How do idiopathic scoliosis patients who improve after surgery differ from those who do not exceed a minimum detectable change?

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Abstract

Introduction The minimum detectable change (MDC) of the SRS-22 subtotal score is 6.8 points. With the use of this value, patients who have undergone surgery for idiopathic scoliosis can be dichotomized into two groups: the successful (S) group (those who have reached or exceeded this limit) and the unsuccessful (Un-S) group (those in whom the change was smaller). The aim of this study was to analyze the clinical and radiological differences between these patient groups, as well as those related to the surgical technique.

Material and Methods The study included 91 patients (77 women and 14 men, mean age 18.1 years). All patients completed the SRS-22 questionnaire preoperatively and at follow-up (mean 45.6 months). In addition, radiological and surgical data were collected: levels instrumented, number of fused vertebrae, and use of thoracoplasty.

Results Based on the MDC of the SRS-22 subtotal score, patients were assigned to the Un-S group (44 cases, 48.4%) or S group (47 cases). Groups were similar in age, sex, number of fused vertebrae, percentage of patients who underwent thoracoplasty, and the upper and lower instrumented levels. The magnitude of the major curve and percentage of correction after surgery were also similar (Un-S group 62.3°, 53.2%; S group 64.3°, 49.9%). As compared to Un-S group, S patients had a poorer preop score in all the SRS-22 domains, and a clinically significant

postop improvement in pain, perceived body image, mental health, and subtotal score. In contrast, the Un-S group showed a worsening of pain, function, mental health, and subtotal score, and a clinically nonsignificant improvement in perceived body image on the follow-up questionnaire. There were no significant differences in the satisfaction domain score between groups (4.36 vs. 4.62). On ROC curve analysis, a preop subtotal score of 74 points predicted allocation to the S or Un-S group at follow-up with 79% sensitivity and 76% specificity.

Conclusion The preop subtotal score of the SRS-22 is a good predictor of the clinical response to surgery.

Keywords Idiopathic scoliosis · Health-related quality of life · Minimal important difference · Outcome

Introduction

The outcome of surgical treatment for idiopathic scoliosis is usually evaluated by process measures, such as the change in the radiologic magnitude of the curve. Nonetheless, it is currently accepted that the evaluation should also include patient-oriented measures, which can be obtained with the use of patient-reported outcome instruments (PRO). There is evidence that PROs enable the clinician to better judge the patient's problems with the aim of providing the most suitable management for the patient's condition [1].

The SRS-22 questionnaire is the PRO instrument most widely used for assessing the clinical status of patients with idiopathic scoliosis [2]. The questionnaire is divided into four domains (pain, function, perceived body image, and mental health), and includes two questions about the patient's satisfaction with the treatment received. Each domain has a sum score ranging from 5 to 25, except for

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satisfaction, which ranges from 2 to 10. The sum of the first four domains gives a maximum subtotal of 100. It has been determined that the minimum detectable change (MDC) for the SRS-22 subtotal score is 6.8 points [3]. The MDC [4] is the minimal score change above which (with 95% certainty) it is guaranteed that the difference is not due to measurement error. The MDC is calculated from the standard error of measurement (SEM), which is the measurement error inherent to the instrument. For the SRS-22, the MDC was calculated as follows: $1.96 \times \sqrt{2} \times \text{SEM}$ [3].

Once the MDC of the SRS-22 subtotal score has been established, we can categorize patients who received surgical treatment for idiopathic scoliosis according to whether they have exceeded this value, which would place them in the group we have labeled successful (S) or whether they have not, which would place them in the group labeled unsuccessful (Un-S). We emphasize that this methodology does not intend to judge the success or not of surgery. Allocation to a group indicates a response to surgery according to the SRS-22 subtotal score change.

In this study, we analyze a series of patients who underwent surgery for idiopathic scoliosis and determine the percentage who exceed the MDC of the SRS-22 subtotal score in the follow-up evaluation. The differences between the two groups formed are then examined in terms of their clinical status, radiologic measures (magnitude of the curve preoperatively and at final follow-up, and percentage of correction), and characteristics of the surgery (number of fused vertebrae, level of end vertebrae). Lastly, the preoperative and perioperative variables that could be predictive of the patients' outcome group are determined.

Methods

Study population

Patients from the two participating hospitals were prospectively included in the study. The eligibility criteria were a diagnosis of idiopathic scoliosis scheduled for surgical correction, age between 10 and 40 years, adequate radiologic study, and completion of the SRS-22 questionnaire. Between July 2001 and July 2006, 97 patients were included, and after a minimum of 2 years following surgery, they were contacted to attend a clinical and radiologic follow-up visit.

Data collection

The patients' clinical status was assessed with the SRS-22 questionnaire. As was described above, this instrument contains 22 questions covering five domains: function/

activity, pain, self-perceived body image, mental health, and satisfaction with treatment. The sum of the first four domains gives a maximum subtotal score of 100. The questionnaire used in the study is the revised version, which includes the modification of question 18 [5].

The radiologic data collected were the magnitude of the curve (Cobb angle) in the PA view, and thoracic kyphosis (T4–T12) and lumbar lordosis (L1–S1) in the sagittal view. The surgical data included the proximal and distal levels of the instrumentation, the number of vertebrae within the fusion, and whether thoracoplasty had been performed as an adjuvant to vertebral fusion.

The data were analyzed with SPSS 11.0. Descriptive data (mean and SD) were calculated for each variable. Comparison of the means between groups was carried out with the Student's *t* test for variables with a normal distribution, and the non-parametric Mann–Whitney test for variables with a non-normal distribution. The Chi square test was used to compare percentages. In addition, ROC curves were analyzed to determine what cut-off value of the SRS-22 domain scores best predicted a patient's outcome group. Significance was set at a *p* value of 0.05.

Results

Characteristics of the patients

Of the 97 patients included in the study, four were lost to follow-up and two refused to attend the study follow-up visit. Thus, the analysis is based on the results from 91 patients (93.8% response rate), 77 females and 14 males, with a mean age at the time of surgery was 18.1 years (range 10–38 years). The mean follow-up time was 45.6 months (range 24–87 months). All patients had idiopathic scoliosis and received surgical treatment. The type of surgery was posterior spinal fusion and instrumentation in 74 cases, anterior spinal fusion and instrumentation in eight cases, and anterior and posterior fusion in nine cases. Thoracoplasty was carried out in 40 patients. The mean upper instrumented vertebra was T4.8 (range T1–T12) and the mean lower instrumented vertebra was L1.9 (range T11–L5). A mean of 10.1 (range 4–16) vertebrae were fused.

Curve patterns were determined according to the Lenke classification [6], and included 32 type 1 cases, 17 type 2, 10 type 3, 5 type 4, 10 type 5, and 17 type 6. Mean magnitude of the upper thoracic curve was 49.8° (SD 10.3), main thoracic curve 61.5° (SD 15.6), and thoracolumbar/lumbar curve 60.8° (SD 13.6). At the time of the follow-up study, the magnitude of the upper thoracic, main thoracic and thoracolumbar/lumbar curve was 32.8° (SD 12.7), 29.4° (SD 10.5), and 30.1° (SD 13.4), respectively. The magnitude of the largest of these three curves (CMAX) was

recorded for each patient. The CMAX averaged 63.3° (range 37°–115°) before surgery and 30.9° (range 0°–64°) at follow-up. Mean preoperative and follow-up values were 29.1° and 25.8°, respectively, for thoracic kyphosis, and 56.3° and 53.4°, respectively, for lumbar lordosis.

Outcome measures

The scores on the SRS-22 domains before surgery (T0) and at the follow-up study are shown in Table 1. A statistically significant improvement was found for the subtotal score and for the pain, image and mental health domains, but not for the function domain. Data on satisfaction, which were only collected at the follow-up visit, showed elevated satisfaction with surgery (mean 4.5).

Analysis of the groups

Based on an MDC cut-off of 6.8 for the subtotal score change, 44 patients (48.4%) did not exceed this value and were classified in the Un-S group and 47 patients equaled or exceeded this value and were classified in the S group.

Radiographic data

The radiologic values related to the upper thoracic, main thoracic, thoracolumbar and CMAX curves at preop and at follow-up, as well as thoracic kyphosis and lumbar lordosis are shown in Table 2. There were no significant differences between the groups for any of these variables. Of particular note is the fact that there was no difference regarding the percentage of correction of the different curves between the groups.

General and operative data

The patient age and sex, number of fused vertebrae, percentage of patients who underwent thoracoplasty, and the upper and lower instrumented levels are shown in Table 3. There were no significant differences between the groups.

Table 1 Mean scores on the SRS-22 patient questionnaire before surgery (T0) and at follow-up

	T0 (±SD)	Follow-up	Mean change
Pain	3.9 (±0.8)	4.2	0.3*
Function/activity	4.2 (±0.7)	4.3	0.1
Image	2.9 (±0.8)	3.9	1.0**
Mental health	3.8 (±0.7)	3.9	0.1*
Satisfaction		4.5	
Subtotal score	74.1 (±12.3)	82.5	8.4**

* $p < 0.05$ ** $p < 0.0001$

Table 2 Means of the radiologic parameters between the successful (S) and unsuccessful (Un-S) groups

	Group Un-S	Group S	<i>p</i>
UpTh			
Preop (°)	49.8	49.8	ns
Follow-up (°)	30.8	33.7	ns
Correction (%)	39.8	33.7	ns
MTh			
Preop (°)	59.8	63.1	ns
Follow-up (°)	27.2	31.5	ns
Correction (%)	54.4	48.1	ns
ThL			
Preop (°)	64	57.9	ns
Follow-up (°)	31.3	29	ns
Correction (%)	54.4	50	ns
CMAX			
Preop (°)	62.3	64.3	ns
Follow-up (°)	29.5	32.2	ns
Correction (%)	53.2	49.9	ns
Th kyphosis			
Preop (°)	29.2	29.1	ns
Follow-up (°)	24.7	26.9	ns
Lumbar lord			
Preop (°)	55.8	56.8	ns
Follow-up (°)	55.6	51.3	ns

CMAX curve of maximum magnitude, *Lumbar lord* lumbar lordosis, *MTh* main thoracic curve, *Th kyphosis* thoracic kyphosis, *ThL* thoracolumbar/lumbar curve, *UpTh* upper thoracic curve, *ns* non-significant

Clinical data

Mean scores for the SRS-22 domains and the subtotal and total scores for each group are shown in Table 4.

The clinical status of patients in group S was significantly poorer than that of group Un-S before surgery, and they achieved a greater improvement in all the domains and in the subtotal. The total score (postoperative subtotal + satisfaction; range 22–110) was also significantly higher in group S. Satisfaction, however, was similar in the two groups.

To analyze the possible ceiling effect of the questionnaire, we calculated the benefit obtained by surgery (postoperative subtotal minus preoperative subtotal) in relation to the possible benefit (100 minus preoperative subtotal). As is shown in Table 4, the possible benefit and obtained benefit were clearly higher in group S. It would be expected that the percentage of possible benefit attained would be similar in the groups, but instead, there was a gain of 54% in group S and a loss of 20% in group Un-S.

Table 3 General and operative data per group

	Group Un-S	Group S	<i>p</i>
Age	17.6	18.4	ns
Sex	81.8	87.2	ns
(% women)			
Thoracoplasty	40.9	46.8	ns
(% patients receiving)			
Time to follow-up (months)	46.4	44.8	ns
Upper instrumented level	T4.27	T5.3	ns
Lower instrument level	L1.9	L1.9	ns
Number of fused vertebrae	10.7	9.6	ns

Table 4 Mean SRS-22 scores between groups

	Group Un-S	Group S	<i>p</i>	MDC*
Pain				
Preop	4.29	3.53	0.0001	
Postop	4.04	4.42	0.01	
Difference	−0.25	0.88	0.0001	0.6
Function/activity				
Preop	4.5	3.89	0.0001	
Postop	4.25	4.4	ns	
Difference	−0.25	0.5	0.0001	0.8
Body image				
Preop	3.27	2.54	0.0001	
Postop	3.75	4.11	0.01	
Difference	0.48	1.56	0.0001	.5
Mental health				
Preop	4.14	3.52	0.0001	
Postop	3.86	4.1	ns	
Difference	−0.28	0.58	0.0001	0.4
Subtotal score				
Preop	81.1	67.4	0.0001	
Postop	79.6	85.2	0.01	
Difference	−1.5	17.7	0.0001	6.8
Satisfaction	4.36	4.62	ns	
Total sum at follow-up (subtotal at follow-up + satisfaction)	88.3	94.4	0.006	
Possible benefit	18.8	32.5	0.0001	
Obtained benefit	−1.5	17.7	0.0001	
% of possible benefit obtained	−19.5	54.9	0.0001	

* Data on the minimal detectable change (MDC) of the SRS-22 Patient Questionnaire following surgical treatment of idiopathic scoliosis [3]

ROC curve analysis

For each of the SRS-22 domains and the subtotal score, we determined the value that best predicted a patient's

Table 5 ROC curve analysis

	Cut-off	AUC	Sensitivity	Specificity
Pain	3.4	0.73	88.6	55.3
Function/activity	4.6	0.77	52.3	95.7
Image	3	0.77	70.5	80.9
Mental health	3.6	0.75	55.3	84.1
Subtotal	74	0.84	79.5	76.6

The cut-off value, area under the curve (AUC), and sensitivity and specificity to predict a patient's outcome group are shown for each of the SRS-22 domain scores and for the subtotal score

belonging to the successful or unsuccessful groups. The optimal cut-off value, area under the curve (AUC), sensitivity, and specificity, and the significance of testing when the ROC curve found differed from a hypothetical value of 0.5 are shown in Table 5.

Focussing on the subtotal score, we see that a score of 74 enables a quite accurate prediction of which outcome group a patient will be classified in. On a 2×2 contingency table, 80% of patients in group S had a subtotal score ≤ 74 , whereas only 24% of patients in group Un-S had this score (χ^2 28.6, $p = 0.0001$).

Discussion

In a sample of surgically treated patients with idiopathic scoliosis, we found that only 51.6% of cases equaled or exceeded the calculated minimum detectable change on the SRS-22 questionnaire. Furthermore, according to the 95% confidence interval, this percentage would not exceed 62% even in the most favorable scenario. These data suggest that the effect of surgery on the clinical status of these patients as evaluated with the SRS-22 is smaller than would be expected.

For the overall series, the score change was clinically notable in the body image scale and subtotal score, fair in the pain scale, and clinically insignificant in mental health and function. Similar results were reported by Carreon et al. [7] in adolescents with idiopathic scoliosis and by Bridwell et al. [8] in adults with this condition. In both the series, the patients' health-related quality of life (HRQL) was evaluated with the SRS-22 questionnaire. Howard et al. [9] also described a moderate change in the patients' postoperative clinical status using a different PRO, the Quality of Life Profile for Spine Deformities. This instrument includes four scales, labeled psychosocial functioning, sleep disturbances, back pain, body image, and trunk flexibility [10].

A primary aim of our research was to determine what variables have an influence on a patient's assignment to one or the other outcome. There was no influence of age,

sex or follow-up time. Nor were there differences related to the surgical technique (number of fused vertebrae, upper or lower level of the instrumentation, or the use of adjuvant thoracoplasty). Of note, the radiologic magnitude of the curves was of no value in predicting the outcome group. In the frontal plane, neither the preoperative nor follow-up curve magnitude, nor the percentage of correction showed significant differences between the two outcome groups for the various curves studied (upper thoracic, main thoracic, or thoracolumbar curve). Furthermore, there were no significant differences between the groups for thoracic kyphosis or lumbar lordosis in either the preoperative or follow-up measures.

A significant correlation between the radiologic magnitude of scoliosis and the SRS-22 scores is usually reported [2, 11, 12], although the correlation coefficients range from low to moderate. In the follow-up of surgically treated patients, a moderate correlation has been described between the radiologic improvement and SRS-22 scores [12, 13]. However, there is no study analyzing the relationship between radiologic improvement and the change in SRS-22 scores. We found no differences between the S and Un-S groups in the percentage of correction of any of the three curves, or of the curve with the largest magnitude (CMAX). These findings indicate that the percentage of curve correction does not have a determinant effect on the patient's perception of a clinically significant change.

As compared to the Un-S group, the S group had a greater degree of pain and a poorer body image before surgery. Both these domains had improved at follow-up and showed a postoperative change that exceeded the MDC. Function was poorer than in the Un-S group before surgery, similar at follow-up, and the postoperative change was larger, but it did not exceed the MDC. In the mental health domain, the score was lower than in Un-S patients before surgery, no different at follow-up, and the change was larger and exceeded the MDC. In the subtotal score, the S group again showed a lower mean score than the Un-S group before surgery, a higher score at follow-up, and a greater change that exceeded the MDC. In the Un-S group, as was mentioned, there was a deterioration of the pain, function, mental health, and subtotal score, although the differences observed did not exceed the MDC. The only improvement, which occurred in the body image score, did not surpass the MDC. Interestingly, the mean satisfaction scores were not statistically different between the two groups (Table 4).

Simplifying our results to the extreme, we can say that patients with the lowest scores preoperatively are those that attain the highest scores after surgery. This tendency could be attributed to a defect of the measurement instrument. Indeed, the SRS-22 has shown an elevated ceiling effect (usually over 20%) in several studies [2, 12, 14], and this

characteristic could limit the instrument's sensitivity to change. Thus, it can be argued that patients with high preoperative scores would show only a small postoperative improvement, or no improvement because the instrument would not be able to register the change. Nevertheless, our analysis showed that the possible benefit and obtained benefit with surgery were clearly higher in group S. In the S patients, there was an improvement of 55% of the maximum possible benefit, whereas in the Un-S group there was a loss of 20% of the possible benefit. According to these data, it is unlikely that the difference between the two groups is attributable to the ceiling effect of the instrument.

In a sample of healthy adolescents with a mean age similar to those in our study (16 vs. 18 years), Verma et al. [15] reported mean SRS-22 scores of 4.0 in function, 4.3 in pain, 4.2 in image, 3.8 in mental health, and 82 for the subtotal. A comparison between these values and the means obtained in our Un-S group shows that with the exception of the image scale, the preoperative scores of these patients were higher or equal to those reported in healthy individuals. In contrast, all the preoperative S group scores were below the means in healthy adolescents. These data suggest that the health status of an elevated percentage of adolescents who undergo surgery for idiopathic scoliosis is difficult to improve and similar to that of healthy adolescents, except regarding the issue of body image. Our data show that the main difference between the S and Un-S groups resides in the preoperative scores. Using ROC curve analysis, we found that a preoperative subtotal score of 74 predicted a response to surgery with a sensitivity of 79% and a specificity of 76%.

Our series is somewhat heterogeneous with respect to age. Although all the patients had scoliosis, an analysis of the clinical outcome of patients aged 10–38 years could be debatable. Nonetheless, the mean of the sample (18.1 years) is close to the median (16 years). By the way of orientation, we mention that only 13 patients were older than 25. It is a known fact that age has a negative impact on quality of life. According to our results, however, age did not seem to have an influence on the magnitude of the clinical change that occurred following surgery.

One potential criticism of this research might be that the way of presenting the results as success or failure according to the minimal important difference cutoff (in this case the MDC) is a rather simplistic approach. Nonetheless, some experts advocate this type of dichotomization of the results, particularly for understanding the changes in response to treatment recorded by PRO instruments. The rationale is that this procedure enables clinicians who are not experts in the material to better comprehend the data presented, expressed in the idea of “the great merit of simple-minded dichotomies for clinicians” [16, 17]. Dichotomization can be based on various strategies, one of

which is to categorize patients according to the minimal important difference (MID) [16] of an outcome instrument, which is the method we used.

This leads to another potential problem of our research, since there is controversy regarding the best method for determining the MID of a PRO instrument. In the present study, we determined the minimum detectable change. This is a distribution-based MID calculated using the standard error of measurement of the instrument and the intraclass correlation coefficient as an indicator of the instrument's reliability. The MDC represents the minimal score change above which (with 95% certainty) it is guaranteed that the change is not due to measurement error [4, 18]. Many experts prefer the use of anchor-based methods rather than distribution-based methods because the consistency across measures is better [19]. In addition, anchor-based methods incorporate the patients' opinion, which is a part of the definition of minimally important difference [17, 20]. To our favor, other authors have suggested that anchor-based MID are more subject to bias because the significance of a change in a subjective measure is based on another subjective rating, namely the perceived overall effect [21, 22]. Moreover, the MDC we used for dichotomization (6.8 points) is very close to one-half of the SD of the previously reported mean subtotal score change [3]. This factor is considered by many to be a good approximation of the MID of the instrument [18, 23].

We are aware that the quality of the results of surgery in the case of idiopathic scoliosis cannot be based only on the magnitude of change recorded by an outcome instrument. It is evident that surgery produces a series of effects that are not contemplated by PROs. First, it modifies the natural history of scoliosis. If vertebral fusion is indicated to avoid progression of the deformity, the effect of surgery cannot be picked up by any PRO instrument. In the case of young adolescents, the available data [24] have established the risk of progression of the curve, and this would justify the indication for surgery, even if it is known that an immediate benefit will not be obtained. However, in persons who have reached skeletal maturity without evident radiologic progression of the curve, our results can be useful to inform patients of the possible clinical benefits of surgery. Second, surgery results in a dramatic change in the radiologic magnitude of the curves. For many years, this radiologic improvement has been used as the only way to evaluate the outcome of surgery. There is however, considerable consensus favoring the use of clinical measures in addition to radiologic parameters to assess the surgical outcome. Moreover, our data further support the scant relationship between the clinical and radiologic results in these patients [12, 13], and this fact highlights the need to include both the measures when evaluating the outcome of surgery. Lastly, the patients' satisfaction with surgery must also be

included in the outcome evaluation. General observation has shown that patients are highly satisfied with surgery for scoliosis. Bago et al. [25] reported that 90% of patients were satisfied with the surgery outcome, and 87% would undergo a similar procedure. In addition, 91% of patients stated that they were better or much better than before surgery. We found no differences between the mean scores for satisfaction between the groups, and this result supports the idea that the changes in SRS-22 scores are not intimately related with the satisfaction with treatment.

Conclusion

In a clinical series of idiopathic scoliosis patients treated surgically, only 51% of the total obtained an important clinical improvement based on the MDC of the SRS-22 questionnaire. The success group was characterized by the lower preoperative scores on this instrument than the unsuccessful group, and the change following surgery was clinically important in all the domains except function. In contrast, surgery did not result in a clinically important change in the unsuccessful group. There were no differences between the groups with regard to age, sex, or the technical characteristics of the procedure (e.g., levels fused, thoracoplasty). Of note, there was no relationship between the improvement in the radiologic magnitude of the curve and the changes in the SRS-22 scores. The preoperative scores, particularly the subtotal score, can predict the clinical response to surgery with moderate-to-high sensitivity and specificity. Our data show that patients who obtain greater clinical benefits from surgery are those with poorer preoperative scores. Patients in the unsuccessful group had preoperative scores similar to those of healthy adolescents. Although this point should be examined in greater depth, it seems evident that this patient group would have little possibility of attaining a significant clinical improvement. Therefore, the objectives of surgery in this group should be clearly established. The aims would be to correct the curve, and above all, to modify the natural course (i.e., avoid progression) of the disease. These objectives should be attained with the safest surgical technique that can be offered to the patient.

Conflict of interest None.

References

1. Greenhalgh J (2009) The applications of PROs in clinical practice: what are they, do they work, and why? *Qual Life Res* 18(1):115–123
2. Asher MA, Lai SM, Burton D, Manna B (2003) Discrimination validity of the scoliosis research society-22 patient questionnaire:

- relationship to idiopathic scoliosis curve pattern and curve size. *Spine* 28(1):74–78
3. Bagó J, Pérez-Grueso FJS, Les E, Hernández P, Pellisé F (2009) Minimal important differences of the SRS-22 Patient Questionnaire following surgical treatment of idiopathic scoliosis. *Eur Spine J* 18(12):1898–1904
 4. van der Roer N, Ostelo RWJG, Bekkering GE, van Tulder MW, de Vet HCW (2006) Minimal clinically important change for pain intensity, functional status, and general health status in patients with nonspecific low back pain. *Spine* 31(5):578–582
 5. Asher MA, Lai SM, Glatte RC, Burton DC, Alanay A, Bago J (2006) Refinement of the SRS-22 Health-Related Quality of Life questionnaire Function domain. *Spine* 31(5):593–597
 6. Lenke LG, Betz RR, Harms J, Bridwell KH, Clements DH, Lowe TG, Blanke K (2001) Adolescent idiopathic scoliosis: a new classification to determine extent of spinal arthrodesis. *J Bone Joint Surg Am* 83-A(8):1169–1181
 7. Carreon LY, Sanders JO, Diab M, Sucato DJ, Sturm PF, Glassman SD, the Spinal Deformity Study Group (2010) The minimum clinically important difference in Scoliosis Research Society-22 Appearance, Activity, and Pain Domains after surgical correction of adolescent idiopathic scoliosis. *Spine* 35(23):2079–2083
 8. Bridwell KH, Berven S, Glassman S, Hamill C, Horton WC, Lenke LG, Schwab F, Baldus C, Shainline M (2007) Is the SRS-22 instrument responsive to change in adult scoliosis patients having primary spinal deformity surgery? *Spine* 32(20):2220–2225
 9. Howard A, Donaldson S, Hedden D, Stephens D, Alman B, Wright J (2007) Improvement in quality of life following surgery for adolescent idiopathic scoliosis. *Spine* 32(24):2715–2718
 10. Climent JM, Reig A, Sanchez J, Roda C (1995) Construction and validation of a specific quality of life instrument for adolescents with spine deformities. *Spine* 20(18):2006–2011
 11. Climent JM, Bago J, Ey A, Perez-Grueso FJ, Izquierdo E (2005) Validity of the Spanish version of the Scoliosis Research Society-22 (SRS-22) patient questionnaire. *Spine* 30(6):705–709
 12. Sanders JO, Carreon LY, Sucato DJ, Sturm PF, Diab M, Spinal Deformity Study Group (2010) Preoperative and perioperative factors effect on adolescent idiopathic scoliosis surgical outcomes. *Spine* 35:1867–1871
 13. Takayama K, Nakamura H, Matsuda H (2009) Quality of life in patients treated surgically for scoliosis: longer than sixteen-year follow-up. *Spine* 34(20):2179–2184
 14. Bago J, Climent JM, Ey A, Perez-Grueso FJ, Izquierdo E (2004) The Spanish version of the SRS-22 patient questionnaire for idiopathic scoliosis: transcultural adaptation and reliability analysis. *Spine* 29(15):1676–1680
 15. Verma K, Lonner B, Hoashi JS, Lafage V, Dean L, Engel I, Goldstein Y (2010) Demographic factors affect Scoliosis Research Society-22 performance in healthy adolescents: a comparative baseline for adolescents with idiopathic scoliosis. *Spine* 35(24):2134–2139
 16. Schünemann HJ, Akl EA, Guyatt GH (2006) Interpreting the results of patient reported outcome measures in clinical trials: the clinician's perspective. *Health Qual Life Outcomes* 4:62
 17. Brozek JL, Guyatt GH, Schünemann HJ (2006) How a well-grounded minimal important difference can enhance transparency of labelling claims and improve interpretation of a patient reported outcome measure. *Health Qual Life Outcomes* 4:69
 18. Copay AG, Subach BR, Glassman SD, Polly DW, Schuler TC (2007) Understanding the minimum clinically important difference: a review of concepts and methods. *Spine J* 7(5):541–546
 19. Turner D, Schünemann HJ, Griffith LE, Beaton DE, Griffiths AM, Critch JN, Guyatt GH (2010) The minimal detectable change cannot reliably replace the minimal important difference. *J Clin Epidemiol* 63(1):28–36
 20. Revicki D, Hays RD, Cella D, Sloan J (2008) Recommended methods for determining responsiveness and minimally important differences for patient-reported outcomes. *J Clin Epidemiol* 61(2):102–109
 21. Carragee EJ (2010) The rise and fall of the “minimum clinically important difference”. *Spine J* 10(4):283–284
 22. Gatchel RJ, Lurie JD, Mayer TG (2010) Minimal clinically important difference. *Spine* 35(19):1739–1743
 23. Guyatt G, Schunemann H (2007) How can quality of life researchers make their work more useful to health workers and their patients? *Qual Life Res* 16(7):1097–1105
 24. Lonstein JE, Carlson JM (1984) The prediction of curve progression in untreated idiopathic scoliosis during growth. *J Bone Joint Surg Am* 66(7):1061–1071
 25. Bago J, Perez-Grueso F, Les E, Hernandez P, Pellisé F, Fernandez-Baillo N, Villanueva C, Garcia A (2009) Clinical outcome of surgery for idiopathic scoliosis. Evaluation by satisfaction with treatment and overall perceived effect. *Eur Spine J* 18:139–140