

Long-Term Follow-Up of Patients with Adolescent Idiopathic Scoliosis Treated Conservatively: An Analysis of the Clinical Value of Progression

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Summary: In a retrospective study, 217 patients with conservatively treated adolescent idiopathic scoliosis (AIS) were investigated. Forty-nine cases were operated and 168 were treated only conservatively and had been out of the brace for at least 4 years at the time of the investigation. The progression between cessation of brace treatment and follow-up (a mean of 6.9 years later)

was 5.1°. Almost all progression (4.5°) occurred within 2 years of the end of weaning, however. The incidence of failure with regard to the length of follow-up was also studied. A follow-up of 2 years was sufficient to predict with great accuracy (97%) all incidences of failure. **Key Words:** Adolescent idiopathic scoliosis—Brace treatment—Failure—Long-term follow-up—Progression.

The question of whether brace treatment can change the natural history of adolescent idiopathic scoliosis (AIS) has been widely discussed in the literature (4,6,7,9) during the last few years. Several long-term follow-up studies (2,4-6,8,11) have found a slight progress up to 10 years after weaning for most curves treated with the Milwaukee brace. No studies, however, have analyzed the clinical value of this late progress, i.e., whether the number of failures increase continuously with time. If so, brace treatment would merely change the time course of the natural history rather than prevent development of failures. Surgical intervention as a consequence of failed brace treatment could then be performed when the patients were in their late twenties rather than when they were teenagers.

We studied the rate of late progress after weaning of brace treatment to determine whether a 2-year follow-up after weaning and cessation of growth is enough to predict the clinical result, i.e., whether or not operation will be necessary later. Our purpose was not to define different patterns of progression or to seek early predictors.

MATERIAL AND METHODS

A retrospective study of 233 consecutive patients conservatively treated for AIS between 1969 and

1981 was made in Malmö in 1986. Forty-nine of 233 patients were operated either within 2 years after weaning from brace treatment (37 patients) or after 2-year follow-up (12 patients). One hundred eighty-four of 233 were treated only conservatively and had been out of the brace for at least 4 years at the time of examination. Only patients with a period of brace treatment of at least 6 months were included in the study.

The indication for brace treatment was a progressive curve ≥ 25 degrees in a child with a skeletal age < 16 years for girls and < 17 years for boys. For curves $> 30^\circ$ when diagnosed, the progression criteria was not necessary. All patients were treated and regularly reexamined exclusively at the Spine Unit in Malmö General Hospital.

The end of weaning (EW) was defined as the point at which the patient was out of the brace completely during the day. Failure of brace treatment was defined as a Cobb angle of $\geq 45^\circ$, i.e., a generally accepted indication for surgery. For each patient, the Cobb angle was registered at the start of brace treatment (PRE), at EW, at the follow-up after 2 years (2y), and at the last follow-up (LAST) at least 4 years after weaning. Of the original 184 patients treated conservatively only, two moved abroad within 4 years of termination of brace treatment and 14 refused, despite repeated calls, to be examined at least 4 years after weaning. One hundred sixty-eight patients were thus available for this survey, a follow-up rate of 91%.

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TABLE 1. Curve magnitude and age at different observation times

Parameter	PRE	EW	2y	LAST
Magnitude (degrees)	33.2 ± 6.5	28.0 ± 10.7	32.5 ± 10.5	33.1 ± 11.5
Age (yr)	14.3 ± 1.6	16.0 ± 2.2	18.1 ± 1.4	22.9 ± 2.9

PRE, before start of brace treatment; EW, end of weaning from brace; 2y, 2-year follow-up; LAST, last follow-up.

RESULTS

Table 1 shows the age and curve and the magnitude at the beginning of brace treatment and at different observations up to the last follow-up, for the 168 cases treated only conservatively. The curve progression from EW to the 2-year follow-up was 4.5°. A slight further progress of 0.6° occurred up to the last follow-up. For the 12 cases operated after at least 2 years of follow-up, the progression between EW and 2y was 10.2° and a further 5.4° to the last follow-up; i.e., at the time of operation.

The distribution of time for follow-up is illustrated in Fig. 1. The mean follow-up from EW to LAST was 6.9 ± 2.5 years. All patients were followed for at least 4 years, and 50% were followed for >6 years 3 months. The change in degrees between EW and LAST is shown in Fig. 2. The progression mean was 5.1°. The change in degrees between EW and 2y is shown in Fig. 3. The mean value was 4.5°. Figure 4 shows that the change in degrees between 2y and LAST had a bell-shaped distribution around the mean of 0°.

Tables 2 and 3 show the development of failure. Of the 184 patients with a prebrace curve <45°, 24 developed failure during the brace treatment and all but one continued to have failure throughout the follow-up. Five of 138 patients with good results at the 2-year follow-up ended with failure at the final follow-up. For these five patients, the mean prebrace curve was 36.4° as compared with 32.8° for all 184 patients. Furthermore, the mean follow-up from EW to 2y was only 1.5 years for these patients (i.e., somewhat shorter than that of the entire group), and

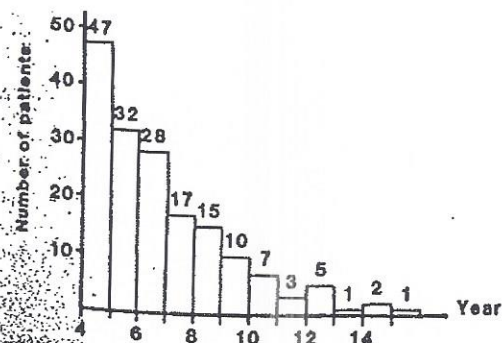


FIG. 1. Distribution of time for follow-up from early weaning (EW) to last follow-up (LAST); $n = 168$. Mean = 6 years 11 months; median = 6 years 3 months.

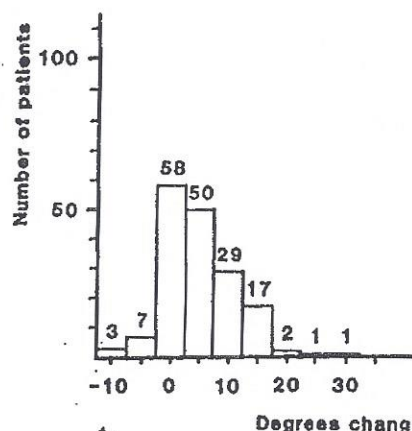


FIG. 2. Frequency of change in degrees from early weaning (EW) to last follow-up (LAST); $n = 168$. Mean = 5.1°.

the curve magnitude at follow-up was a mean of $39.7 \pm 4.0^\circ$.

For 10 of 33 patients with a prebrace curve $\geq 45^\circ$, the result of brace treatment was successful in that the Cobb angle decreased to $<45^\circ$; thus, these patients no longer required surgery. However, for the majority (7 of 10) of these successful cases, the result was not acceptable, since the curve increased after the end of brace treatment and 2 years later was again $>45^\circ$. For 210 of 217 patients (97%) the clinical result at 2-year follow-up was a good predictor of the end result, whether or not failure had occurred.

DISCUSSION

The aim of the present study was to examine whether a follow-up of two years was enough to predict late progression or development of failure of brace treatment. When a patient treated conservatively meets the indications for surgery, the conservative treatment is considered a failure.

We chose to use the term failure, as defined as a

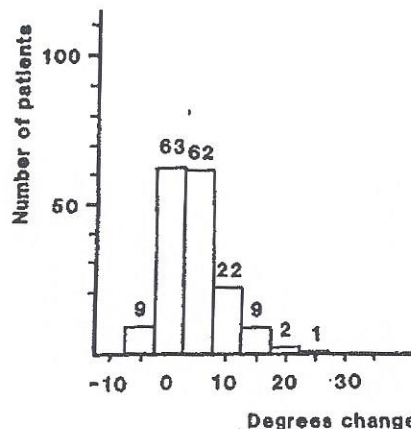


FIG. 3. Frequency of change in degrees from early weaning (EW) to 2-year follow-up (2y); $n = 168$. Mean = 4.5°.

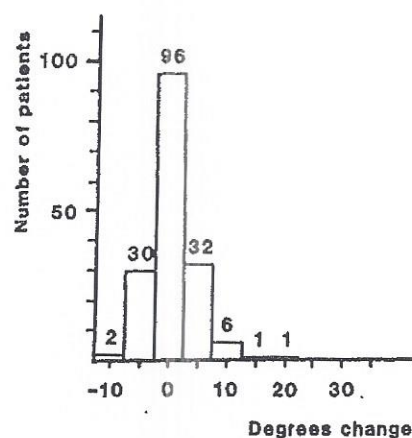


FIG. 4. Frequency of change in degrees from 2-year follow-up (2y) to last follow-up (LAST); $n = 168$. Mean = 0.6° .

Cobb angle $\geq 45^\circ$, instead of the number of cases actually operated as a target for failed conservative treatment because even if the indications for surgery are generally accepted, a variety of factors influence the decision to perform an operation. Once

the indications for surgery are fulfilled, conservative treatment has failed no matter how the patient is later treated. A Cobb angle of 45° is chosen as the lower boundary for failure since it is a generally accepted limit for surgical intervention.

In the literature, the result of studies examining progression is usually expressed as the risk (as a percentage) for a progression of 5 or 10° . In a mixed group of both conservative and surgical cases, the risk for progression will be statistically underestimated, because the cases already operated cannot progress. The conclusions concerning progression from such a study are invalid, both for cases treated conservatively and for surgical cases. If, on the other hand, surgical cases are excluded from the study, the result is a selection of cases with moderate progression as a consequence of a successful conservative treatment. Therefore, we believe that the only way to include surgical cases is to evaluate the development of failures.

Clinical evaluations in this sense have not, to our knowledge, been previously published. Even studies concerning long-term follow-up of AIS rarely appear in the literature (1,4-6,8,10). In most, the

TABLE 2. Development of failure^a

PRE	EW	2y	LAST	Prediction
NF	NF	NF	NF	Correct ^b
			$n = 133$ PBC = 31.0	
		$n = 138$ PBC = 31.2	F	Incorrect ^c
			$n = 5$ PBC = 36.4	
	$n = 160$ PBC = 31.9	F	NF	Incorrect ^c
		$n = 22$ PBC = 37.0	$n = 1$ PBC = 37.0	
			F	Correct ^b
			$n = 21$ PBC = 37.0	Correct ^b
$n = 184$ PBC = 32.8	F	NF	NF	
		$n = 0$	$n = 0$	Correct ^b
			$n = 0$	
	$n = 24$ PBC = 38.9	F	NF	Incorrect ^c
		$n = 24$ PBC = 38.9	$n = 1$ PBC = 38.0	
			F	Correct ^b
			$n = 23$ PBC = 39.0	

PBC, prebrace curvature, Cobb angle just before brace treatment; NF, no failure, Cobb angle $< 45^\circ$; F, failure, Cobb angle $\geq 45^\circ$; other abbreviations as in Table 1.

^a Patients with a curve $< 45^\circ$ at start of brace treatment.

^b Correct prediction at 2 y follow-up ($n = 210$).

^c Incorrect prediction at 2 y ($n = 7$).

TABLE 3. Development of failure^a

PRE	EW	2y	LAST	Prediction ^b
			NF n = 3	Correct
		NF n = 3 PBC = 47.7	PBC = 47.7	
		F n = 0	F n = 0	Correct
	NF n = 10 PBC = 47.4		NF n = 0	Correct
		F n = 7 PBC = 47.3	F n = 7 PBC = 47.3	Correct
F n = 33 PBC = 48.2			NF n = 0	Correct
		NF n = 0	F n = 0	Correct
	F n = 23 PBC = 48.7		NF n = 0	Correct
		F n = 23 PBC = 48.7	F n = 23 PBC = 48.7	Correct

Abbreviations as in Tables 1 and 2.

^a Patients with a curve $\geq 45^\circ$ at start of brace treatment (n = 33).^b At 2y follow-up.

magnitude of the prebrace curvature was $\geq 40^\circ$ in most patients, a curve for which the risk of progression is greatest. To be able to draw reliable conclusions about a study, the number of patients lost to follow-up must be minimized (3). Ninety-one percent of the original number of the patients were included in our study. The patients lost to follow-up did not differ from group as a whole with regard to age, curve magnitude, and result up to 2-year follow-up.

In 1977, Mellencamp et al. showed a slow progression in patients aged ≤ 30 years. They reported a mean progression of 7° between EW and LAST (8). However, he did not make a measurement between EW and LAST and thus could not say when the curves progressed. In our study, as in a few others (4,6), all curves were measured ~ 2 years after cessation of brace treatment. The progression from EW to LAST was 5° , similar to results in the study of Mellencamp et al., but almost all progression appeared within 2 years of EW.

In 1983, Hassan and Bjerkreim (6) reported that 60% of the curves progressed after age 20 years. However, for curves with a prebrace magnitude $< 40^\circ$, progression was almost negligible. Cochran and Nachemson, in 1985 (4), also reported a late

progression. They showed a relationship between late progression and pregnancy. Because we did not register the occurrence of pregnancy in our study, we cannot draw any conclusions about this aspect.

The greatest progression in this study was evident within 2 years EW, independent of the magnitude of the prebrace curve. On the other hand, prebrace curve magnitude was of vital importance for development of failure. Only 10% of all failures, operations included, had a prebrace curve $< 35^\circ$. For comparison, in 75% of all successful cases, brace treatment was started with a curvature $< 35^\circ$.

As in most other studies, for most of our conservatively treated patients curve progression definitely ceased, and there was no tendency to require late operations. Ten percent of all operations did occur late, i.e., after the 2-year follow-up. However, all five late cases had already met the indications for surgery within 2 years of cessation of the brace treatment and therefore actually were not late operations.

CONCLUSION

From this study we conclude that brace treatment does not postpone curve progression to the late

twenties; thus, there is no ground for the statement that surgical interventions will occur later. We also conclude that a follow-up 2 years after weaning is sufficient to predict the clinical result with great accuracy (97%).

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