62
doi: 10.3944/AOTT.2016.14.0421

Adult spinal deformity: a very heterogeneous population of patients with different needs

Rıfat Emre ACAROĞLU[1], Özgür DEDE[1], Ferrán PELLISÉ[2], Ümit O GÜLER[1], Montse DOMINGO-SÀBAT[2], Ahmet ALANAY[3], Francisco Sanchez PÉREZ-GRUESO[4] and European Spine Study Group (ESSG)

[1]Ankara Spine Center, Department of Orthopedics, Ankara, Turkey
[2]Hospital Vall d'Hebron, Department of Orthopedics, Barcelona, Spain
[3]Acıbadem Maslak Hospital, Department of Orthopedics, İstanbul, Turkey
[4]Hospital La Paz, Department of Orthopedics, Madrid, Spain

Objective: The purpose of this study was to analyze and demonstrate the heterogeneity in adult spinal deformity (ASD) populations by baseline health-related quality of life (HRQL) data.

Methods: ASD was defined as patients over 18 years of age with any of the following: coronal deformity >20°, sagittal vertical axis (SVA) >5 cm, pelvic tilt >25°, or thoracic kyphosis >60°. Three hundred fifty-two patients meeting the above definition of ASD were analyzed for measures of HRQL (Oswestry disability index [ODI], SRS-22 [Scoliosis Research Society-22], and SF-36 [Short form-36 health survey] questionnaires) at presentation. Age groups were defined as 18–40, 40–60, and >60 years. Deformity was analyzed as either degenerative (DS) or idiopathic (IS) (294 patients; 71 degenerative, 223 idiopathic).

Results: There were significant differences between age groups–predominantly between the lower age group (18–40) and others –for all HRQL parameters except SRS-22 mental health and SF-36 mental component score. Similarly, HRQL measures for DS and IS deformities were significantly different. Regarding location of main curves, thoracolumbar/lumbar (TL/L) (70.2%) was dominant for the DS group and thoracic (55%) for the IS group. Mean age was 65 years for the DS group and 36 for the IS group, which were significantly different. Radiographic parameters were also significantly different between these groups, with IS patients having more coronal deformity and better sagittal balance.

Conclusion: ASD patients are very heterogeneous at presentation, depending on age and diagnosis. There is a distinct need to stratify ASD as early and late presentation ASD and/or by diagnosis. Patients with IS deformity may be very different from those with DS deformity, even at time of presentation. These differences must be taken into consideration in treatment of these patients, as well as for the analysis of the results of treatment.

Keywords: Adult; spinal deformity, HRQL, radiology.

Level of Evidence: Level III, Cross-sectional descriptive study.

Correspondence: Rıfat Emre Acaroğlu, MD. Ankara Spine Center, İran Caddesi, No: 45/2, 06700 Kavaklıdere, Ankara, Turkey.
Tel: +90 312 – 477 04 42 e-mail: acaroglue@gmail.com

Submitted: November 19, 2014 **Accepted:** September 27, 2015

©2016 Turkish Association of Orthopaedics and Traumatology

Available online at
www.aott.org.tr
doi: 10.3944/AOTT.2016.14.0421
QR (Quick Response) Code

Spinal deformity has been shown to have significant impact on quality of life in affected individuals.[1–4] In order to assess this impact, a variety of clinical questionnaires have been developed.[5–7] These questionnaires are also utilized to compare pre- and posttreatment health-related quality of life (HRQL) and to judge the efficacy of a treatment modality.[8,9] However, the adult spinal deformity (ASD) population is a very large and heterogeneous group of patients, encompassing a wide spectrum of spinal and spino-pelvic deformities in coronal and sagittal planes in patients across all age ranges. The current literature compiles ASD patients under a single uniform diagnostic category, which may cause misinterpretations when analyzing and comparing HRQL scores. Consequently, the variability of reported outcomes after operative and nonoperative treatment for spinal deformity may be a result of the flawed perception of ASD as a fairly uniform diagnostic category.

There is some evidence pointing to the effect of age on HRQL scores[10] and that characteristics of the deformity such as location and etiology may have similar effects.[2,11–13] These differences are important because of the potential implications on subsequent treatment decisions and results. The aim of this study was to analyze the HRQL scores of adult patients presenting with spinal deformity in regard to patient age and etiology as an attempt to stratify ASD into subcategories. Such stratification may prove to be extremely important in future efforts for further classification of ASD.

Patients and methods

This study was based on a prospective database on ASD. The purpose of this database is to evaluate the end results of treatment in this population; however, for the purposes of the present study, only the baseline data at presentation were used. The study was conducted on a total of 352 adult deformity patients enrolled into the database from 4 separate spine clinics. Institutional review board approvals were taken from each clinic separately, allowing for the patients –all of whom gave consent– to be included in this database. Inclusion criteria for this database were patients over 18 years of age with any of the following: coronal deformity >20°, sagittal vertical axis (SVA) >5 cm, pelvic tilt >25°, or thoracic kyphosis >60°. The only criterion for exclusion was the presence of an acute destructive lesion as the cause of the deformity. All patients fulfilling these criteria were enrolled, regardless of the etiology of the deformity (degenerative [DS], idiopathic [IS], congenital, etc.) and any previous treatments. All were asked to complete Oswestry disability index (ODI) and SRS-22 (Scoliosis Research Society-22) questionnaires, as well as SF-36 (Short form-36 health survey) HRQL forms, as part of their routine evaluation.

Anteroposterior and lateral X-rays of the whole spine were obtained for all patients. Those that were not digital were scanned, and all were entered into an X-ray analysis software program (Surgimap Spine, Nemaris Inc., New York, NY, USA) for processing. Measured variables included the coronal Cobb angle(s), lumbar lordosis, T2-12 kyphosis, T1 sagittal tilt, sacral slope, pelvic tilt, pelvic incidence, and SVA. Body mass index data were also collected. HRQL evaluation was performed using SRS-22, age-adjusted SF-36 and ODI questionnaires. Subsets of these questionnaires were then compared between age groups (empirically selected as 18–40, 40–60, and >60 years), and 2 major curve etiology groups (DS vs IS). DS was defined as de novo spinal deformity secondary to degenerative changes in the spinal column for degenerative scoliosis, while IS was defined as spinal deformity conforming with the curve patterns of idiopathic scoliosis, regardless of the presence of (secondary) degenerative changes or age at diagnosis. In all cases, curve etiology determination was based on the treating surgeon's decision. All patients were included for comparisons by age groups, whereas only those with DS or IS etiologies were included for comparisons by etiology. Statistical analyses were performed using SAS software (version 9.2, SAS Institute, Inc., Cary, NC, USA), with the acceptable level of α type error set as 0.05.

Results

Three hundred fifty-two consecutive patients formed the study population. Mean age was 44.1±19 years, and 80.3% of the patients were female. Of the total population, 294 patients were included in one of the 2 most common etiological groups (IS or DS); 71 patients had DS curves versus 223 IS curves.

In 266 patients, the curves were classified and analyzed according to location by etiology. Main thoracic and thoracolumbar/lumbar (TL/L) curves were observed in the majority of cases (123 for each). For main thoracic curves, 93.5% were identified as IS. Apart from these 2 major types, 10 patients had lumbosacral curves, and another 10 patients had proximal thoracic curves. Most lumbosacral curves were identified as being DS (70%), whereas most proximal thoracic curves were IS (80%). The majority of DS curves were located in the TL/L region (70%) (Table 1), whereas most of the IS curves were thoracic (55%). For IS subtype, however, TL/L curves constituted a fairly large subset (40%). Upon comparison of age distribution of patients, mean

age of patients with DS deformity was found to be 65.6 years (range: 30–89 years), which contrasted significantly ($p<0.001$) with the mean age of IS patients, at 36.4 years (range: 18–77 years).

Three hundred twenty-six patients completed the SRS questionnaires, and 325 patients completed the ODI questionnaires. SF-36 scores were available for 313 patients and were summarized as physical component summary (PCS) and mental component summary (MCS) scores.[14] Comparisons of HRQL scores between the diagnostic groups were performed in 294 patients, which are summarized in Table 2 and by age in Table 3. Patients with degenerative deformity had higher ODI scores when compared with IS curves, to the point of statistical significance. ODI scores were also affected by age. The younger age group had the lowest ODI scores, and the oldest group had the highest. SF-36 PCS scores were highest for the youngest age group and decreased

Table 1. Curve pattern distribution amongst degenerative and idiopathic patients.

Main curve	Degenerative (n)	Idiopathic (n)	Total (n)
Proximal thoracic	2	8	10
Main thoracic	8	115	123
Thoracolumbar/lumbar	40	83	123
Lumbosacral	7	3	10
Total	57	209	266

Table 2. Comparison of HRQL scores between the 2 major etiological groups using ODI, SRS-22, and SF-36 scoring systems.

HRQL/diagnosis	Degenerative	Idiopathic	p
	Mean±SD	Mean±SD	
ODI score	51.6±20.7	21.6±19.3	<0.0001
SRS-22 subtotal	2.9±0.7	3.5±0.7	<0.0001
SRS-22 function/activity	3.0±0.8	4.0±0.9	<0.0001
SRS-22 pain	2.7±0.9	3.5±1.0	<0.0001
SRS-22 image/appearance	2.7±0.8	3.2±0.9	0.0002
SRS-22 mental health	3.0±0.9	3.4±0.8	0.0010
SF-36 MCS	37.4±12.2	44.7±10.1	<0.0001
SF-36 PCS	34.9±9.4	42.9±8.8	<0.0001

HRQL: Health-related quality of life; SD: Standard deviation; ODI: Oswestry disability index; SRS-22: Scoliosis Research Society-22 form; SF-36: Short form-36 health survey; MCS: Mental component score; PCS: Physical component score.

Table 3. Comparison of HRQL scores between the 3 age groups using ODI, SRS-22, and SF-36 scoring systems.

HRQL/Age	18–40	40–60	>60	p
	Mean±SD	Mean±SD	Mean±SD	
ODI score	17.1±17.6	34.5±20.7	45.7±22.1	<0.0001
SRS22 subtotal	3.7±0.7	3.1±0.8	2.9±0.7	<0.0001
SRS22 function/activity	4.2±0.8	3.4±1.0	3.0±0.9	<0.0001
SRS22 pain	3.8±0.8	2.9±1.0	2.7±0.9	<0.0001
SRS22 image/appearance	3.3±0.9	2.8±0.9	2.8±0.9	<0.0001
SRS22 mental health	3.4±0.8	3.3±0.8	3.2±0.9	0.114
SF-36 MCS	43.9±9.2	44.5±12.1	42.2±13.7	0.389
SF-36 PCS	45.7±7.5	37.6±9.7	33.9±9.1	<0.0001

HRQL: Health-related quality of life; SD: Standard deviation; ODI: Oswestry disability index; SRS-22: Scoliosis Research Society-22 form; SF36: Short form-36 health survey; MCS: Mental component score; PCS: Physical component score.

Table 4. Radiographic deformity parameters of patients with degenerative and idiopathic scoliosis.

Diagnosis (n)/Parameter	Degenerative (71)	Idiopathic (223)	p
	Mean±SD	Mean±SD	
Age (years)	65.57±11.27	36.42±15.47	<0.0001
Body mass index	27.00±3.78	22.61±4.43	<0.0001
Major cobb (°)	33.53±15.82	46.44±24.32	<0.0001
Lordosis (L1-S1) (°)	-41.17±17.63	-54.83±15.07	<0.0001
Pelvic incidence (°)	61.20±12.28	51.46±12.25	<0.0001
Pelvic tilt (°)	25.32±10.53	14.18±9.87	<0.0001
Sacral slope (°)	35.20±11.64	38.51±9.94	<0.0001
SVA (mm)	45.63±65.90	-6.75±39.40	<0.0001
T1 sagittal tilt (°)	-1.30±6.34	-4.84±3.96	<0.0001
T2-T12 kyphosis (°)	38.57±17.09	37.45±17.17	=0.046

SVA: Sagittal vertical axis, showing the offset from the SVA; SD: Standard deviation.

as age increased (Table 3) (p<0.0001). Similarly, the IS group had better (higher) PCS scores when compared with the DS group (p<0.0001). MCS scores were not statistically significant between the age groups; however, there was a significant difference between the DS and IS groups. The differences between the SRS pain and function scores were rather large between the youngest group (18–40) and the older groups (Table 3). Additionally, in terms of pain and function subsets, differences between the IS and DS groups were significant (Table 2). Analysis of radiographic parameters revealed that all measured parameters except for the T2-12 kyphosis were significantly different between the etiological groups (p<0.001 for coronal Cobb, lordosis, pelvic incidence, pelvic tilt, SVA, and T1 sagittal tilt; p=0.03 for sacral slope) (Table 4). IS patients had a significantly higher major coronal Cobb angle (46.4° in the IS vs 33.5° in the DS group), whereas analysis of the main sagittal balance parameter (SVA) demonstrated that IS patients had better sagittal alignment than DSpatients (-6.7 mm in IS vs +45.6 mm in dDS). Body mass index was also significantly higher in patients with DS deformity (27 vs 22.6) (p<0.001).

Discussion

This study aimed to analyze the pretreatment radiographic parameters, age, and HRQL scores of adults with spinal deformity in an attempt to categorize ASD. Our results suggest that both age and etiology have significant effects on the quality of life measures, with especially large differences between the youngest and the older groups in regards to pain and function.

The disparity of treatment results and the potentially high complication rates of surgical treatment add to the difficulty of decision-making in cases of ASD.[15] Furthermore, the wide variability of treatment methods among surgeons indicates the less than perfect comprehension of this patient population.[16] In the present study, in an attempt to enhance our understanding of ASD, patients were evaluated at initial presentation and stratified according to age, etiology, and curve classification (location). HRQL scores using ODI, SRS-22, and SF-36 questionnaires were collected and compared between age groups and deformity types.

We found that etiology indicated the location of the deformity, as most of the degenerative curves were between the TL/L junctions. Age was also correlated with the type of deformity, with DS curves having a higher mean age. These findings are consistent with the literature.[17,18]

Both age and etiology of the deformity are strong predictors of higher pain scores and decrease in function. Older groups showed the highest disability and pain scores on HRQL assessment. The difference between the youngest group and the older groups is especially striking. DS patients had higher disability and pain scores when compared with IS cases. This finding is consistent with the correlation between age and deformity etiology, as older patients are also the patients with DS deformities.

The heterogeneity of adult deformity, along with the inconsistency of treatment decisions and results, calls for the delineation of factors that define disability and pain.[15,19] For this purpose, classification systems have been proposed.[2,20,21] However, these systems are primarily based on radiologic parameters and do not take other factors such as patient age into account. Literature is fairly scant on the reasons that drive patients towards surgical treatment; in the present study, we were able to retrieve only one study that specifically investigated the impact of age on surgical decision-making. In that study,

Bess et al. reviewed 290 patients treated for adult scoliosis in a multicenter environment.[10] Patients treated operatively and nonoperatively were compared, and factors affecting treatment decisions were evaluated, making no distinctions between IS and DS curves. It was found that younger patients (<50 years) were more likely to have surgical treatment in cases of larger curves. On the other hand, older patients who elected to undergo surgical treatment had significantly worse HRQL scores than patients who elected nonoperative treatment. It was noted that despite similar radiographic findings (major Cobb, sagittal parameters) in the same age group, some patients—those who elected surgical treatment—had worse HRQL scores. Our findings are similar to this study, in that older patients had higher positive sagittal balance, decrease or loss of lumbar lordosis, higher pelvic tilt, and worse total ODI, SRS-22, and SF-36 scores.

In our study population, as expected, patients with DS deformity had a higher average age than patients with IS deformity. Positive sagittal balance was also more common in the DS group. Patients with IS deformity had better sagittal balance but also higher Cobb angles. Additionally, IS patients had better HRQL scores. These findings show that age, DS disease, and positive sagittal balance are intercorrelated and associated with poor HRQL scores.

These findings further suggest that ASD patients form a very heterogeneous group, even at presentation for medical advice. For the etiologies evaluated in this study, patients with IS were very different from those with DS deformity, not only based on the radiological parameters but also for the reasons of seeking treatment. We can safely suggest that younger patients with IS seek treatment mainly because of the deformity and less so for the disability caused by it, whereas older patients with DS deformity seek treatment mainly based on their disabilities. Therefore, criteria for "successful treatment" may be fundamentally different for these 2 populations.

Of note, the elderly population is predisposed to a higher rate of comorbidities and treatment complications.[22–26] In this regard, when these patients are pooled with younger patients in studies evaluating treatment results, their relatively higher risks may be diluted and remain underemphasized. Based on these findings, it is recommended that ASD be evaluated—be it for characteristics or treatment results—in a stratified manner based on age as well as the etiology of deformity. Failure to do so may result in underrecognition of the unique demands of different subpopulations and underestimation of the relevant risks associated with different treatment modalities.

We recognize some limitations arising from the study design. Due to the large scale and multiple centers, it was not possible to collect full data from all patients. Some of the patients did not complete all 3 questionnaires. Additionally, when stratifying patients according to 2 radiological diagnoses, some data loss occurred. However, we attempted to report all of the available data where possible, and considering that we were able to report radiologic data on 84% (294 of 352) and HRQL data on 92% (325 of 352) of our entire cohort, we believe that this group is fairly representative of the population in question.

Another quasi-shortcoming of this study design is the inability to differentiate the effects of age versus deformity. We demonstrated that the ASD population is very heterogeneous on the basis of age and diagnosis, but we were unable to demonstrate whether one of these factors—be it age or diagnosis—is the decisive parameter for HRQL. It has to be noted in this respect that the identification of this very parameter was not the purpose of the present study. Future work with different statistical methodologies will be required for this end.

ASD affects a large heterogeneous group of patients, consisting of different ages and etiologies. Our data show that age and etiology has a large impact on HRQL scores and may therefore act as confounding variables when evaluating the efficacy of a treatment modality. Patients with IS deformity may be very different from those with DS deformity, even at the time of presentation. Failure to understand this heterogeneity may result in underrecognition of the demands of different subpopulations and underestimation of the relevant risks associated with different treatment modalities. For further studies and future classifications, stratification of the ASD population into at least 2 different subgroups of young-idiopathic versus elderly-degenerative is suggested.

Acknowledgements

The authors of this manuscript received a research grant from the European Spine Study Group funded by Depuy Spine Inc. The European Spine Study Group consists of Emre Acaroğlu, MD; Ahmet Alanay, MD; Frank Kleinstück, MD; Ibrahim Obeid, MD; Ferrán Pellisé, MD; and Francesco Sanchez Pérez-Grueso, MD.

References

1. Baldus C, Bridwell KH, Harrast J, Edwards C 2nd, Glassman S, Horton W, et al. Age-gender matched comparison of SRS instrument scores between adult deformity and normal adults: are all SRS domains disease specific? Spine

(Phila Pa 1976) 2008;33:2214–8. CrossRef
2. Schwab F, Farcy JP, Bridwell K, Berven S, Glassman S, Harrast J, et al. A clinical impact classification of scoliosis in the adult. Spine (Phila Pa 1976) 2006;31:2109–14.
3. Wollowick AL, Glassman SD, Perra JH, Schwab FJ. Patient evaluation and clinical assessment of adult spinal deformity. Instr Course Lect 2012;61:469–79.
4. Sánchez-Mariscal F, Gomez-Rice A, Izquierdo E, Pizones J, Zúñiga L, Alvarez-González P. Correlation of radiographic and functional measurements in patients who underwent primary scoliosis surgery in adult age. Spine (Phila Pa 1976) 2012;37:592–8. CrossRef
5. Fairbank J. Use of Oswestry Disability Index (ODI) Spine (Phila Pa 1976) 1995;20:15357.
6. Bridwell KH, Cats-Baril W, Harrast J, Berven S, Glassman S, Farcy JP, et al. The validity of the SRS-22 instrument in an adult spinal deformity population compared with the Oswestry and SF-12: a study of response distribution, concurrent validity, internal consistency, and reliability. Spine (Phila Pa 1976) 2005;30:455–61. CrossRef
7. Grevitt M, Khazim R, Webb J, Mulholland R, Shepperd J. The short form-36 health survey questionnaire in spine surgery. J Bone Joint Surg Br 1997;79:48–52. CrossRef
8. Kim YJ, Bridwell KH, Lenke LG, Cheh G, Baldus C. Results of lumbar pedicle subtraction osteotomies for fixed sagittal imbalance: a minimum 5-year follow-up study. Spine (Phila Pa 1976) 2007;32:2189–97. CrossRef
9. Pellegrino LN, Avanzi O. Prospective evaluation of quality of life in adolescent idiopathic scoliosis before and after surgery. J Spinal Disord Tech 2014;27:409–14. CrossRef
10. Bess S, Boachie-Adjei O, Burton D, Cunningham M, Shaffrey C, Shelokov A, et al. Pain and disability determine treatment modality for older patients with adult scoliosis, while deformity guides treatment for younger patients. Spine (Phila Pa 1976) 2009;34:2186–90. CrossRef
11. Sponseller PD, Flynn JM, Newton PO, Marks MC, Bastrom TP, Petcharaporn M, et al. The association of patient characteristics and spinal curve parameters with Lenke classification types. Spine (Phila Pa 1976) 2012;37:1138–41.
12. Schwab FJ, Lafage V, Farcy JP, Bridwell KH, Glassman S, Shainline MR. Predicting outcome and complications in the surgical treatment of adult scoliosis. Spine (Phila Pa 1976) 2008;33:2243–7. CrossRef
13. Glassman SD, Berven S, Bridwell K, Horton W, Dimar JR. Correlation of radiographic parameters and clinical symptoms in adult scoliosis. Spine (Phila Pa 1976) 2005;30:682–8. CrossRef
14. Jenkinson C. The SF-36 physical and mental health summary measures: an example of how to interpret scores. J Health Serv Res Policy 1998;3:92–6.
15. Berven SH, Lowe T. The Scoliosis Research Society classification for adult spinal deformity. Neurosurg Clin N Am 2007;18:207–13. CrossRef
16. Berven SH, Deviren V, Mitchell B, Wahba G, Hu SS, Bradford DS. Operative management of degenerative scoliosis: an evidence-based approach to surgical strategies based on clinical and radiographic outcomes. Neurosurg Clin N Am 2007;18:261–72. CrossRef
17. Aebi M. The adult scoliosis. Eur Spine J 2005;14:925–48.
18. Kebaish KM, Neubauer PR, Voros GD, Khoshnevisan MA, Skolasky RL. Scoliosis in adults aged forty years and older: prevalence and relationship to age, race, and gender. Spine (Phila Pa 1976) 2011;36:731–6. CrossRef
19. Irwin ZN, Hilibrand A, Gustavel M, McLain R, Shaffer W, Myers M, et al. Variation in surgical decision making for degenerative spinal disorders. Part I: lumbar spine. Spine (Phila Pa 1976) 2005;30:2208–13. CrossRef
20. Lowe T, Berven SH, Schwab FJ, Bridwell KH. The SRS classification for adult spinal deformity: building on the King/Moe and Lenke classification systems. Spine (Phila Pa 1976) 2006;31(19 Suppl):119–25. CrossRef
21. Schwab F, Ungar B, Blondel B, Buchowski J, Coe J, Deinlein D, et al. Scoliosis Research Society-Schwab adult spinal deformity classification: a validation study. Spine (Phila Pa 1976) 2012;37:1077–82. CrossRef
22. Charosky S, Guigui P, Blamoutier A, Roussouly P, Chopin D; Study Group on Scoliosis. Complications and risk factors of primary adult scoliosis surgery: a multicenter study of 306 patients. Spine (Phila Pa 1976) 2012;37:693–700.
23. Yadla S, Maltenfort MG, Ratliff JK, Harrop JS. Adult scoliosis surgery outcomes: a systematic review. Neurosurg Focus 2010;28:E3. CrossRef
24. Glassman SD, Hamill CL, Bridwell KH, Schwab FJ, Dimar JR, Lowe TG. The impact of perioperative complications on clinical outcome in adult deformity surgery. Spine (Phila Pa 1976) 2007;32:2764–70. CrossRef
25. Daubs MD, Lenke LG, Cheh G, Stobbs G, Bridwell KH. Adult spinal deformity surgery: complications and outcomes in patients over age 60. Spine (Phila Pa 1976) 2007;32(20):2238–44. CrossRef
26. Cloyd JM, Acosta FL Jr, Cloyd C, Ames CP. Effects of age on perioperative complications of extensive multilevel thoracolumbar spinal fusion surgery. J Neurosurg Spine 2010;12:402-8. CrossRef