Brain and Spine 2 (2022) 100934

Contents lists available at ScienceDirect

Brain and Spine

journal homepage: www.journals.elsevier.com/brain-and-spine

Ability of Visual Analogue Scale to predict Oswestry Disability Index improvement and surgical treatment decision in patients with adult spinal deformity

Prashant Adhikari[a,*], Engin Çetin[b], Mehmet Çetinkaya[c], Vugar Nabi[d], Selcen Yüksel[e], Alba Vila Casademunt[f], Ibrahim Obeid[g], Francesco Sanchez Perez-Grueso[h], Emre Acaroğlu[i], European Spine Study Group (ESSG)

[a] Hospital for Advance Medicine and Surgery (HAMS), Dhumbarai, Mandhikatar Road, Kathmandu, Nepal
[b] Gaziosmanpasa Training and Research Hospital, Karayolları Mahallesi, Osmanbey Caddesi, 621, Sokak, 34255, Gaziosmanpaşa, Istanbul, Turkey
[c] Başakşehir Çam ve Sakura City Hospital, Başakşehir Olimpiyat Bulvarı Yolu, 34480, Başakşehir, Istanbul, Turkey
[d] Antalya Training and Research Hospital, Varlık Mh, Kazım Karabekir Cd, 07100, Antalya, Turkey
[e] Yıldırım Beyazıt University, Department of Biostatistics, Yıldırım Beyazıt Üniversitesi Biyoistatistik Departmenı, Ankara, Turkey
[f] Hospital Universitario Vall d'Hebron, Barcelona, Spain
[g] Bordeaux University Department of Orthopaedics, Bordeaux University Hospital, Department of Orthopaedics, Bordeaux, France
[h] Hospital Universitario La Paz, Department of Orthopaedics, Department of Orthopaedics, Madrid, Spain
[i] Ankara Spine Center, Iran Caddesi 45/2, Kavaklidere, 06700, Ankara, Turkey

ARTICLE INFO

Keywords:
VAS
ODI
Adult spinal deformity
HRQOL
Scoliosis

ABSTRACT

Introduction: The effect of pain on HRQoL scores in ASD patients is not well studied. Disability is a major factor on decision and outcomes. On the other hand, little is known about the effect of perceived and reported pain on these parameters, especially in the elderly population. We hypothesized that baseline back and leg pain would not affect the treatment decision whereas may have a negative effect on outcomes.
Research question: To determine the correlation between preoperative ODI and VAS scores; and to identify the effect of baseline VAS score on treatment decision and ODI improvement following treatment.
Material and methods: In this retrospective study, patients with a follow-up duration of minimum 2 years were enrolled from a prospective multicentric ASD database. Pearson and Spearman correlation tests were used to evaluate the correlation between ODI and VAS scores; univariate binary logistic regression method was used to analyze the effect of VAS on treatment decision as well as the outcomes.
Results: 1050 patients (mean age 48.2) were analyzed. Baseline ODI and back, leg pain VAS scores were significantly correlated ($P < 0.001$). One unit increase in baseline back and leg pain VAS scores, increased the probability of improvement in ODI by 1.219 ($P = 0.016$) and 1.182 times ($P = 0.029$), respectively in surgically treated patients; and reduced it by 0.894 times ($P = 0.012$) for conservatively treated patients. For patients >70 years old, one-unit increase in baseline leg pain VAS score increased the probability of deciding on surgical treatment by 1.121 times ($p = 0.016$).
Discussion and conclusions: Preoperative back and leg pain VAS scores were found to be significantly correlated with the preoperative ODI scores. Additionally, preoperative baseline back and leg pain VAS scores were useful in predicting the improvement in disability as assessed by ODI. Another important finding was that, higher baseline leg pain (but not back pain) VAS scores increased the rate of elderly patients preferring surgical treatment.

* Corresponding author. Hospital for Advance Medicine and Surgery (HAMS), Dhumbarai, Mandhikatar Road, Kathmandu, Nepal.
E-mail addresses: adhikariprashant@hotmail.com (P. Adhikari), enginctn@yahoo.com.tr (E. Çetin), drcetink@gmail.com (M. Çetinkaya), drvugarnabizade@gmail.com (V. Nabi), Selcenpehlivan@yahoo.com (S. Yüksel), albavilacasedemunt@gmail.com (A. Vila Casademunt), Ibrahim.obeid@gmail.com (I. Obeid), perezgrueso@gmail.com (F. Sanchez Perez-Grueso), acaroglue@gmail.com (E. Acaroğlu).

https://doi.org/10.1016/j.bas.2022.100934
Received 11 May 2022; Received in revised form 26 July 2022; Accepted 24 August 2022
Available online 28 August 2022

1. Introduction

In addition to growth of the aging population, increased awareness of quality of life has made adult spinal deformity (ASD) an important health care concern. As a result, adult patients, especially the elderly, seek health care for treatment for disabling spinal conditions (Daubs et al., 2007). First-line treatment for symptomatic ASD patients presenting with pain and disability without progressive neurological deficit usually involves non-operative treatment strategies, such as physical therapy, injections, non-steroidal anti-inflammatory drugs and/or narcotic analgesics (Glassman et al., 2006; Smith et al., 2011). When it is indicated, instrumented arthrodesis of the spine is widely used to correct the spinal deformity and restore balance and to improve pain and overall HRQoL (Kondo et al., 2017). In the surgically treated ASD group, treatment satisfaction has been shown to be moderately correlated with the preoperative disability, measured by the Oswestry Disability Index (ODI) and Short Form-36 Physical Component Summary (SF36 PCS) (Hamilton et al., 2017; Faraj et al., 2018). Also, satisfaction was not associated with radiographic parameters or the presence or absence of peri-operative complications (Hamilton et al., 2017; Faraj et al., 2018). Self-assessment disability scales were found to be more useful in evaluating preoperative disability than pain severity scales, radiographs, CT scans and MRI examinations (Sigmundsson et al., 2011).

Spine healthcare professionals always want to have decision-making tools based on objective criteria when deciding surgery in patients with ASD. Using health-related quality of life scales (HRQoL) to assess disability (e.g., ODI) serves this purpose; however, little is known whether this also applies to back or leg pain scales (i.e., back or leg pain Visual Analogue Scale (VAS)) (Acaroglu et al., 2016). In this regard, DeVine et al. in their systemic review found that the correlation between ODI and VAS was not strong in patients with ASD (DeVine et al., 2011). Gronblad et al., analyzed the correlations between ODI, PDI (Pain Disability Index) and VAS in patients with LBP and found that the correlations between ODI and PDI were strong (r = 0.83) whereas, correlations between VAS scores and ODI were not as strong (r = 0.62). (Grönblad et al., 1993).

We noticed a gap in our knowledge in that it is not clear whether the disability in the ASD population is based on or even, affected by the perception of pain and if so, to what extent. In this context, it may be important to analyze the relationship between perceived disabilities and perceived pain levels in these patients, i.e., is pain the only cause of their disability? If this is the case, the correlation between disability measure (ODI) and pain measure (VAS leg/back) should be very strong. Another valid question in the same context is on the effects of these factors on decision-making in surgical treatment, predominantly by patients, but to some extent by surgeons as well. Can the surgery decision be significantly affected by pain; if so, do both back and leg pain contributes to this effect? And finally, what may be the effect of initial pain on treatment (surgical or non-surgical) results?

This current study was performed to analyze the correlation between preoperative and postoperative ODI and VAS scores in adult patients with spinal deformity; and to identify the effect of baseline VAS score on treatment decision and ODI improvement. We hypothesized that baseline back and leg pain do not affect the treatment decision but negatively affect the outcomes.

2. Materials and methods

In this retrospective study on prospectively collected ASD data, patients were enrolled from an international prospective multicentric ASD database. Patients with a follow-up duration of at least 2 years were selected according to the following criteria: age >18 years and scoliosis >20° and/or sagittal vertical axis (SVA) > 5 cm and/or pelvic tilt >25° and/or thoracic kyphosis >60°. Patients' demographic data (age, gender, co-morbidities and body mass index (BMI)), baseline, post-treatment and follow-up ODI and VAS scores (leg and back), radiological parameters (Sagittal vertical axis (SVA), T2-T12 kyphosis, coronal balance, major curve Cobb angle, lordosis gap (L Gap) (Aurouer et al., 2009), global tilt (Obeid et al., 2016), and T1 sagittal tilt) were analyzed. Patients were stratified with deformity etiology (idiopathic or degenerative) and treatment method (surgical or non-surgical).

2.1. Visual Analogue Scale for pain

The VAS represents a method of assessment of a feeling. It consists of a 100-mm long line (the designated dolorimeter); the left end signifying no pain and the right unbearable and unprecedented pain. It requires the transfer of a sensation into another dimension. A virtual continuous parameter is artificially reified at a certain point and transferred into a digital system (Ohnhaus and Adler, 1975).

2.2. Oswestry low back Pain Disability Index

The ODI was developed in a specialist referral clinic for patients with chronic LBP (Fairbank et al., 1980). The item selection was based on an interview designed to assess limitations in various activities. It is a self-reported questionnaire of a patient's perceived disability based on 10 areas of pain and daily activities (pain intensity, personal hygiene, lifting, walking, sitting, standing, sleeping, sexual activity, social activity and travelling). Each section is scored on a 6-point scale (0–5), with 0 representing no limitation and 5 representing maximal limitation. The sub-scales combined add up to a total maximal score of 50. The score is then doubled and interpreted as a percentage of the patient-perceived disability (the higher the score, the greater the disability). In cases where patients did not answer all the 10 sections, the sum score of the answered sections are divided by the number of completed sections followed by multiplication by ten for purposes of the normalization of the score (Grotle et al., 2003).

2.3. Statistical analysis

The main aim of this study related to statistical analysis was to find out the correlation between back and leg pain VAS scores with preoperative ODI scores and postoperative ODI improvement in surgically or non-surgically treated patients. A univariate binary logistic regression method was used using dependent and independent variables listed above.

Before the correlation analysis the type of distribution behavior of the variables, whether homogenous or not, was tested first. According to the distribution behavior, Pearson or Spearman correlation coefficient was used to evaluate the correlation between ODI and VAS scores and the correlation between the baseline back and leg pain VAS scores with the postoperative ODI scores improvement. Type-I error rate was taken as $\alpha = 0.05$ for statistical significance for all analyses.

3. Results

1050 patients (887 females and 163 males), with a mean age of 48.2, were enrolled from the ASD database. While 334 of these patients had a degenerative etiology, 718 had idiopathic deformity (Table 1). Six hundred and ninety-eight of them received non-surgical treatment whereas 352 of them underwent surgery. Spearman's correlation coefficient (rho) was 0.459 for baseline backpain VAS score and baseline ODI score; and 0.443 for baseline leg pain VAS score and baseline ODI score. Correlations between baseline ODI score and baseline back and leg pain VAS scores were found as statistically significant ($P < 0.001$) (Table 2).

The mean age of the surgically treated 352 patients (287 females and 65 males) was 53.0 years. 165 of them had spinal deformities due to degenerative spine conditions and 187 had due to idiopathic etiology (Table 3). Univariate logistic regression test results showed for surgically treated patients that, one unit increase in baseline back and leg pain VAS score increased the probability of improvement in ODI by 1.219 times (P

Table 1
Characteristics of ASD patients.

	n, Mean ± SD, min-max
Age, years	1035, 48.2 ± 19.9, 18-89
BMI	1010, 24.01 ± 4.79, 15.40–54.60
Sex	**n (%)**
Female	887 (84.5)
Male	163 (15.5)
Diagnosis	**n (%)**
Degenerative	332 (31.6)
İdiopathic	718 (68.4)
Treatment	**n (%)**
Surgical	352 (33.5)
Non-surgical	698 (66.5)
Baseline Radiological parameters	**n, Mean ± SD, min-max**
T2-T12 kyphosis	972, 39.12 ± 16.64, 1-98
Major curve Cobb angle	991, 43.82 ± 20.05, 4-151
Lordosis gap (L Gap)	923, 16.93 ± 14.48, 0.04–83.02
Global tilt	885, 21.93 ± 15.29, 1-70
T1 sagittal tilt	890, 4.89 ± 3.26, 0-23
SVA	**n (%)**
0	650 (69.3)
+	201 (21.4)
++	87 (9.3)
Coronal balance	**n (%)**
D	370 (36.2)
L	231 (22.6)
N	295 (28.8)
T	127 (12.4)
Baseline scores	**n, Mean ± SD, min-max**
ODI	1000, 30.18 ± 20.70, 0-100
Back pain VAS	1027, 5.48 ± 2.75, 0-10
Leg pain VAS	1027, 3.12 ± 3.28, 0-10
1st year scores	
ODI	536, 25.46 ± 18.69,0-82
Back pain VAS	549, 4.27 ± 2.93, 0-10
Leg pain VAS	549, 2.63 ± 2.94, 0-10

Table 2
Correlations among baseline ODI and baseline back and leg pain VAS.

		Baseline leg pain VAS	Baseline ODI
Baseline back pain VAS	Rho	**0.289****	**0.459****
	P	< **0.001**	< **0.001**
	n	339	329
Baseline leg pain VAS	rho		**0.443****
	p		< **0.001**
	n		329

**Correlation is statistically significant at the 0.01 level.

Table 3
Characteristics of surgically treated patients.

	n, Mean ± SD, min-max
Age, years	352, 53 ± 20.10, 18-86
Sex	**n (%)**
Female	287 (81.5)
Male	65 (18.5)
Diagnosis	**n (%)**
Degenerative	165 (46.9)
İdiopathic	187 (53.1)
Baseline scores	**n, Mean ± SD, min-max**
ODI	331,40.02 ± 20.67, 0-98
Back pain VAS	339, 6.19 ± 2.59, 0-10
Leg pain VAS	339, 4.06 ± 3.33, 0-10
1st year scores	**n, Mean ± SD, min-max**
ODI	191, 28.76 ± 17.98, 0-76
Back pain VAS	195, 3.44 ± 2.66, 0-10
Leg pain VAS	195, 2.28 ± 2.77, 0-10

= 0.016) and 1.182 times (P = 0.029), respectively (Tables 4 and 5).

In the non-surgical group, there were 698 patients (600 females and 98 males), 167 with degenerative and 531 with idiopathic spinal conditions. The mean age among this group was 45.7 years (Table 6). The univariate logistic regression test results, one unit increase in baseline back pain VAS score, reduced the probability of improvement in ODI by 0.894 times.

Table 4
Univariate logistic regression test results for back pain baseline VAS scores for surgically treated patients.

Dependent variable	OR (95% C.I.)	P
ODI improvement	1.219 (1.038–1.431)	0.016

Table 5
Univariate logistic regression test results for leg pain baseline VAS scores for surgically treated patient.

Dependent variable	OR (95% C.I.)	P
ODI improvement	1.182 (1.017–1.373)	0.029

Table 6
Characteristics of non-surgically treated patients.

	n, Mean ± SD, min-max
Age, years	683, 45.75 ± 19.49, 18-89
Sex	**n(%)**
Female	600 (86)
Male	98 (14)
Diagnosis	**n(%)**
Degenerative	167 (23.9)
İdiopathic	531 (76.1)
Baseline scores	**n, Mean ± SD, min-max**
ODI	669, 25.31 ± 18.93, 0-100
Back pain VAS	688, 5.13 ± 2.77, 0-10
Leg pain VAS	688, 2.66 ± 3.15, 0-10
1st year scores	**n, Mean ± SD, min-max**
ODI	345, 23.63 ± 18.85, 0-82
Back pain VAS	354, 4.72 ± 2.97, 0-10
Leg pain VAS	354, 2.82 ± 3.02, 0-10

P = 0.012), while baseline leg pain VAS score had no effect on ODI improvement ($P > 0.05$) (Tables 7 and 8).

17.2% of the ASD patients (151 females and 30 males) were over 70 years old. 80.7% of them had degenerative deformity while 19.3% had idiopathic deformity. 28.7% of them underwent surgical treatment and 71.3% had conservative treatment (Table 9). Univariate logistic regression test results showed that baseline back pain VAS score had no effect on deciding surgical treatment for elderly population (patients with age ≥70) (Table 10). On the other hand, It was seen that one unit increase in baseline leg pain VAS score increased the probability of deciding on surgical treatment for elderly population by 1.121 times (p = 0.016) (Table 11).

4. Discussion

This study was performed on a cohort of adult patients with spinal deformities to find out whether the back and leg pain VAS scores correlated with the preoperative ODI scores; and to investigate the effects of the preoperative VAS scores on patients' treatment decision and on ODI improvement following surgical and non-surgical treatment. Our results showed that, baseline back and leg pain VAS scores were significantly correlated with the preoperative ODI scores. The univariate logistic regression tests showed for surgically treated patients that, one unit increase in baseline back and leg pain VAS score increased the probability of improvement in ODI by 1.219 times and 1.182 times respectively; and for patients treated non-surgically one unit increase in baseline back pain VAS, reduced the probability of improvement in ODI by 0.894 times, while baseline leg pain VAS had no effect on ODI improvement. In elderly patients, one unit increase in baseline leg pain VAS score increased the probability of deciding on surgical treatment by

Table 7
Univariate logistic regression test results for back pain baseline VAS scores for non-surgically treated patients.

Dependent variable	OR (95% C.I.)	P
ODI improvement	0.894 (0.819–0.975)	0.012

Table 8
Univariate logistic regression test results for leg pain baseline VAS scores for non-surgically treated patients.

Dependent variable	OR (95% C.I.)	P
ODI improvement	0.960 (0.891–1.035)	0.292

Table 9
Characteristics of the elderly patients (age >70 years).

	n, Mean ± SD, min-max
Age, years	181, 75.54 ± 4.33, 70-89
Sex	**n (%)**
Female	151 (83.4)
Male	30 (16.6)
Diagnosis	**n (%)**
Degenerative	146 (80.7)
İdiopathic	35 (19.3)
Treatment	
Surgical	85 (47)
Non-surgical	96 (53)
Baseline scores	**n, Mean ± SD, min-max**
ODI	179, 44.70 ± 17.59, 4-98
Back pain VAS	178, 6.38 ± 2.26, 0-10
Leg pain VAS	178, 4.41 ± 3.27, 0-10
1st year scores	**n, Mean ± SD, min-max**
ODI	73, 35.98 ± 18.69, 2-82
Back pain VAS	74, 4.27 ± 3.10, 0-10
Leg pain VAS	74, 3.12 ± 3.09, 0-10

Table 10
Univariate logistic regression test results for back pain baseline VAS scores on deciding surgical treatment for elderly population (patients with age ≥70).

Dependent variable	OR (95% C.I.)	P
Surgery group	1.071 (0.939–1.222)	0.307

Table 11
Univariate logistic regression test results for leg pain baseline VAS scores on deciding surgical treatment for elderly population.

Dependent variable	OR (95% C.I.)	P
Surgery group	1.121 (1.022–1.230)	0.016

1.121 times, whereas baseline back pain VAS score had no effect on treatment decision.

As previously reported in the literature, VAS scores and ODI were moderately correlated with each other (Faraj et al., 2018). This significant association was not unexpected because the cause of disability in elderly patients with ASD was mostly limited range of motion due to pain or pain rather than spinal deformity, but the level of correlation (moderate) was quite lower than expected. The most frequent symptom of patients with ASD is low back pain, which is the main reason of disability in daily life of these individuals whose average age is quite high (Lonergan et al., 2016). The ODI scoring system evaluates disability not only by pain intensity, but also by personal hygiene, lifting, walking, sitting, standing, sleeping, sexual activity, social activity, and travelling (Fairbank and Pynsent, 2000). The frequency of these activities and the way they are carried out may vary for each individual; moreover, the perception of restriction in each area may vary from person to person, even the actual level of limitation is equal. These differences between individuals may be the reason for the moderate correlation between scores.

Higher improvement in postoperative ODI scores with worse baseline HRQoL scores have been demonstrated previously in several studies (Ames et al., 2019). We also found that patients with higher preoperative back and leg pain VAS scores, worse baseline condition in terms of disability, showed higher improvement in postoperative ODI scores. This finding indicates a significant correlation of the back and leg pain VAS scores with the ODI scores.

It was previously reported that the results of nonoperative treatment methods in ASD were worse than operative treatment (Acaroglu et al., 2016; Acaroglu and European Spine Study Group, 2016; Acaroglu et al., 2017). Patients who did not undergo surgery had unchanged or worse ODI scores compared to their baseline scores. This knowledge was also supported by the present study, improvement rate in ODI scores were lower in patients with higher baseline back pain VAS scores; however leg pain VAS scores were not correlated with ODI improvement in this group of patients.

The improvement in the ODI score may not always be detectable by the patient, even with a statistically significant change in ODI after surgery. The minimum clinically important difference (MCID) and minimum detectable change (MDC) values of ODI were reported as 14.31 and 10.65 respectively, in the study of Yüksel et al. (Yuksel et al., 2019) However, very low VAS improvements may be reported by patients after surgery. A patient who describes an improvement in pain of up to almost 10 points actually experiences an improvement in ODI score below the MCID and MDC values (since one unit change in baseline VAS score changes the ODI improvement by about 1.2 times in our study). This can be highlighted as the superiority of VAS assessment over ODI scoring in the evaluation of postoperative patients.

Despite the improvement in the ODI scores over MCID values, dissatisfaction after ASD treatment is a common problem. Carragee and Cheng described minimum acceptable outcome concept for satisfaction following surgery (Carragee and Cheng, 2010). Reflecting the patients' clinical condition only by pain may be insufficient, as only by ODI evaluation. On the other hand, Ruiz and colleagues showed that ODI correlated better with extremes of lumbar motion and activities of daily living compared to VAS pain scores (Ruiz et al., 2014).

Numerous factors have been examined for the treatment decision in ASD. Fujishiro et al. reported that, worsening HRQOL and in particular perception of worsening appearance based on SRS-22 self-image domain guided surgical treatment in the ASD population. In addition, pain and disability increased the rate of surgical treatment selection in older patient, while greater coronal deformity was more important for younger patients. Finally the lack of lumbar lordosis in relation to pelvic incidence was a strong driver to pursue surgical treatment in ASD patients (Fujishiro et al., 2018). Adult spinal deformity surgical decision-making score was developed to guide the decision-making process for ASD patients aged above 40 years (Fujishiro et al., 2019, 2020). In the present study, higher baseline leg pain VAS score was found to have a significant effect on surgical treatment decision in elderly patients. As a difference, pain parameter was directly evaluated by VAS score, not as an integral part of SRS-22, ODI, and NRS. It gave us the opportunity to see the effect of pain more clearly. In elderly patients, one unit increase in baseline leg pain VAS score increased the probability of deciding on surgical treatment by 1.121 times, whereas baseline back pain VAS score had no effect on treatment decision.

The surgery for ASD is not always performed to relieve pain. Some of the procedures are performed to correct the deformity, decompress the spinal canal, correct sagittal imbalance, improve functionality or prevent progression of the deformity, especially in younger adults. This means that VAS or ODI scores should not always be expected to improve after surgery, and even some patients do not have any pain before and after the surgery, but their postoperative ODI scores are worse. Therefore, studies investigating the correlation between VAS and HRQoL measurements should be conducted based on single unique groups with similar demographic and surgical indication characteristics.

4.1. Limitations

The most significant limitation of this study is its multicenter nature which may lead to variation in demographic characteristics of patients and treatment modalities that may have caused different outcomes, especially in regard to treatment choice. Also, radiographic measurements and measurement of HRQoL scores were made by different staff in different countries and in different institutes. Another limitation is the miscellaneous diagnoses of the patients enrolled in the ESSG registry.

5. Conclusions

In adult patients with spinal deformity, preoperative back and leg pain VAS scores were found to be significantly correlated with the preoperative ODI scores. Additionally we found that, preoperative baseline back and leg pain VAS scores were useful in predicting the improvement in disability, rated by ODI. However, the outcomes after conservative treatment methods were estimated only by the baseline back pain VAS scores, which were found to be inversely correlated with improvement in disability. In addition, it was shown that, higher baseline leg pain VAS scores in elderly patients (age >70 years) increased the rate of patients choosing surgical treatment.

Declaration of competing interest

The authors of this manuscript have no competing interests that influence the results and discussion of this paper.

Acknowledgement

This study as well as the intellectual owner of the database it is based on, The European Spine Study Group (ESSG), are funded by a research grant from Depuy-Synthes Spine.

References

Acaroglu, E., European Spine Study Group, 2016. Decision-making in the treatment of adult spinal deformity. EFORT open Rev 1 (5), 167–176. https://doi.org/10.1302/2058-5241.1.000013.

Acaroglu, E., Yavuz, A.C., Guler, U.O., et al., 2016. A decision analysis to identify the ideal treatment for adult spinal deformity: is surgery better than non-surgical treatment in improving health-related quality of life and decreasing the disease burden? Eur. Spine J. 25 (8), 2390–2400. https://doi.org/10.1007/s00586-016-4413-8.

Acaroglu, E., Guler, U.O., Cetinyurek-Yavuz, A., et al., 2017. Decision analysis to identify the ideal treatment for adult spinal deformity: what is the impact of complications on treatment outcomes? Acta Orthop. Traumatol. Turcica 51 (3), 181–190. https://doi.org/10.1016/j.aott.2017.03.003.

Ames, C.P., Smith, J.S., Pellisé, F., et al., 2019. Development of deployable predictive models for minimal clinically important difference achievement across the commonly used health-related quality of life instruments in adult spinal deformity surgery. Spine (Phila Pa 1976) 44 (16), 1144–1153. https://doi.org/10.1097/BRS.0000000000003031.

Aurouer, N., Obeid, I., Gille, O., Pointillart, V., Vital, J.-M., 2009. Computerized preoperative planning for correction of sagittal deformity of the spine. Surg. Radiol. Anat. 31 (10), 781–792. https://doi.org/10.1007/s00276-009-0524-9.

Carragee, E.J., Cheng, I., 2010. Minimum acceptable outcomes after lumbar spinal fusion. Spine J. 10 (4), 313–320. https://doi.org/10.1016/j.spinee.2010.02.001.

Daubs, M.D., Lenke, L.G., Cheh, G., Stobbs, G., Bridwell, K.H., 2007. Adult spinal deformity surgery: complications and outcomes in patients over age 60. Spine (Phila Pa 1976) 32 (20), 2238–2244. https://doi.org/10.1097/BRS.0b013e31814cf24a.

DeVine, J., Norvell, D.C., Ecker, E., et al., 2011. Evaluating the correlation and responsiveness of patient-reported pain with function and quality-of-life outcomes after spine surgery. Spine (Phila Pa 1976) 36 (21 Suppl. l), S69–S74. https://doi.org/10.1097/BRS.0b013e31822ef6de.

Fairbank, J.C., Pynsent, P.B., 2000. The Oswestry disability index. Spine (Phila Pa 1976) 25 (22), 2940–2952. https://doi.org/10.1097/00007632-200011150-00017 discussion 2952.

Fairbank, J.C., Couper, J., Davies, J.B., O'Brien, J.P., 1980. The Oswestry low back pain disability questionnaire. Physiotherapy 66 (8), 271–273.

Faraj, S.S.A., De Kleuver, M., Vila-Casademunt, A., et al., 2018. Sagittal radiographic parameters demonstrate weak correlations with pretreatment patient-reported health-related quality of life measures in symptomatic de novo degenerative lumbar scoliosis: a European multicenter analysis. J. Neurosurg. Spine 28 (6), 573–580. https://doi.org/10.3171/2017.8.SPINE161266.

Fujishiro, T., Boissière, L., Cawley, D.T., et al., 2018. Decision-making factors in the treatment of adult spinal deformity. Eur. Spine J. 27 (9), 2312–2321. https://doi.org/10.1007/s00586-018-5572-6.

Fujishiro, T., Boissière, L., Cawley, D.T., et al., 2019. Adult spinal deformity surgical decision-making score : Part 1: development and validation of a scoring system to guide the selection of treatment modalities for patients below 40 years with adult spinal deformity. Eur. Spine J. 28 (7), 1652–1660. https://doi.org/10.1007/s00586-019-05932-3.

Fujishiro, T., Boissière, L., Cawley, D.T., et al., 2020. Adult spinal deformity surgical decision-making score. Part 2: development and validation of a scoring system to guide the selection of treatment modalities for patients above 40 years with adult spinal deformity. Eur. Spine J. 29 (1), 45–53. https://doi.org/10.1007/s00586-019-06068-0.

Glassman, S.D., Berven, S., Kostuik, J., Dimar, J.R., Horton, W.C., Bridwell, K., 2006. Nonsurgical resource utilization in adult spinal deformity. Spine (Phila Pa 1976) 31 (8), 941–947. https://doi.org/10.1097/01.brs.0000209318.32148.8b.

Grönblad, M., Hupli, M., Wennerstrand, P., et al., 1993. Intercorrelation and test-retest reliability of the Pain Disability Index (PDI) and the Oswestry Disability Questionnaire (ODQ) and their correlation with pain intensity in low back pain patients. Clin. J. Pain 9 (3), 189–195. https://doi.org/10.1097/00002508-199309000-00006.

Grotle, M., Brox, J.I., Vøllestad, N.K., 2003. Cross-cultural adaptation of the Norwegian versions of the roland-morris disability questionnaire and the Oswestry disability index. J. Rehabil. Med. 35 (5), 241–247. https://doi.org/10.1080/16501970306094.

Hamilton, D.K., Kong, C., Hiratzka, J., et al., 2017. Patient satisfaction after adult spinal deformity surgery does not strongly correlate with health-related quality of life scores, radiographic parameters, or occurrence of complications. Spine (Phila Pa 1976) 42 (10), 764–769. https://doi.org/10.1097/BRS.0000000000001921.

Kondo, R., Yamato, Y., Nagafusa, T., et al., 2017. Effect of corrective long spinal fusion to the ilium on physical function in patients with adult spinal deformity. Eur. Spine J. 26 (8), 2138–2145. https://doi.org/10.1007/s00586-017-4987-9.

Lonergan, T., Place, H., Taylor, P., 2016. Acute complications after adult spinal deformity surgery in patients aged 70 Years and older. Clin spine Surg 29 (8), 314–317. https://doi.org/10.1097/BSD.0b013e3182764a23.

Obeid, I., Boissière, L., Yilgor, C., et al., 2016. Global tilt: a single parameter incorporating spinal and pelvic sagittal parameters and least affected by patient positioning. Eur. Spine J. 25 (11), 3644–3649. https://doi.org/10.1007/s00586-016-4649-3.

Ohnhaus, E.E., Adler, R., 1975. Methodological problems in the measurement of pain: a comparison between the verbal rating scale and the visual analogue scale. Pain 1 (4), 379–384. https://doi.org/10.1016/0304-3959(75)90075-5.

Ruiz, F.K., Bohl, D.D., Webb, M.L., Russo, G.S., Grauer, J.N., 2014. Oswestry disability index is a better indicator of lumbar motion than the visual analogue scale. Spine J. 14 (9), 1860–1865. https://doi.org/10.1016/j.spinee.2013.10.027.

Sigmundsson, F.G., Kang, X.P., Jönsson, B., Strömqvist, B., 2011. Correlation between disability and MRI findings in lumbar spinal stenosis: a prospective study of 109 patients operated on by decompression. Acta Orthop. 82 (2), 204–210. https://doi.org/10.3109/17453674.2011.566150.

Smith, J.S., Shaffrey, C.I., Glassman, S.D., et al., 2011. Risk-benefit assessment of surgery for adult scoliosis: an analysis based on patient age. Spine (Phila Pa 1976) 36 (10), 817–824. https://doi.org/10.1097/BRS.0b013e3181e21783.

Yuksel, S., Ayhan, S., Nabiyev, V., et al., 2019. Minimum clinically important difference of the health-related quality of life scales in adult spinal deformity calculated by latent class analysis: is it appropriate to use the same values for surgical and nonsurgical patients? Spine J. 19 (1), 71–78. https://doi.org/10.1016/j.spinee.2018.07.005.