



Observational retrospective study on socio-economic and quality of life outcomes in 41 patients with adolescent idiopathic scoliosis 5 years after bracing combined with physiotherapeutic scoliosis-specific exercises (PSSE)

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Abstract

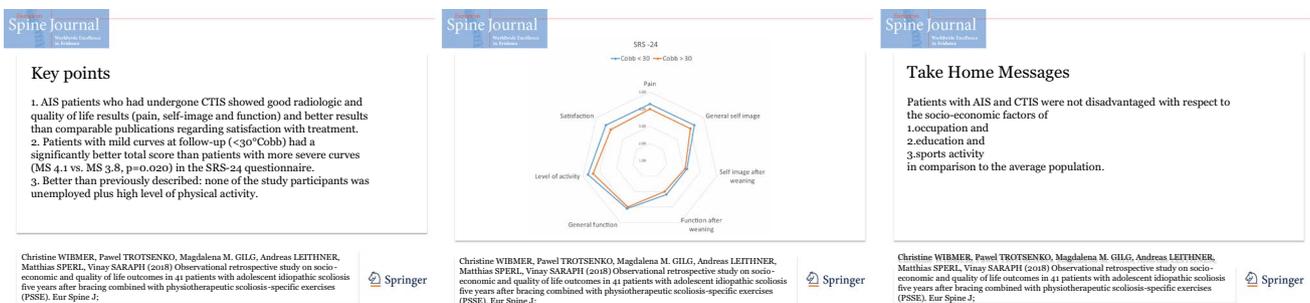
Purpose We analysed socio-economic- and health-related quality of life (primary outcome) and radiological outcome (secondary outcome) 5 years after full time rigid bracing (FTRB) plus physiotherapeutic scoliosis-specific exercises (PSSE) in adolescent idiopathic scoliosis.

Methods We included 41 patients (38 female and 3 male) treated with FTRB (Chêneau brace) and PSSE (Schroth) between 2001 and 2010. The study protocol included a clinical and radiological examination, the completion of the SRS-24 questionnaire and acquisition of data on socio-economic factors (educational and employment status) and physical activity. Descriptive statistics were used to analyse the data; differences between patients with mild ($< 30^\circ$) and severe curves (30° – 50°) regarding hrQoL outcomes were analysed using the Mann–Whitney *U* Test.

Results Primary outcomes showed full employment (higher education, 39%, and full-time work, 61%) and the majority of the patients (79.9%) performing moderate sports two to four times per week. The SRS-24 questionnaire produced a total mean score (MS) of 4.0 (79.9%). Patients with mild curves had a significantly better total score (MS 4.1 vs. MS 3.8, $p = 0.020$) and were more satisfied with the treatment (MS 4.3 vs MS 3.9, $p = 0.020$). As to the secondary outcomes, from start of bracing to follow-up (a mean of 6.7 years after brace weaning), the average Cobb angle changed from 28.6° to 25.6° (range 4° – 48°); in 51.2% the curve angles could be maintained after weaning.

Conclusions Compared with the literature, our results showed similar curve development and hrQoL (pain, self-image and function) and better results regarding satisfaction with treatment. In comparison with the average population, there were no disadvantages as to occupation, education and sports.

Graphical abstract These slides can be retrieved under Electronic Supplementary Material.



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Keywords Adolescent idiopathic scoliosis · Conservative treatment · Full time rigid bracing · Physiotherapeutic scoliosis-specific exercises · Quality of life questionnaire

Background

For the treatment of adolescent idiopathic scoliosis (AIS), the SOSORT (Society on Scoliosis Orthopedic and Rehabilitation Treatment) guidelines [1] recommend stage-specific treatment strategies. Conservative treatment with full time rigid bracing (FTRB) and physiotherapeutic scoliosis-specific exercises (PSSE) is recommended for curve angles between 20° and 45° Cobb and/or curve progression in skeletally immature patients. According to the SOSORT recommendations, various types of PSSE and FTRB are equally advisable, including the Schroth method [2] as PSSE and the Chêneau brace as FTRB, as used in our department.

Only one out of six patients with AIS needs treatment and of these only one out of four will need surgery because of curve progression [3]. Disproportionally, there are more than ten times as many publications on surgical treatment of idiopathic scoliosis than on conservative treatment (CTIS): a Medline search using the terms “idiopathic scoliosis” and “surgery” showed 3508 publications; using the term “conservative treatment” instead resulted in only 228 published articles (retrieval date October, 2016). This suggests that studies on conservative treatment of idiopathic scoliosis are under-represented in the current literature.

The effectiveness of brace treatment to prevent curve progression has been validated in several studies [4–7]; moreover, a combination of bracing with PSSE has been shown to decrease spinal deformities and improve quality of life in comparison with bracing alone [1, 7–10], but adolescents may be disinclined to comply with this enduring therapy. We aimed to examine patients’ socio-economic factors and quality of life after fulfilling years of brace treatment combined with PSSE. We therefore designed a mid-term follow-up study of patients with AIS who had undergone conservative treatment of idiopathic scoliosis (CTIS), focussing on socio-economic (educational and employment status, childbearing, and physical activity) and quality of life outcomes (pain, function, self-image, and satisfaction with treatment (SRS-24 questionnaire)) as the primary research question and comparing them to data from the average population; clinical and radiological outcomes were also assessed (secondary outcome).

Methods

After ethics board approval (EK 27-094 ex 14/15), the databases at the authors’ institution (paediatric orthopaedic unit) were searched for patients with AIS who had undergone CTIS between 2001 and 2010. The patients were contacted by mail and invited to participate in the study, which included one follow-up visit for clinical and radiological examination. Exclusion criteria were scoliosis other than adolescent idiopathic scoliosis, CTIS dropout before skeletal maturity, < 5 years’ follow-up after brace weaning, history of spinal surgery, or current pregnancy.

CTIS at our institution combines FTRB with the Chêneau brace until skeletal maturity with concomitant PSSE according to the Schroth method [2]. This is in accordance with the SOSORT guidelines [1]. Delivery of the brace is performed stepwise (reaching FTRB within a week) accompanied by supervised PSSE. To assess the in-brace correction of the curve, a plain radiograph of the entire vertebral column is taken with the brace in place at the time of brace delivery and throughout the treatment period at six-month intervals. The patients are instructed to wear the brace at least 23 h a day. At three-month intervals, the patients are examined by an orthopaedic surgeon specialized in spinal deformities in the outpatient clinic, with assessment of medical history (menstrual status, medication, and present complaints), inspection of the back in stance and with Adam’s forward bending test (rotation, flexibility, waist and shoulder asymmetry), measurement of height and weight, and brace check (brace inspection, patients and parents oral questioning on compliance). The patients also undergo supervised outpatient physiotherapy sessions throughout the bracing period and are taught an individualized home training programme (duration approximately 30 min at least 5 times a week) comprising Schroth breathing exercises, exercises for elongation, auto-correction, and exercises in front of a mirror to transfer the corrective posture to everyday activities. Patients are considered skeletally mature if standing height remains unchanged over two consecutive visits (> 6-month intervals) and the menarche was more than 2 years earlier [11]; skeletal age is also determined using the method of Greulich and Pyle. Thereafter, brace weaning is initiated as follows: brace weaning for 6 h a day for 3 months; brace weaning during daytime (12 h a day) for the next 3 months, followed by discontinuation of bracing. The patients continue to receive supervised PSSE sessions twice a month and an individualized home training programme during the weaning period and until one year after weaning.

The clinical follow-up examination for the purpose of the study consisted of a structured medical history including pain, physical activity, educational status, employment, and childbearing. Height and weight were measured, an inspection of the back in stance and Adam's forward bending test to assess rotation (measured with the scoliometer) was performed, and flexibility of the vertebral column was assessed.

The radiological examination consisted of a posterior-anterior radiograph of the entire vertebral column. In all female patients, ongoing pregnancy was ruled out with a urine pregnancy test before the X-ray. The Cobb angle was measured by one blinded orthopaedic surgeon specialized in spinal deformities [12]. Acknowledging the known intra-observer variability of approximately 5° upon manual measurement [13, 14], the curve was considered stable if it had changed by < 5°. This is in accordance with the recommendations of the SRS (Scoliosis Research Society) for the analysis of bracing outcome [11].

The patients were asked about the frequency and types of any sports they performed. For comparison with a standard population, the anamnestic data on the patients' sports activities were analysed with an adapted scoring system previously described by Parsch et al. [15] for patients with idiopathic scoliosis (Table 1). This score allows a classification of the mentioned types of sports according to their strenuousness and reported frequency. If the frequency of performed sports was not specified, the sport score equalled two for moderately and one for mildly strenuous types of sports. This produced a standardized value for the amount of moderate sports activity per week and patient.

The clinical and radiological findings were analysed with descriptive methods, as were the data on socio-economics and physical activity.

To evaluate post-treatment quality of life outcome, the disease-specific SRS-24 questionnaire [16], which also

includes an explicit query about ability to perform sports and post-treatment self-image and function, was adapted for CTIS, translated into German and given to the patients. Answers were analysed using the SRS manual [17]. Differences between patients with mild curve angles at follow-up (< 30° Cobb) were compared to patients with more severe curves (> 30° Cobb) using the Mann–Whitney *U* Test; a *p* value of < 5% was regarded as significant. The IBM SPSS Statistics Version 22 software package was used for statistical analysis.

Results

We retrieved 121 patients (103 female and 18 male) who underwent CTIS for AIS. Six patients were excluded (5%, 4 female and 2 male) due to fusion surgery, of whom three (1 female and 2 male) initially presented with severe curves (> 40° Cobb) and two (2 female) did not comply with CTIS. Another 11 patients (9%, 6 female and 5 male) did not comply with CTIS until skeletal maturity and also could not be included in this QoL study. Of the 104 patients eligible for the study, 41 (39%) agreed to participate, presented for the follow-up examination, and completed the SRS-24 questionnaire (Fig. 1).

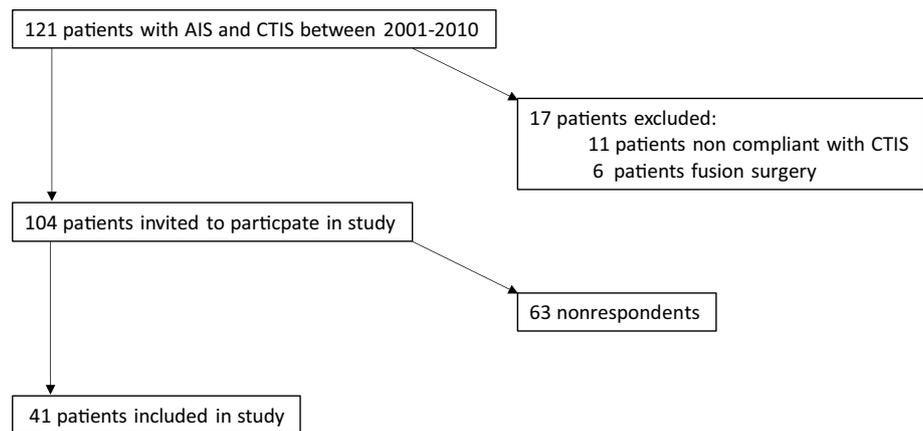
Our study population consisted of 38 female and 3 male participants with AIS; their average age at the start of brace treatment was 13.3 years (median 13.6), and the mean duration of brace treatment was 2.8 years (median 2.7). The mean age at the follow-up examination was 23.7 years (median 23.8), and the mean follow-up time after brace weaning was 6.7 years (median 6.5). In comparison with these study participants, the patient collective that did not take part in the follow-up study (*n* = 63 patients) consisted of 55 female and 8 male patients with AIS, with a similar average age at the

Table 1 Physical activity score, modified after Parsch et al. [15]

Anamnestic data on sports activity		Amount of moderate sports/week
Type of sports activity	Frequency	
Moderately strenuous*	<i>n</i>	→ Score = <i>n</i>
Mildly strenuous**	<i>n</i>	→ Score = <i>n</i> /3
Moderately strenuous*	Not specified	→ Score = 2
Mildly strenuous**	Not specified	→ Score = 1
Inconsistencies	Inconsistencies	Clinician's subjective assessment
*Moderately strenuous types of sport: strength training, ball sports, running, cycling, swimming, riding, dancing, climbing, skiing, martial arts, ice hockey, blading, yoga		Examples for calculation: (1) Running, <i>n</i> = 4; climbing, <i>n</i> = 1 → Score = 5 × moderate sports/week (2) Nordic walking, <i>n</i> = 6 → Score = 2 × moderate sports/week (3) Running, (no frequency specified) → Score = 2 × moderate sports/week

**Mildly strenuous: Nordic walking, strolling/walking, specific physical exercises

Fig. 1 Flow chart inclusion of 41 patients with AIS and CTIS in QoL study



start of treatment of 13.7 years (median 13.10 years) as the study population and a mean Cobb angle of 30.3° in the primary curve (median 28.0°), which is slightly higher than in the study population.

Radiographic findings

The most common curve patterns in our patient collective were double curves (thoracic and lumbar), predominant curve thoracic in 16 cases (39%) and predominant curve lumbar in 8 cases (19.5%). Isolated curve thoracolumbar was present in 8 patients (19.5%). Curve angles in the primary curves changed from an average of 28.6° Cobb (median 26.0°) at the start of brace therapy to 21.1° Cobb (median 20.0°) after brace weaning to 25.6° Cobb (median 24.0°) at the follow-up examination. Curve severity decreased from the start of bracing to follow-up by an average of 3.0° (median 2.0°). Loss of correction could be prevented: on average, the curve angle increased by 4.4° Cobb after weaning (median 4.0°). The curve severity was maintained in 39% and improved in 12% of the patients after weaning. It

increased in 49% of the patients, but no patient worsened beyond 50° Cobb (Table 2).

Socio-economic factors

All participants were either pursuing higher education (39.0%) or working full time (61.0%). The most common professions were skilled trades (24.4%), office jobs (14.6%), and social/health professions (12.2%). All participants were as yet childless.

Physical activity

A high level of physical activity was found, with 92.7% of all participants performing moderate sports at least once a week. The vast majority (75.6%) even performed moderate sports two to four times a week. Only three participants (7.3%) reported that they performed no sports at all. Running (20.3% of all answers) and strength training (21.9% of all answers) were the most frequently mentioned sports.

Table 2 Demographic and radiological findings in 41 participants with AIS

	Mean (SD)	Median	Minimum	Maximum
Gender f:m	38:3			
Age at start of FTRB (years)	13.3	13.6	9.5	15.2
Age at weaning (years)	16.1	16.0	13.4	19.6
Age at FU [years]	23.7	23.8	20.3	27.4
Duration bracing (years)	2.8	2.7	1.0	6.7
Curve angle at start of FTRB*	28.6° (7.2)	26.0°	20.0°	50.0°
Curve angle at weaning*	21.1° (9.1)	20.0°	4.0°	47.0°
Curve angle at FU*	25.6° (9.3)	24.0°	4.0°	48.0°
Change in curve angle start FTRB to weaning*	- 7.4° (8.2)	- 6.0°	- 24°	+11°
Change in curve angle start FTRB to FU*	- 3.0° (8.4)	- 2.0°	- 28°	+12°
Change in curve angle weaning to FU	4.4° (7.8)	4.0°	- 10°	+21°

FTRB...full time rigid bracing, FU...follow-up, *curve angle of main curve (° Cobb)

Health-related quality of life

The total mean score of the SRS-24 was 4.0 (79.9%). The different domains of the questionnaire resulted in the following mean scores: pain 4.2 (83.9%), general self-image 4.2 (83.3%), self-image after weaning 3.2 (63.3%), function after weaning 3.1 (62.9%), general function 4.0 (79.8%), general level of activity 4.6 (92.7%) and satisfaction with treatment 4.2 (83.1%) (Table 3). Patients with mild curves at follow-up (< 30° Cobb) had a significantly better total score than patients with more severe curves (MS 4.1 vs. MS 3.8, *p* = 0.020) (Fig. 2). Regarding the domains, only satisfaction with treatment revealed a significantly better result for the group with mild curves (< 30°) (MS 4.3 vs MS 3.9, *p* = 0.020). Pain results tended to be better in the group with mild curves (*p* = 0.053).

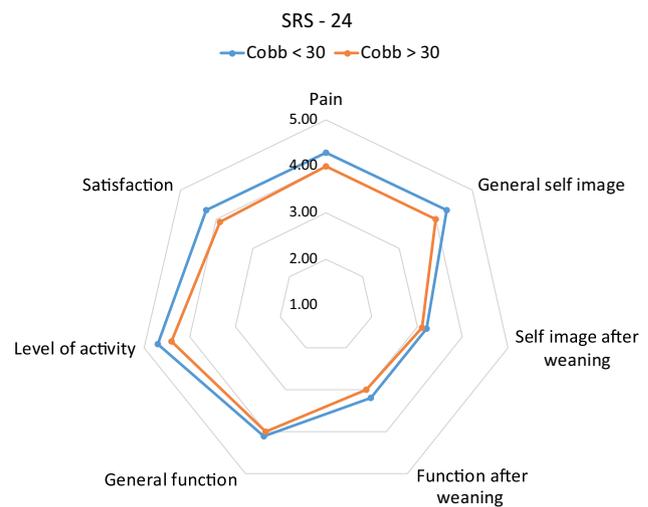


Fig. 2 Comparison of SRS-24 results between patients with mild and severe curves (<30° Cobb vs. 30°–50° Cobb)

Discussion

This single-institution mid-term follow-up study investigated the outcomes of 41 patients with AIS treated with CTIS (consisting of FTRB and PSSE) and analysed differences in health-related quality of life outcomes between patients with mild (< 30° Cob) and severe curves (30°–50° Cobb).

Radiographic findings

Comparing our results to similar reports, the maintenance of the curve severity is in line with published data [18–21]. Between start of brace treatment and follow-up, we saw a decrease in the curve angle of 3.0° Cobb in our study population, comparable studies reported between – 4.4° Cobb and +1° Cobb. The Cobb angle at weaning was maintained until follow-up (mean increase in curve angle 4.4° Cobb); in comparable reports, the curve angle changes range between 3.5

and 7.9° Cobb. Only one of the compared studies included PSSE in its treatment [22], as we did.

Socio-economic factors

The socio-economic outcome in this study was better than previously described: none of the study participants was unemployed, whereas Lange et al. and Danielsson et al. [19, 20, 23]. reported rates of employment or current education between 82 and 91% (Table 4). The underlying causes for these differing results could not be identified, but a brief comparison of the patient collectives shows the following results: the compared studies reported larger numbers of participants, a greater mean age and higher mean Cobb angles than we did, and reflected the difference in treatment approaches, whereas we combined FTRB and PSSE, and the compared studies only prescribed FTRB.

Table 3 Results of the SRS-24 questionnaire in 41 patients with AIS after CTIS

	All patients (n = 41)	Curve severity < 30° Cobb (n = 26)	Curve severity > 30° Cobb (n = 15)	Difference between curve severity groups*
	MS (%)	MS (%)	MS (%)	<i>p</i> value
Total score	4.0 (79.9%)	4.1 (81.8%)	3.8 (76.5%)	0.020**
Pain	4.2 (83.9%)	4.3 (86.6%)	4.0 (79.2%)	0.053
General self-image	4.2 (83.3%)	4.3 (85.9%)	4.0 (78.7%)	0.101
Self-image after weaning	3.2 (63.3%)	3.2 (63.6%)	3.1 (62.7%)	0.735
Function after weaning	3.1 (62.9%)	3.2 (64.6%)	3.0 (60.0%)	0.683
General function	4.0 (79.8%)	4.1 (80.0%)	4.0 (79.6%)	0.762
General level of activity	4.6 (91.7%)	4.7 (93.6%)	4.4 (88.4%)	0.498
Satisfaction with treatment	4.2 (83.1%)	4.3 (86.2%)	3.9 (77.8%)	0.020**

MS...mean score, *analysed with Mann–Whitney *U* test, **significant

Table 4 Comparison of employment data in similar reports of follow-up after CTIS

	Treatment	No. of study subjects	Mean age (years)	Mean curve angle (° Cobb)	Employment
Lange [19]	FTRB	109	35	34.2	Employed (80%) Student (2%)
Lange [20]	FTRB	272	40.4	32.5	Employed (86%)
Danielsson [23]	FTRB	116	39.3	37.6	Employed (81.0%) Student/maternity leave (10.4%)
This study	FTRB + PSSE	41	23.7	25.6	Employed (61%) Student (39%)

Physical activity

We compared the results from our study participants with those of the Austrian Health Interview Survey in a similar age group [24], where approximately 55% of the population between 18 and 29 years (females 47%, males 63%) perform moderately strenuous physical activities for more than 150 min per week. Our study population, 76% of whom performed moderate sports two to four times a week, seems to be at least as active as the corresponding age group in the overall population. This is in contrast to the results of Parsch et al., where the sports activity of the CTIS group was lower than in the control group ($p=0.006$) [15].

Health-related quality of life

Compared to studies with a longer follow-up [19, 20, 25, 26] and accordingly higher mean age (between 32 and 41 years), our results were in range of the published data in all of the quality of life-related domains of the SRS-24 (pain, self-image, and general function) but in the domain satisfaction with treatment where we received slightly more positive feedback from our study population (this study: MS 4.2 vs compared studies: MS 3.5-3.8). In contrast to the compared studies [19, 20, 25, 26], where FTRB was the only treatment, in our study population continuous PSSE, supervised at regular intervals, was standard of care, as in a short-term follow-up study [27] (satisfaction with treatment MS 3.9). In addition to the positive impact of PSSE on the effectiveness of the treatment described elsewhere [8–10], PSSE might also lead to higher satisfaction with the treatment [8]. On the whole, CTIS for AIS seems not to decrease quality of life, as Simony et al. [26] found similar hrQoL outcomes between patients with AIS and the general population, a meta-analysis of 7 included studies even found higher hrQoL outcomes in treated vs untreated patients with AIS [28], and Schwieger et al. reported that the amount of brace wear did not negatively affect QoL [29].

We acknowledge the limitations of this study: the most important one being the low response rate to the invitations for participation in this study (39%), which produces a selection bias. We compared demographic and radiological data of the study participants to the patients not taking part in the follow-up study and could show that the sample is representative for the total patient collective. However, since we may have only reached the most compliant patients, care should be taken in interpreting or generalizing our results. Although self-reports on compliance are less reliable than in brace monitors, no specific measurement of quantity of brace wear could be performed as proposed in other studies [29–31] as this study was based on the patient collective of an outpatient clinic.

Furthermore, the retrospective study design without control group allows only limited analysis of the effects of the undergone treatment on socio-economic factors and quality of life outcomes. We tried to address this by comparing our results to similar studies (socio-economics and QoL) and a nation-wide survey on physical activity.

Conclusions

This single-institution mid-term outcome study of AIS patients who had undergone CTIS showed good radiological and quality of life results (pain, self-image and function) and better results than comparable publications regarding satisfaction with treatment. In comparison with the average population, our study population was not disadvantaged with respect to the socio-economic factors of occupation and education and sports activity.

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Compliance with ethical standards

Conflict of interest All authors declare that they have no conflict of interest.

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