

JUVENILE KYPHOSIS : EFFECTS OF DIFFERENT VARIABLES ON CONSERVATIVE TREATMENT OUTCOME

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We reviewed the records of 212 patients with idiopathic or Scheuermann-type juvenile kyphosis (Scheuermann's disease). The 200 patients available for follow-up were divided into three groups depending on the degree of angular deformity, and the influence of different variables on treatment outcome in each group was investigated. A very influential positive variable was combined treatment with a body cast plus brace ; exercise treatment also produced acceptable results. Other variables that positively influenced the outcome of treatment were compliance with treatment, and (unexpectedly) elevated initial Risser sign (skeletal maturity). An initial Risser sign of 0 or 1 was, in contrast with other studies, associated with smaller improvement. However, initial maximal wedging, etiology and initial assessment of curve flexibility did not influence the degree of improvement in the initial angular deformity.

Keywords : juvenile kyphosis ; treatment ; vertebral wedging ; compliance ; Risser ; etiology ; flexibility.

Mots-clés : cyphose juvénile ; traitement ; cunéiformisation ; compliance ; Risser ; étiologie ; flexibilité.

INTRODUCTION

Juvenile kyphosis can be categorized as Scheuermann's disease, or as idiopathic, these two causes together accounting for 90% of all cases (4). The origin of Scheuermann's disease is unknown, although studies of family series have suggested that it may be of autosomal dominant inheritance (7,11). McKenzie and Sillence (11) proposed that Scheuermann's disease may be linked to the *COL1A1* gene.

In clinical terms, the presence of back pain can help distinguish between Scheuermann's disease and idiopathic kyphosis. The methods of treatment

used thus far include exercise programs, electrostimulation (currently in disuse), vertebral traction (currently in disuse for correcting the curve or increasing flexibility before a cast is applied), various types of braces and casts, and surgery (not discussed here).

In this study we analyzed the effectiveness of different conservative treatment methods in juvenile kyphosis, and also examined the influence of other variables (initial maximal wedging, patient compliance, initial Risser sign, cause of kyphosis, and initial flexibility of the curve) on treatment outcome.

PATIENTS AND METHODS

Patients

All 212 patients in this study were seen between 1978 and 1990. Some patients discontinued treatment, and a total of 200 patients completed the full course. All were diagnosed as having juvenile kyphosis. The patients were divided into three groups on the basis of their initial angular deformity. At the start of the study, Group A consisted of 58 patients (27.3%) whose kyphosis measured 30-50°, Group B comprised 76 patients (35.8%) with deviations of 51-60°, and the 78 patients in Group C (36.8%) had deviations of 61° or more. At the end of the study, Group A comprised

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57 patients, Group B 71, and Group C 72, totaling 200 patients. Of the entire group, 98 patients (46.2%) were men, and 114 (53.8%) were women. The diagnosis was Scheuermann's disease in 99 patients (46.7%) and idiopathic kyphosis in 113 (53.3%). Mean age at the start of the study was 12 years and 6 months, and at the end of follow-up 16 years and 9 months; mean height was 152.3 cm at the start of the study and 165.6 cm at follow-up; 24.3% of the patients regularly practised sports.

Clinical examination

Flexibility of the spine was clinically determined by measuring the horizontal distances from C₇, T₇, L₄ and S₂ to a vertical line denoted by a string and plumb bob suspended from the posterior-most point of the patient's spine, with the spine in its usual position and in maximum active correction. The difference in millimeters between the distances indicated active flexibility of the curves. Percent active flexibility was calculated; a value of 50% or less indicated rigid kyphosis, while a value of 51% or higher indicated flexible kyphosis. Angular deformity in kyphosis, and scoliosis (if present), were measured radiographically according to the Cobb method. Moreover, three groups were considered, depending on the degree of maximal vertebral wedging: 0-5°, 6-10°, and more than 10°. Three levels of skeletal maturity were considered on the basis of the Risser sign (Risser 0-1, 2-3, and 4-5). The Risser sign was evaluated in 196 out of 200 patients.

Treatment methods

The original 212 patients were divided into four treatment groups: Group 1, exercise program, 76 patients (38.0%); Group 2, corrective brace, 45 patients (22.5%); Group 3, cast followed by maintenance brace, 51 patients (25.5%); Group 4 (combined treatment), exercise followed by corrective brace, 28 patients (14.0%). Combined treatment was used for patients who showed no satisfactory improvement with an exercise program and were switched to a brace.

In each treatment group, we recorded initial and final (at the end of follow-up) angular deformity, improvement in the curve both in degrees and as a percentage of the initial value, and initial flexibility as smaller or larger than 50%. Compliance with treatment was judged good if the patient did all exercises daily, or kept the brace on for 22 hours daily; fair if exercises were done 3 or 4 days per week or if the brace was

kept on for 16 hours a day; and poor if exercises were done less than 3 days a week, or if the patient was in the brace for less than 16 hours a day. Compliance with treatment could be evaluated in 175 patients (55 from Group A, 59 from Group B and 61 from Group C) (Table II).

Swaim, Deramond, Milwaukee and Maguelone braces were used in this study. An extension cast or a Cotrel cast, which provided a combination of elongation and extension, was used.

The mean duration of treatment was 44.6 months with exercise (Group 1), 20.0 months with a brace (Group 2), 18.3 months with a cast followed by a brace (Group 3), and 55.5 months with exercise followed by a brace (Group 4). Mean duration of follow-up after the brace was removed was 20.0 months in Group 2, 22.1 months in Group 3, and 23.7 months in Group 4.

Statistical analysis

Descriptive analysis for all variables was based on frequency distributions expressed as means \pm standard deviation. One-way analysis of variance (ANOVA) was used to compare different groups, using the Bonferroni correction if the results of ANOVA were significant. Multiple regression analysis was used to determine the net effects of each variable studied.

RESULTS

1. Treatment methods

The efficiency of each treatment method was analyzed regardless of the subgroups A, B and C. In patients treated with a cast followed by a brace (Group 3), the mean initial deformity was 64.7°, a value significantly higher than in any of the other three treatment groups ($P < 0.0001$). The largest reduction in angular deformity (20.3°) was also obtained with a cast + brace; this improvement was significantly greater than in any of the other groups ($P < 0.0001$). Table I summarizes the mean percentage of improvement attained with each treatment. Global percentage of improvement was significant ($P < 0.005$). When we compared pairs of treatments, exercises led to significantly ($P < 0.0005$) less percentage improvement than any other treatment, while

Table I. — Percentage improvement in kyphosis
(difference between initial and final angular deformity)
according to type of treatment (200 cases)

	Group 1 : Exercises	Group 2 : Brace	Group 3 : Cast + Brace	Group 4 : Exercises, then Brace
Mean % improv.	17.55%	25.21%	30.88%	23.47%
Standard dev.	19.19%	19.17%	17.62%	20.06%
Maximum	58.00%	59.67%	71.79%	60.65%
Minimum	-44.44%	-41.46%	-15.25%	-10.20%
Cases (n)	76	45	51	28
$F_{exp} = 5.21 ; (3 ; 196) \text{ df} ; P < 0.005 \text{ (significant)}$				

cast + brace led to a greater percentage improvement than any other treatment ($P < 0.01$).

2. Effect of initial maximal wedging on treatment outcome

Mean initial maximal vertebral wedging, measured in the vertebra with the greatest wedging, was 7.1° , and mean final wedging was 6.1° .

We examined the influence of initial maximal wedging on treatment outcome in the entire group of patients, and in groups A, B and C.

In patients with initially greater maximal wedging (more than 10°), the mean initial angle (63.0°) was significantly higher than in patients with low ($0-5^\circ$) or moderate wedging ($6-10^\circ$) ($P = 0.0067$). The final mean angle (48.0°) was also significantly higher in patients with initial wedging greater than 10° than in patients with lesser degrees of wedging ($P = 0.0282$), as expected. However, we found no significant differences between the effects of different degrees of initial maximal wedging on improvement in kyphosis when this improvement was expressed in degrees ($P = 0.7934$) or when it was expressed as a percentage reduction ($P = 0.9853$).

In groups A, B and C we found no correlation between initial maximal wedging and mean percentage improvement in kyphosis ($P = 0.0747$, $P = 0.7414$ and $P = 0.2457$, respectively).

3. Influence of compliance on treatment outcome

For the entire sample of patients, we found no significant differences ($P = 0.6545$) in mean initial angular deformity in relation with the degree of patient compliance with treatment (good, fair or poor). When we evaluated final angular deformity, lesser degrees of kyphosis were significantly associated with better compliance ($P = 0.0246$). Improvement in kyphosis expressed in degrees ($P = 0.0127$) and (Table II) as percentage improvement ($P = 0.0064$) was significantly lower in patients whose compliance was considered poor than in fair and good compliers.

In group A patients (mild kyphosis), compliance had no significant correlation with initial angular deformity ($P = 0.8210$), final angular deformity ($P = 0.1703$), improvement in degrees ($P = 0.1758$) or percentage improvement ($P = 0.1421$).

Table II. — Patient compliance
and percentage improvement in kyphosis
(difference between initial and final angular deformity)
(175 out of 200 cases)

Compliance :	Good	Fair	Poor
Mean % improv.	29.95%	25.61%	18.48%
Standard dev.	18.95%	16.29%	22.25%
Maximum	71.79%	59.67%	61.66%
Minimum	-9.43%	-34.37%	-44.44%
Cases (n)	46	53	76
$F_{exp} = 5.20 ; (2 ; 172) \text{ df} ; P = 0.0064 \text{ (significant)}$			

In contrast, compliance by group B patients was almost significantly associated with percentage improvement ($P = 0.0505$), and compliance showed an almost linear association with improvement in angular deformity (Table III).

Table III. — Compliance with treatment by patients with initially moderate kyphosis (Group B : 51°-60°) and percentage improvement in kyphosis (difference between initial and final angular deformity) (59 out of 71 patients)

Compliance :	Good	Fair	Poor
Mean % improv.	33.28%	27.87%	20.08%
Standard dev.	20.02%	10.60%	18.10%
Maximum	64.28%	43.63%	61.66%
Minimum	-9.43%	9.09%	-15.25%
Cases (n)	15	17	27
Fexp = 3.15 ; (2 ; 56) df ; P = 0.0505 (almost significant)			

In group C patients, compliance had no influence on improvement of kyphosis.

4. Influence of initial Risser sign on treatment outcome

The initial Risser sign was 0-1 in 59.0%, 2-3 in 24.9%, and 4-5 in 16.1% of the patients. Final Risser values were 0-1 in 8.6%, 2-3 in 3.2%, and 4-5 in 88.2% of the patients.

For the entire sample of patients, initial angular deformity was significantly higher ($P < 0.0001$) in patients with greater skeletal maturity at the beginning of the study. The improvement in kyphosis expressed in degrees ($P = 0.0077$) and as percentage improvement ($P = 0.0277$) was significantly lower in patients with an initial Risser value of 0 or 1 in comparison with those who had higher Risser signs (Table IV).

However, when each subgroup of patients with kyphosis of different severity was analyzed separately, we found no significant association between initial Risser sign and initial angle, final angle, improvement in kyphosis expressed in degrees, or percentage improvement ($P > 0.18$ in all cases).

Table IV. — Initial Risser sign and percentage improvement in kyphosis (difference between initial and final angular deformity) (196 out of 200 patients)

	Risser 0-1	Risser 2-3	Risser 4-5
Mean % improv.	20.38%	28.94%	26.22%
Standard dev.	20.97%	16.37%	16.89%
Maximum	60.65%	71.79%	61.66%
Minimum	-44.44%	-6.00%	-11.32%
Cases (n)	118	46	32
Fexp = 3.66 ; (2 ; 193) df ; P = 0.0277 (significant)			

5. Influence of etiology on treatment outcome

The type of kyphosis diagnosed (Scheuermann or idiopathic) had no influence on percentage improvement when patients were considered as a single group, or when each subgroup was considered separately ($P > 0.10$ in all cases).

6. Influence of initial flexibility on treatment outcome

None of the analyses detected a significant effect for initial flexibility. When all patients were considered as a single group, those with more rigid curves showed a mean improvement of 23.8%, whereas in those with more flexible curves (greater than 50% flexibility) mean improvement was 28.7% ($P > 0.25$, not significant). When patients were divided on the basis of severity of kyphosis, the significance values were $P > 0.35$ in group A, $P > 0.40$ in group B, and $P > 0.70$ in group C.

7. Multivariate analysis

The variables treatment, initial maximal wedging, compliance, initial Risser sign, etiology and initial flexibility were used in multivariate analysis to determine the independent effect of each on the outcome of treatment. The data were adjusted with multiple linear regression in order to determine the independent effect of each variable on treatment outcome (Table V). Treatment type, compliance and initial Risser had a significant effect, while initial maximal wedging, etiology and flexibility had no significant effect.

Table V. — Results of multivariate analysis

Term	Coefficient	Standard error	T _{exp}	P
Independent	26.08	6.2310	4.19	0.00005 (S.)
Treatment type	11.35	4.778	2.38	0.0188 (S.)
Init. max. wedging	-1.05	0.633	1.66	0.0994 (N.S.)
Compliance	-7.05	2.156	3.27	0.0014 (S.)
Initial Risser	5.82	2.549	2.28	0.0244 (S.)
Etiology	5.19	3.673	1.41	0.1610 (N.S.)
Flexibility	6.37	5.610	1.14	0.2566 (N.S.)

DISCUSSION

1. Effect of treatment methods on outcome

Of the four different treatments compared, the lowest mean percentage improvement was found with exercise treatment (17.5%). This was not surprising, as exercise is the least aggressive of the treatments used. Patients treated with a cast + brace, a more aggressive mode, showed the largest improvement (30.9%); the difference in comparison with each of the other three treatments was significant.

Other (12, 13) series have yielded larger improvement after use of a cast + brace in comparison with other methods, but have reported much poorer results with exercise. The large differences between our findings and those published by others suggest that thanks to frequent, firm reminders, our patients may have complied better with their exercise program than those in other series.

2. Effect of initial wedging on treatment outcome

As in other studies, T₇ and T₈ were the vertebrae with the greatest initial wedging (1, 2, 8, 14, 19). Percentage improvement in wedging at the end of treatment was variable, with a mean of 15% in our patients. However, other studies reported much larger improvements of 41% (1) or 42.2% (8). The figure published by Montgomery and Erwin (14) (13.9%) is similar to ours, whereas Raeder (18) found no improvement in initial wedging.

We found no significant differences in treatment success (about 22%) between subgroups of patients with different degrees of initial maximal wedging. Montejano *et al.* (13), who used the same wedging subgroups as we did, similarly found that mean improvement was 29.6% in patients with initially mild, 32.0% in patients with moderate, and 28.3% in patients with severe wedging; these figures apparently did not differ significantly. In a study of 173 patients, Florez and Conejero (7) likewise found no relation between initial wedging and treatment success. This conclusion is also supported by the results of a multivariate analysis by Sachs *et al.* (19) and Florez *et al.* (6), who failed to detect significant differences in treatment outcome between patients with different degrees of initial wedging. However, other authors (1, 2, 14) have reported that a mean initial wedging of more than 10° is associated with treatment failure.

In patients with initially severe kyphosis (group C), we found, like Montejano *et al.* (13), that patients with wedging greater than 10° also had more severe kyphosis, and there were no significant differences in improvement between subgroups with different degrees of initial wedging. Therefore, there was no unanimity as to the influence of initial maximal wedging on final outcome.

3. Influence of compliance on treatment outcome

When all patients were analyzed as a single group, compliance strongly influenced treatment outcome: when compliance was poor, mean improvement (in absolute and percentage values) was significantly lower in comparison with patients

who showed fair or good compliance. Patients and members of their family should thus be urged to follow the instructions for treatment conscientiously.

Most authors agree that the better the compliance, the better the results. Sachs *et al.* (19) reported that of 10 patients who showed poor compliance with brace wearing, only two achieved any improvement in their kyphosis, whereas the curve worsened in the other eight. Gutowski and Renshaw (8) also concluded that compliance was a key factor, noting that patients who showed excellent compliance attained a mean improvement of 30%, whereas those with poor compliance attained a mean correction of only 4%.

In our group A patients (mild kyphosis), the lack of association between compliance and treatment outcome may have been due to the large variation in outcomes, and the consequent absence of significant differences between the means. The mean improvement in group B approached, but did not reach, significance. In group C, the lack of a significant association between compliance and treatment outcome may reflect the fact that in this group 44.9% of the patients were treated initially with a cast, making compliance with the most aggressive part of their regimen inevitable. In contrast, when they were switched to a brace, some patients may not have kept it on for as long as they were instructed.

4. Influence of initial Risser sign on treatment outcome

When the entire sample was analyzed as a single group, mean improvement in kyphosis was lowest in patients with an initial Risser sign of 0-1, in contrast with the results of other studies. Indeed, Bradford *et al.* (1) suggested that closure of the iliac epiphysis accounted for treatment failure. Miranda (12) considered a Risser sign higher than 3 at the start of treatment as a risk factor for unsatisfactory outcome. In addition, Florez and Conejero (7) also reported better results in patients whose initial Risser sign was 0 or 1.

In a series of 120 cases analyzed with multiple regression, Sachs *et al.* (19) found no relation between initial Risser sign and treatment outcome.

Few large series have been published, and studies using multivariate analysis are also infrequent (19). Methodological differences may explain why our findings with respect to the Risser sign have not been corroborated in other studies. Therefore, our study stands almost alone in its finding that a Risser sign 0-1 predicts a worse result.

5. Influence of etiology on treatment outcome

In the sample as a whole, we found no significant effect of etiology on clinical improvement, a result also reported by Onimus *et al.* (15). However, Montejano *et al.* (13) found better outcomes in patients with idiopathic kyphosis (29.5% mean improvement) than in patients with Scheuermann's disease (15.8%).

Several studies have compared treatment outcomes in patients with moderate angular deformities (comparable to group B). Platero *et al.* (17) reported no difference between patients with idiopathic (18.3% mean improvement) and Scheuermann kyphosis (18.7% mean improvement) regarding the effectiveness of exercise treatment. Paran (16) reported a greater mean improvement in idiopathic (40.2%) than in Scheuermann kyphosis (30.6%), although the data were not analyzed statistically. Florez and Conejero (7) found a slight difference in mean improvement between idiopathic (34.0%) and Scheuermann kyphosis (27.6%); these findings were likewise not substantiated by statistical analysis. Farsetti *et al.* (3) found that at the end of a 19-year follow-up period, kyphosis had worsened with respect to the curves measured initially, both in patients with idiopathic (-21.8% of improvement) and Scheuermann disease (-9.0% of improvement). Thus there is no consensus as to the influence of etiology on the final outcome.

6. Influence of initial flexibility on treatment outcome

We found no significant differences in mean improvement between patients with rigid and flexible curves. This finding is not surprising, as exercise treatment either alone or in combination with other approaches improves flexibility after

approximately 6-8 weeks. Bradford *et al.* (1) found no relation between initial flexibility and the final outcome of treatment. In contrast, Mauroy (10) reported that patients who display a correction of more than 50% in the flexibility test benefitted the most from treatment, although their long-term maintenance of improvement was uncertain. There thus appears to be no unanimity as to the influence of curve rigidity on the final outcome.

7. Multivariate analysis

Multivariate analysis of our data showed that the variables with the greatest influence on treatment outcome were : treatment with cast + brace, compliance with treatment, and initial Risser sign, while initial maximal vertebral wedging, etiology and initial flexibility did not seem to influence the mean percentage improvement of the initial angular deformity.

Few studies have used multivariate analysis to investigate the effects of discrete variables. Sachs *et al.* (19), in a series of 120 patients, based their analysis on five variables, including Risser sign and initial wedging. They found no relation between either of these factors and treatment outcome. Florez *et al.* (6) used multivariate analysis in a study of 49 cases, and found that the only variable that correlated significantly with outcome was initial Risser sign. Unlike us, these authors found better final corrections in patients whose Risser sign at the beginning of treatment was 0 or 1.

The results of the present study suggest a number of conclusions :

1. Although less effective than other treatments, exercise therapy can yield relatively good results if it is prescribed appropriately and followed conscientiously.
2. The initial degree of vertebral wedging should not influence the choice of treatment mode. Even patients with wedging greater than 10° can achieve significant improvement with exercises alone.
3. The patient's cooperation in following the treatment is a prerequisite for satisfactory results. Patients and their relatives should be urged to comply fully with the rules of the treatment prescribed, and the physician should monitor compliance closely.
4. Advanced bone maturity should not be an obstacle to a potentially effective treatment mode ; good results can be obtained even in patients with an initial Risser sign of 4-5.
5. The most conservative treatment (exercises) can be appropriate and effective even in patients with Scheuermann kyphosis ; in our group of patients the etiology did not correlate with treatment outcome.
6. Initially rigid kyphosis need not rule out good treatment results ; appropriate exercise therapy can improve flexibility within a few weeks.

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SAMENVATTING

D. PLATERO, J. D. LUNA, V. PEDRAZA. Juvenile kyfose : invloed van verschillende variabelen op de resultaten van de conservatieve behandeling.

De medische dossiers van 212 patiënten met een idiopathische kyfose of een ziekte van Scheuermann werden nagekeken.

Bij 200 patiënten was het verloop volledig gekend en zij werden verdeeld in 3 groepen afhankelijk van de ernst van de deformatie. Bij elke groep werd de invloed van verschillende variabelen op het resultaat van de behandeling nagekeken.

Een der variabelen met een duidelijke positieve invloed is de combinatie van gipskorset met orthopedisch korset. Ook de behandeling met oefentherapie leverde gunstige resultaten. Andere positieve variabelen zijn de compliance van de patiënten en een initieel verhoogde Risser. Een Risser tussen 0 en 1 was geassocieerd, in tegenstelling tot andere studies met minder verbetering. Anderzijds was de cuneiforme deformatie initieel, de etiologie en de initiële flexibiliteit van de curve zonder invloed op het verbeteren van de initiële angulaire deformatie.

RÉSUMÉ

D. PLATERO, J. D. LUNA, V. PEDRAZA. Influence de différentes variables sur les résultats du traitement conservateur de la cyphose juvénile.

Nous avons revu les dossiers médicaux de 212 patients qui présentaient une cyphose idiopathique ou une maladie de Scheuermann. Les 200 patients dont le suivi était complet ont été répartis en trois groupes en fonction de l'importance de leur déformation angulaire, en recherchant dans chaque groupe l'influence de différentes variables sur les résultats du traitement. Une variable qui a eu une influence très positive a été le traitement combiné par corset plâtré plus corset orthopédique ; le traitement avec des exercices a également produit des résultats acceptables. D'autres variables qui ont influencé positivement les résultats du traitement ont été : la compliance des patients et, de façon inattendue, un Risser initial élevé. Un Risser initial de 0 ou 1 a été associé, contrairement à d'autres études, avec des améliorations plus modestes. D'un autre côté, la cunéiformisation maximale initiale, l'étiologie et la flexibilité initiale de la courbe n'ont pas influencé le degré d'amélioration de la déformation angulaire initiale.