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ORIGINAL ARTICLE

The Impact of Corrective Surgery on Health-Related Quality of Life Subclasses in Adult Scoliosis: Will Degree of Correction Prognosticate Degree of Improvement?

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Abstract

Purpose Objectives in scoliosis corrective surgery include restoration of normal sagittal and coronal parameters to achieve patient satisfaction. HRQLs improvements remain limited after corrective surgery. The aim of this study was to evaluate the HRQL subclass variability specific to the sagittal and coronal correction in adult scoliosis surgery.

Methods This multi-centre prospective analysis of consecutive adult spinal deformity (ASD) patients, from five European centres, only included multilevel instrumentation for scoliosis. d-(delta) values for each parameter represented pre to post-operative changes. Parameters included demographics, baseline, 1- and 2-year. HRQL outcomes (Oswestry disability index (ODI), Scoliosis Research Society (SRS)-22 and Short Form (SF36)), sagittal correction including relative spinopelvic alignment (dRSA) and coronal correction including major Cobb (dCobb) angles.

Results A total of 353 patients reached 1-year and 2-year follow up. All HRQL total scores significantly improved postoperatively, including ODI, SRS-22 and SF36. HRQL subclasses which displayed persistent improvements correlated to dRSA included sex-life, self-image, fatigue, vitality, social functioning. The only HRQL subclass improvement that correlated with dCobb was self-image.

Conclusion Adult scoliosis surgery improves overall HRQL, having a minimal effect on each variable. Importantly, greater coronal deformity correction affects only greater self-image scores, whereas with greater sagittal correction there are many greater HRQL sub-class impacts. Correction and restoration of coronal balance is one of the surgical goals in adult scoliosis but the degree to which Cobb angle is corrected, apart from self-image, does not correlate with gains in sub-classes of HRQL. These results need to be taken into account when planning surgery.

Keywords Adult spinal deformity · Scoliosis · Health related quality of life · Coronal · Deformity correction

Abbreviations

ASD	Adult spinal deformity
BMI	Indicates body mass index
COMI	Core Outcome Measures Index
GT	Global tilt; LL, lumbar lordosis
MCS	Mental Component Summary
ODI	Oswestry Disability Index
PCS	Physical Component Summary

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PI	Pelvic incidence
PT	Pelvic tilt
SF36	Short Form 36
SRS-22	Scoliosis Research Society 22-question Questionnaire
SVA	Sagittal vertical axis
PI-LL	Pelvic incidence minus lumbar lordosis
RSA	Relative spinopelvic alignment
BMI	Body mass index
SVA	Sagittal vertical axis
TK	Thoracic kyphosis
PT	Pelvic tilt

Introduction

Adult scoliosis occurs in a heterogenous population, with diversity of age, diagnosis and magnitude [1]. One's own interpretation of their functional demands, pain and body image further differentiates clinical presentations. Adult spinal deformity (ASD) can be evaluated morphologically by performing full-spine x-rays, in the standing position, to measure specific radiographic parameters. HRQL (Health-related quality of life) questionnaires including Oswestry disability index (ODI), Scoliosis Research Society 22 Questionnaire (SRS-22) and Short Form 36 (SF36) are commonly used to assess adult spinal patients for pain, function and quality of life, with varying degrees of diversity, sensitivity and specificity.

HRQLs overall have been shown to be improved with surgery, at high volume centres, whereas conservative treatments (including physical therapy, chiropractic treatment, bracing and injections) have not shown the same benefit [2–4]. However, surgical treatment of ASD will likely cause more complications than non-operative treatments. Thus, the decision to surgically correct adult scoliosis should weigh the potential benefits, including the improvement in HRQL, against the potential complications of the proposed surgical treatment [5]. These decisions are therefore complex and patients need to understand both the chances of improvement and the burden associated with operative and non-operative approaches in order to offer informed consent [6, 7].

While global improvement in HRQL is useful for patients' knowledge, they are more interested in the specific impact it will have on them. Thus, it is important for patients to understand what HRQL subclasses are more likely to be affected and from what aspects of deformity correction. This cohort evaluated adult scoliosis patients to identify what significant HRQL sub-class changes are likely after surgery and whether they relate to the degree of sagittal or coronal plane correction.

Patients and Methods

Patient Cohort

This study was an analysis of a multicentre prospective database of consecutive ASD patients, who had been evaluated and had undergone surgical treatment at five European spine centres, from June 2007 to June 2016. Each enrolled site obtained institutional review board approval according to the common protocol. The inclusion criteria were patients older than 18 years with whole spine radiographs confirming a coronal Cobb angle $\geq 20°$, sagittal vertical axis (SVA) ≥ 5 cm; thoracic kyphosis (TK) $\geq 60°$; or pelvic tilt (PT) $\geq 25°$ who had surgical deformity correction. Exclusion criteria were all non-scoliotic patients (Schwab coronal N), single level surgery or non-deformity correcting surgeries. Demographic data of the patients, including age, gender and body mass index (BMI) were collected.

Radiographic Data

All patients had obtained standing postero-anterior and lateral full spine radiographs at baseline and at 1- and 2-year follow up. Coronal plane measurements included coronal Cobb angle for the major curve. Sagittal plane measurements included relative spinopelvic alignment (RSA). The relative spinopelvic alignment (RSA) parameter is a PI based global parameter that evaluates the amount of malalignment based on a patient's ideal global tilt (GT) (RSA = GT- ideal GT with ideal GT = 0.48xPI-15) [8, 9]. Relative Sagittal Alignment (RSA) was used in this analysis as it is sufficient as a single sagittal parameter to take into account spinal malalignment and pelvic compensation [10].

HRQL Scores

All patients were asked to complete the Oswestry disability index (ODI) questionnaire, 36-item short-form health survey (SF-36), and Scoliosis Research Society-22 score (SRS-22) at enrolment. The Short Form (SF)-36, Oswestry disability index (ODI) and Scoliosis Research Society (SRS-22) score are universally used for evaluating ASD. The SRS-22 is the only disease specific instrument for ASD, despite being originally developed for adolescent idiopathic scoliosis. The SF-36 health survey comprises 36 items that measure eight sub-classes: physical functioning, role-physical, body pain, general health, vitality (VT), social functioning, role-emotional, and mental health. For each scale, a score ranging from 0 (worst measured health) to 100 (best measured health) was calculated. The ODI contains 10 sections: pain intensity, personal care, lifting, walking, sitting, standing,

sleeping, social life, sex life, and traveling. For each subclass, a score ranging from 0 (best measured health) to 5 (worst measured health) was calculated; to calculate the level of disability, the points for each section were added and used in the following formula: point total/50 × 100 = % disability. SRS-22 scores have been shown to be reliable and with good-to-excellent internal consistency and strong test–retest reliability [11]; it exhibits concurrent validity with the corresponding SF-36, SF-12, and ODI domains. Although the SF-36 is a general health instrument and ODI is an assessment tool that is specific to back pain, four of the five subclasses from SRS- 22 were used: pain, function/activity, self-image, and mental health domains, which reflect the diverse symptoms in this population while satisfaction with management was excluded.

Statistical Analysis

SPSS version 17.0 (SPSS Inc., Chicago, IL) was used for the statistical analyses.

A multivariate analysis was designed to provide the impact of each independent variable on the dependent variable, to allow the statistical analysis of many variables at once.

Multivariate analysis included:

- One dependent variable: dHRQL = HRQL postop – HRQL preop (d, delta)
- Multiple independent variables: dRSA = RSA postop – RSA preop, dCobb = Cobb postop – Cobb preop, age, gender, BMI.

Multivariate analysis for each HRQL item: dHRQL = (a × dRSA) + (b × dCobb) + (c × Age) + (d × Gender) + (e × BMI).

Means and standard deviations (SDs) were used to describe continuous variables. Changes from the baseline to the outcomes at 1- or 2-years were evaluated using a paired t test analysis, and group comparisons were conducted using an unpaired t-test analysis. The significance level was set at 0.05. A standardized beta coefficient (Std. beta) was used to compare the strength of the effect of each individual independent variable to the dependent variable, so that the higher the absolute value of the beta coefficient, the stronger the effect. A negative beta coefficient would indicate that for every 1-unit increase in the predictor variable, the outcome variable would decrease by the beta coefficient value.

As the two most common cohorts were Idiopathic and Degenerative ASD, these were analysed in terms of mean values, standard distribution, distribution (Kolmogorov–Smirnov test of normality, KS) and for significant difference between the mean baseline-2 year changes (independent t-test). Correlations (Pearson's co-efficient) were calculated between increasing age and mean baseline-2 year HRQL subclass changes, to identify if the surgery had an increasing effect on subjects as they got older.

Results

A total of 353 patients were included in this study, comprising of 289 females and 64 males. The average age was 49.1 (SD 19.5) and BMI was 24.3 (SD 4.4). Table 1 demonstrates the changes in radiographic and HRQL scores

Table 1 Univariate analysis

Details	Baseline	1 year	2 years
Major curve Cobb° (SD)	53.4 (16.2)	28.1 (16.1)	28.7 (16.1)*
RSA° (SD)	11.8 (16.2)	6.7 (12.5)	8.2 (12.4)*
NRS Back	6.4	3.6	4.0*
ODI Pain	2.4	1.3	1.4*
ODI Personal care	0.92	0.84	0.83
ODI Lifting	2.44	2.40	2.25
ODI Walking	1.52	1.06	1.19*
ODI Sitting	1.64	1.09	1.15*
ODI Standing	2.45	1.53	1.57*
ODI Sleeping	1.06	0.59	0.66*
ODI Sex life	2.11	1.29	1.12*
ODI Social life	2.42	1.60	1.55*
ODI Travelling	2.04	1.25	1.24*
ODI Score %	35.53	23.75	24.58*
SRS22 Function	3.22	3.55	3.64*
SRS22 Pain	2.81	3.64	3.57*
SRS22 Self image	2.46	3.63	3.56*
SRS22 Mental health	3.23	3.65	3.58*
SRS22 Satisfaction	3.11	4.20	4.05*
SRS22 Subtotal	2.93	3.68	3.58*
SF36 Physical function	38.23	42.62	43.20*
SF36 Body pain	34.88	43.00	42.92*
SF36 Vitality	43.07	48.05	48.47*
SF36 Emotional	41.15	45.51	45.87*
SF36 Mental health	41.91	46.71	46.60
SF36 General health	43.21	48.99	48.14*
SF363d(6).Stairs	1.97	2.31	2.30*
SF363g(9).Walking > mile	1.79	2.31	2.33*
SF363h(10).Walking several blocks	2.09	2.55	2.58*
SF363j(12).Bathing or dressing	2.59	2.55	2.59
SF369b(24). Nervous	3.19	3.60	3.52*
SF369i(31). Feel tired	2.50	2.99	2.97*
SF36 Social functioning	40.39	45.64	46.50*

SD standard deviation, *$p < 0.01$

Table 2 Oswestry Disability Index subclass pre- to post-operative changes (dODI) due to coronal (dCobb) and sagittal (dRSA) corrections (standardized beta coefficient, Std. beta). The only subclass to consistently demonstrate significance of effect was sagittal correction on sex life. No coronal correction affected any HRQL subclass

Dependent variables	dCobb 1y Std. beta	dRSA 1y Std. beta	dCobb 2y Std. beta	dRSA 2y Std. beta
ODI				
dNRS Back pain	0.206***	ns	ns	ns
dODI_Pain Intensity	ns	ns	ns	ns
dODI-personal care	ns	ns	ns	ns
dODI_Lifting	ns	ns	ns	ns
dODI_Walking	ns	ns	ns	ns
dODI_Sitting	ns	ns	ns	ns
dODI_Standing	ns	ns	ns	ns
dODI_Sleeping	ns	ns	ns	0.153*
dODI_Sex Life	ns	0.212*	ns	0.286**
dSocial Life	ns	ns	ns	0.217**
dODI_Traveling	ns	ns	ns	ns
dODI—Score (%)	ns	ns	ns	0.137*

*p < 0.05, **p < 0.01, ***p < 0.001

Table 3 Scoliosis Research Society (SRS22) subclass changes relative to coronal (dCobb) and sagittal (dRSA) corrections (standardized beta coefficient, Std. beta). HRQL subclass variability was persistently associated with dRSA and dCobb for self-image

Dependent variables	dCobb 1y Std. beta	dRSA 1y Std. beta	dCobb 2y Std. beta	dRSA 2y Std. beta
SRS-22				
dSRS-Function	ns	ns	ns	ns
dSRS-Pain	ns	ns	ns	ns
dSRS-Self image	−0.164**	−0.251***	−0.141*	−0.201**
dSRS-Mental health	ns	ns	ns	ns
dSRS-Satisfaction	ns	ns	ns	−0.324***
dSRS-Subtotal score	ns	−0.121*	ns	−0.148*

*p < 0.05, **p < 0.01, ***p < 0.001

Table 4 SF36 subclass changes relative to coronal (dCobb) and sagittal (dRSA) corrections (standardized beta coefficient, Std. beta). HRQL subclass variability was persistently associated with dRSA for reductions in fatigue, vitality and social functioning. No coronal correction affected any HRQL subclass

Dependent variables	dCobb 1y Std. beta	dRSA 1y Std. beta	dCobb 2y Std. beta	dRSA 2y Std. beta
SF-36				
Climbing several flights of stairs	ns	ns	ns	ns
Walking more than a mile	ns	ns	ns	−0.136*
Walking several blocks	ns	−0.136*	ns	ns
Nervous	ns	ns	ns	ns
Fatigue	ns	−0.156*	ns	−0.217***
dBody pain	ns	ns	ns	ns
dVitality	ns	−0.131*	ns	−0.223***
dSocial functioning	ns	−0.158*	ns	−0.155**
dMental health	ns	ns	ns	ns

*p < 0.05, **p < 0.01, ***p < 0.001

over the 2-year period. All HRQL total scores significantly improved postoperatively, including ODI, SRS-22 and SF36.

Tables 2, 3 and 4 demonstrate the beta coefficient results for the ODI, SRS22 and SF36, respectively. Table 5 summarizes the significant findings. HRQL subclasses which displayed persistent (1- and 2-year) improvements which correlated to dRSA included sex life from ODI, self-image from SRS22 and fatigue, vitality and social functioning from SF36. The only HRQL subclass improvement that correlated

Table 5 Summary of HRQL subclass changes relative to coronal (dCobb) and sagittal (dRSA) corrections (standardized beta coefficient, Std. beta)

Dependent variables	dCobb 1y Std. beta	dRSA 1y Std. beta	dCobb 2y Std. beta	dRSA 2y Std. beta
dODI_Sex Life	ns	0.212*	ns	0.286**
dSRS-Self image	−0.164**	−0.251***	−0.141*	−0.201**
Extended Walking (SF36)	ns	−0.136*	ns	−0.136*
dFatigue	ns	−0.156*	ns	−0.217***
dVitality	ns	−0.131*	ns	−0.223***
dSocial functioning	ns	−0.158*	ns	−0.155**

*p < 0.05, **p < 0.01, ***p < 0.001

with dCobb was self-image from SRS22. No other change in HRQL subclass correlated with change in dCobb.

Age profiles of Idiopathic and Degenerative cohorts were means (standard deviation) of 42.4 18.1) and 66.5 (10.3) years, respectively. KS test statistics were 0.12 and 0.07, p-values were 0.11 and 0.72 indicating normal distribution. Mean values for dODI, dSRS, dSF36PCS, dSF36MCS were −10.1 and −14.1, 0.6 and 0.7, 5.7 and 6.8 and 4.0 and 6.0 without significant differences evident for any group ($p > 0.05$). Correlation scores, r assessing increasing age and dODI sex life, dSRS self-image, dSF36 Fatigue, dSF36 vitality and dSF36 social functioning were 0.46, −0.14, −0.17, −0.15 and −0.19, respectively.

Discussion

As adult spinal deformities are increasing in prevalence in western societies, particularly in ageing population groups, HRQLs have gained in popularity as an effective method for evaluating the burden of this disease and benefits of treatment. ASD has been shown to display significantly lower HRQL scores than the other chronic conditions including arthritis, chronic lung disease, diabetes and congestive heart failure [12]. Consistent with previous data from within this and other databases, HRQLs and their sub-classes improve post scoliotic correction in adult spinal deformity cases [2, 13]. Relative sagittal alignment (RSA) was used in this analysis as it is sufficient as a single sagittal parameter to take into account spinal malalignment and pelvic compensation [10]. With overall improvement in HRQL, a limited number of sub-class improvements correlated with improvements in degrees of sagittal correction (dRSA) but only self-image improved relative to coronal correction (dCobb) (Table 5).

The amount of RSA correction persistently correlated with improvements in HQRL for sex life, fatigue and vitality, without corresponding correlations in coronal Cobb angle correction. Social functioning from SF36 also correlated with sagittal correction but was relatively unchanged from 1 to 2 years, although it was also evident from the ODI after 2 years. Walking distances also correlated with sagittal correction from the SF36, albeit expressed as walking "several blocks" at 1-year and "more than a mile" at 2 years. This was not reflected in the ODI and did not correlate with climbing several flights of stairs, perhaps because of other limitations. Pre-existent patient factors, complications, revision surgery and neurologic pain, etc. are also key factors that if experienced effect the HRQLs even with sufficient correction [3, 14–16]. While self-image correlated with both RSA and Cobb changes, it was not as lasting as other significant correlative parameters as it had a lower coefficient at 2 years, indicating that the satisfaction achieved with post-operative appearance is unlikely to improve with further healing or rehabilitation, as expected. Self-image, if reported as a predominant symptom preoperatively, would indicate that measures to achieve a greater Cobb correction are a priority surgical objective. Otherwise, achieving coronal correction in ASD remains important overall, but the degree to which it is achieved will not correlate with gains in sub-classes of HRQL.

The relative influence of clinical and radiological factors on the decision-making process has recently been reported. Some studies have shown that coronal deformity is an essential factor for decision-making in ASD [5, 17]. Proven characteristics that aid the decision-making process in ASD correction in patients under 40 years include self-image score in the SRS-22 score, coronal Cobb angle, PI-LL mismatch, and RSA [5]. In those older than 40 years, pain and self-image domains in the SRS-22 score, the coronal Cobb angle and RSA were reliably the most predictive scores for the selection of surgical management [18]. In both cohorts, coronal correction was linked to sagittal correction. It must be considered that this study focussed on subjects with a preoperative Cobb angle of > 30° residual curve. A residual coronal curve may be an acceptable outcome (Figs. 1 and 2), in the knowledge that a greater coronal angular correction does not yield greater improvements in HRQL.

Identification of a threshold beyond which coronal correction correlates with HRQL sub-class improvement is the subject of ongoing work. Differential item functioning analysis from the same database reveals that coronal balance is not associated with HRQL outcomes but a cobb correction

Fig. 1 Clinical photograph of female patient with coronal and sagittal deformity; preoperative

Fig. 2 Post-operative photograph. Residual coronal curve is less important than achieving head-over-pelvis coronal-plane correction

greater than 33° is associated with a poorer SRS-22 score [15]. Cohorts of Idiopathic and Degenerative scoliosis demonstrated different age patterns, as expected. They did not yield significant differences in baseline-2 years changes in HRQLs nor were there strong correlations between increasing age and the baseline-2 years changes for sex life, self-image, fatigue, vitality or social functioning.

This study has some limitations warranting consideration. Firstly, the mean age of patients from this report is 49 years and standard distribution is 19.1. It is likely that the findings of sex life and self-image may vary according to age which was not assessed. Coronal deformity has more recently been classified according to coronal translation, stiffness, mobility and degeneration of the lumbosacral junction, however these parameters were not analysed in the current study [19, 20]. Previous HRQL subclass analysis on 170 patients from an earlier version of the same database demonstrated the restrictive effects of instrumentation extending to the pelvis [3]. That study demonstrated that personal care and lifting from the ODI were not improved after 1 year. These disadvantages were correlated to sagittal modifiers of SRS-Schwab classification similar to other HRQL. The degree of personal care disadvantage was mainly dependant on the lower instrumented vertebra (LIV) location and preoperative pathology. These parameters were not included in our study. While single level and selective fusions were excluded it cannot be affirmed that all patients were complaining of malalignment. Coronal translation was not included in this study which remains an important aspect of coronal correction, particularly where there is coronal decompensation.

Conclusion

Adult scoliosis correctional surgery improves overall HRQL with a limited number of sub-classes demonstrating improvements relative to the amount of sagittal correction. Achieving coronal correction remains important overall, but the degree to which it is achieved, apart from

self-image, will not correlate with gains in sub-classes of HRQL. Aggressive corrections of coronal deformity may not be required in ASD surgery.

References

1. Acaroglu RE, Dede O, Pellise F, Guler UO, Domingo-Sabat M, Alanay A, Pérez-Grueso FS (2016) Adult spinal deformity: a very heterogeneous population of patients with different needs. Acta Orthop Traumatol Turc 50(1):57–62
2. Bridwell KH, Glassman S, Horton W et al (2009) Does treatment (nonoperative and operative) improve the two-year quality of life in patients with adult symptomatic lumbar scoliosis: a prospective multicenter evidence-based medicine study. Spine 34(20):2171–2178
3. Yoshida G, Boissiere L, Larrieu D et al (2017) Advantages and disadvantages of adult spinal deformity surgery and its impact on health-related quality of life. Spine 42(6):411–419
4. Paul JC, Lonner BS, Goz V et al (2015) Complication rates are reduced for revision adult spine deformity surgery among high-volume hospitals and surgeons. Spine J 15(9):1963–1972
5. Fujishiro T, Boissière L, Cawley DT, 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
6. Acaroglu E, Yavuz AC, Guler UO 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
7. Acaroglu E, Guler UO, 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 Turc 51(3):181–190
8. Boissiere L, Takemoto M, Bourghli A et al (2017) Global tilt and lumbar lordosis index: two parameters correlating with health-related quality of life scores-but how do they truly impact disability? Spine J 17:480–488
9. Yilgor C, Sogunmez N, Boissiere L et al (2017) Global alignment and proportion (GAP) score development and validation of a new method of analyzing spinopelvic alignment to predict mechanical complications after adult spinal deformity surgery. J Bone Joint Surg Am 99(19):1661–1672
10. Kieser DC, Boissiere L, Yilgor CC et al (2019) A single sagittal parameter for decision making in adult spinal deformity. J Spine Neurosurg 8:3
11. Bridwell KH, Cats-Baril W, Harrast J et al (2005) 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 30:455–461
12. Pellisé F, Vila-Casademunt A, Ferrer M et al (2015) Impact on health-related quality of life of adult spinal deformity (ASD) compared with other chronic conditions. Eur Spine J 24(1):3–11
13. Theis J, Gerdhem P, Abbott A (2015) Quality of life outcomes in surgically treated adult scoliosis patients: a systematic review. Eur Spine J 24(7):1343–55. doi: https://doi.org/10.1007/s00586-014-3593-3.
14. Núñez-Pereira S, Vila-Casademunt A, Domingo-Sàbat M et al (2018) Impact of early unanticipated revision surgery on health-related quality of life after adult spinal deformity surgery. Spine J 18(6):926–934
15. Kieser DC, Yuksel S, Boissiere L et al. (2020) Impact of radiologic variables on item responses Of ODI and SRS22 in adult spinal deformity patients: differential item functioning (DIF) analysis results from a multi-center database. In press
16. Takemoto M, Boissière L, Novoa F et al (2016) Sagittal malalignment has a significant association with postoperative leg pain in adult spinal deformity patients. Eur Spine J 25(8):2442–2451
17. Bess S, Boachie-Adjei O, Burton D et al (2009) Pain and disability determine treatment modality for older patients with adult scoliosis, while deformity guides treatment for younger patients. Spine 34:2186–2190
18. Fujishiro T, Boissière L, Cawley DT 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
19. Obeid I, Berjano P, Lamartina C et al (2019) Classification of coronal imbalance in adult scoliosis and spine deformity: a treatment-oriented guideline. Eur Spine J 28:94–113
20. New classification of coronal malalignment for adult spinal deformity: a validation and the role of lateral bending films. In press.