Changes in curve pattern after brace treatment for idiopathic scoliosis

Lodewijk W van Rhijn[1], Chris M T Plasmans[2] and Ben E E M J Veraart[3]

Departments of Orthopaedic Surgery, [1]University Hospital Maastricht, P.O. Box 5800, NL-6202 AZ Maastricht. E-mail: lvr@sort.azm.nl, [2]Onze Lieve Vrouwe Gasthuis, Amsterdam, [3]Orthopaedic surgeon, Blaricum, The Netherlands
Submitted 01-02-17. Accepted 01-10-17

ABSTRACT – We studied whether thoracic Boston brace treatment changes the King type of scoliotic curves in a group of 50 patients with adolescent idiopathic scoliosis. Bending radiographs showed more flexibility of the lumbar curves than that of the thoracic curves. However, after initial application of the brace, the mean lumbar correction in degrees was less than the mean thoracic correction. After brace treatment we found a slight statistically significant increase in the mean lumbar curve, but no significant change in the mean thoracic curve. In 7 of our patients, we found a change in the King classification which seemed to be related to insufficient lumbar correction at the start of brace treatment.

When classifying idiopathic scoliosis, one should bear in mind that the result may be temporary because scoliosis is a dynamic process. A change in curve type can occur during brace treatment.

■

The etiology and mode of development of adolescent idiopathic scoliosis (AIS) are still not clear. In this study, we evaluated whether treatment with a brace can change the type of curve and whether this change can be predicted from the correction obtained at the start of the treatment.

Patients and methods

Our group consisted of patients treated with a thoracic Boston brace for progressive thoracic idiopathic scoliosis (King types 1, 2 and 3) between 1982 and 1997 by the scoliosis team of the Onze Lieve Vrouwe Gasthuis, Amsterdam. The indications for this treatment were a curve between 20° and 50° in a growing child, documented progression or early age at onset. The group consisted of 50 patients (49 girls). Their mean age at the start of brace treatment was 13 (8–16) years. Treatment lasted 3 (1–7) years. The follow-up measurements were made 1 year after brace treatment had ended. They were all treated with a Boston brace of 0° lordosis, made by the same brace maker, after being trained to wear it during a short hospital stay. They wore their braces for 23 hours each day. Patients were radiographically assessed with standing anteroposterior and lateral projections of the thoracolumbar spine before, during and after treatment and supine bending radiographs (patient in supine position with fixed pelvis, maximal lateral bending in the direction of the convexity) before treatment. On these radiographs, the following measurements were made by a single investigator (author): thoracic and lumbar Cobb angles (coronal and sagittal); apical vertebral rotation with Perdriolle's method (Perdriolle and Vidal 1981); L4 tilt (measured as the angle between the L4 vertebrae and the intercrestal line). The scoliosis was classified before and after treatment, using King's criteria (King and Moe 1983). We chose King's classification system (a manual for selecting fusion levels in surgical treatment) to evaluate conservative treatment because we think it important to be prepared for surgical treatment, if necessary.

The statistical analysis was done with a computer, using SPSS 6.1, paired samples t-test.

Results (Tables 1 and 2)

The mean kyphosis before treatment was 20 (0–46)° and the mean lordosis 45 (18–72)°. The apex of the thoracic curve was at T7 (n 3), T8 (n 22) or T9 (n 24). The bending radiographs showed a mean reduction in the thoracic curve of 17 (6–35)° and a mean reduction in the lumbar curve of 23 (0–37)° ($p = 0.001$). The means of the relative reductions were 57% and 87%, respectively.

Radiographs of the patients after 6 weeks of brace treatment showed a mean correction in the thoracic curve of 9° and in the lumbar curve of 7° ($p = 0.03$) The means of the relative corrections were 30% and 25%, respectively.

At the end of treatment, 32 patients showed improvement (> 5° reduction) or stabilization of both the major and minor curves. 15 patients had an increase in their lumbar Cobb angle of more than 5°, 11 patients had an increase in their thoracic Cobb angle of more than 5° (no difference, chi-square McNemar test). The mean lumbar Cobb angle had increased by 2° ($p = 0.04$), but the mean thoracic Cobb angle had not changed significantly.

The lumbar rotation increased by more than 5° in 14 patients. The thoracic rotation increased by more than 5° in 9 patients.

We studied the relation between the thoracic and lumbar curves by calculating the pre-, per- and posttreatment correlation coefficients. We found a correlation between the thoracic and lumbar Cobb angles before ($R = 0.41$, $p < 0.003$), during ($R = 0.67$, $p < 0.001$) and after treatment ($R = 0.61$, $p < 0.001$). These figures show that the correlation between the thoracic and lumbar Cobb angles increased during treatment and remained at this new level after treatment. There were also differences between the thoracic and lumbar Cobb angles before, during and after treatment ($p < 0.001$).

7 patients (nos. 8, 12, 20, 22, 24, 30, 40) had a change in King type during treatment (Table 1). One curve changed from type 2 into type 3, 3 curves changed from type 3 into 2, and 3 curves changed from type 2 into 1. In 5 of these patients, the lumbar curve had increased with a mean of 8 (3278–14)° and they had shown less than a 50% correction of the curve in the brace at the start of treatment.

Discussion

The results of nonsurgical treatment for idiopathic scoliosis are well documented. Several authors have stated that brace therapy can stop progression of the scoliosis (Carr et al. 1980, Emans et al. 1986, Lonstein and Winter 1994). This was confirmed by Nachemson and Peterson (1995) in a prospective study and by Rowe et al. (1997) in a meta-analysis. They also concluded that brace treatment can change the natural history of idiopathic scoliosis.

However, these authors mainly studied the major curve. Less information is available on the minor curve and the curve pattern.

Styblo (1991) found a correlation between the response of the major and minor curves. If the major curve responded well to brace treatment, so did the minor curve and vice versa. In our study, we found a pretreatment correlation between the size of the thoracic and lumbar curves and this correlation increased during treatment.

The best way to predict the results of brace treatment is said to be the response of the curve to application of the brace (Carr et al. 1980, Emans et al 1986, Styblo 1991). Patients with a Cobb angle correction of less than 50% at the start of treatment responded poorly to brace treatment, while those with a correction of more than 50% responded well. In our group, bending radiographs showed that the likelihood of a mean correction of the lumbar curves was greater than that of the thoracic curves. However, after application of the brace, the mean thoracic correction was better than that of the lumbar curve. After treatment the mean lumbar curve had increased, but the mean thoracic curve had not changed. These findings suggest that a thoracic Boston brace does not stop progression of the lumbar curve as well as it stops progression of the thoracic curve. Although the lumbar curve was more flexible, it seemed to respond less to conservative treatment. Andriacchi et al. (1976) reported a similar phenomenon when they described that the mid-thoracic regions showed the best response to correction by a Milwaukee brace while the lumbar curves responded only about one-fourth as well. According to the hypothesis of Hueter (1862), increased stress on the epiphysis slows growth, but reduced stress, accelerates it. It seems conceivable that this process causes the compensatory lumbar

Table 1. Results—patients treated with a Cuxhaven Boston brace

Case	Age	King type		L4-tilt		Cobb angle								Rotation			
		before	after	before	after	before		bending		in brace		after		before		after	
						a	b	a	b	a	b	a	b	a	b	a	b
1	12.8	2	2	7	8	31	27	19	4	22	20	34	34	10	10	10	20
2	14.4	1	1	6	9	29	35	17	10	28	24	30	34	20	0	20	5
3	14.5	1	1	17	15	20	29	9	0	20	20	22	30	0	15	0	15
4	14.8	2	2	5	5	30	18		0	21	20	28	14	15	5	20	10
5	10.7	2	2	10	10	34	37			21	26	30	28	0	15	0	25
6	12.9	2	2	6	7	40	20	14	20	20	10	40	16	30	0	30	0
7	13.5	2	2	16	10	34	32	19	2	22	20	34	34	0	10	0	20
8	16.9	2	3	10	0	35	15	26	15	20	16	40	15	20	0	25	0
9	12.1	2	2	6	6	28	15			10	0	21	17	15	0	15	0
10	14.6	2	2	12	15	38	21	25	0	18	10	31	20	5	15	5	15
11	13	1	1	10	10	24	25	0	0	12	12	17	17	0	5	0	5
12	9.8	3	2	0	9	24	11	0	0	0	6	20	18	0	0	5	5
13	12.9	2	2	6	10	31	15	8	0	24	7	31	24	15	0	25	0
14	13.5	2	2	6	5	26	16	16	0	23	20	44	32	7	12	25	20
15	13.9	2	2	6	12	32	20		0	12	14	19	22	5	5	2	17
16	14	2	2	5	7	28	22			7	13	18	21	0	0	0	10
17	12.2	2	2	8	7	40	25	31	5	32	27	53	41	20	0	25	10
18	8.1	1	1	13	23	45	40	28	8	41	36	53	60	5	25	0	35
19	14	1	1	13	20	38	44	20	8	31	30	43	43	13	15	15	20
20	12.9	2	1	12	9	32	27	26	8	25	28	34	34	25	17	15	22
21	14	2	2	12	16	38	36	19	7	32	21	41	42	10	15	10	20
22	13.9	2	1	8	16	36	32	13	0	27	27	25	35	20	10	15	17
23	9.8	3	3	0	0	33	18	9	2	25	10	35	13	5	0	20	5
24	15.8	3	2	0	10	32	16	17	0	25	16	43	30	10	0	27	5
25	13.2	2	2	10	15	38	26	16	0	28	20	45	32	15	0	15	5
26	14.5	2	2	10	7	32	18	9	0	26	15	35	16	5	0	10	0
27	11.2	2	2	9	12	37	24	12	0	24	14	23	16	10	10	15	15
28	12.6	2	2	5	7	22	21	11	0	13	18	24	20	5	5	5	15
29	13.2	2	2	15	14	48	42	25	12	36	35	41	41	10	20	15	20
30	14	2	1	12	11	35	31	0	0	13	23	25	30	0	12	0	15
31	13.1	2	2	10	7	35	30	13	0	23	21	30	20	20	5	15	7
32	12.8	2	2	3	4	40	25	25	0	24	20	40	25	20	7	20	12
33	11.8	2	2	4	9	23	24	10	0	15	25	23	18	5	15	10	15
34	13.4	2	2	13	14	36	34	23	9	36	35	47	39	10	5	30	5
35	11.4	2	2	10	9	28	21	0	0	21	16	43	31	0	5	15	15
36	15.9	2	2	10	9	37	31	9	23	25	26	38	27	0	10	0	12
37	14.8	2	2	1	10	38	31	18	9	25	26	38	27	5	10	5	10
38	14.8	2	2	8	10	35	23	28	0	30	20	49	35	20	15	27	15
39	14.5	2	2	7	9	18	25	0	0	14	15	21	21	0	0	5	0
40	15	3	2	0	7	28	17	16	0	20	14	25	23	15	0	15	0
41	10	2	2	4	9	32	24	12	0	17	15	30	28	0	0	15	0
42	15.1	1	1	17	6	26	37	6	0	20	17	25	25	0	25	0	20
43	9	2	2	11	10	23	24	16	0	15	13	25	19	25	0	25	0
44	14.4	2	2	7	10	25	34	17	0	29	16	40	39	10	15	5	25
45	15	1	1	15	12	16	26	1	0	12	20	17	29	0	7	5	12
46	16.5	2	2	14	12	32	28	30	6	25	25	40	36	10	15	15	32
47	12.7	2	2	14	12	28	27	7	6	22	11	31	29	5	15	10	25
48	15.5	2	2	12	13	40	32	20	0	36	27	39	37	15	20	10	25
49	13.6	2	2	5	10	20	15	0	0	11	0	14	18	5	8	0	10
50	12.7	2	2	10	7	37	27	14	0	34	21	47	30	15	15	35	18

Cobb angle in degrees; rotation measured with Perdriolle's method
[a] thoracic
[b] lumbar

Table 2. Mean angles at the start of treatment (m1), on bending radiographs (m2), after initial application of the brace (m3) and after treatment (m4)

	Before treatment m1	Bending m2	In brace m3	After treatment m4	Difference m1–m3	Difference m1–m4
Cobb angle, thoracic curve	32 (18–48)	15 (0–31)	22 (0–41)	33 (14–53)	$p < 0.001$	ns
Apical rotation of thoracic curve	9 (0–30)	9 (0–30)	10 (0–30)	13 (0–35)	ns	$p = 0.002$
Cobb angle, lumbar curve	26 (11–44)	3 (0–23)	19 (0–36)	28 (13–60)	$p < 0.001$	$p = 0.05$
Apical rotation of lumbar curve	8 (0–25)	4 (0–25)	8 (0–27)	13 (0–35)	ns	$p < 0.001$
Frontal tilting L4–sacrum	9 (0–17)			10 (0–23)		ns

Cobb angle in degrees; rotation measured with Perdriolle's method; paired samples t-test
ns = not significant ($p > 0.05$)

curve, which is insufficiently corrected by brace treatment, to become structural.

To analyze the effects of brace treatment on the type of curve, we classified the scoliosis with the system described by King et al. (1983). From our data it is clear that the type of curve can change during brace treatment. This occurred in 7 of the 50 patients. In 5 of these 7 cases, the lumbar curve had increased. These 5 patients had had less than 50% correction of the lumbar curve in the brace. This indicates that insufficient correction of the lumbar curve can lead to progression of that curve and to a change in King type.

Our findings suggest that idiopathic scoliosis is a dynamic process and that the type of curve can change due to external influences. We found no information in the literature about changes in King type with time, whether untreated or treated with a brace.

If brace treatment fails, surgical stabilization of the scoliosis may be indicated. At this operation, it is important to spare the lumbar region as much as possible. During brace treatment, this should be kept in mind. If scoliosis worsens, the lumbar curve needs to be carefully evaluated to prevent progression of a type 2 scoliosis into a type 1, since this markedly affects the size of the spinal fusion needed (King et al. 1983, Kalen and Conklin 1990, Knapp et al. 1992, Large et al. 1991, Richards 1992).

No funds have been received to support this study.

Andriacchi T P, Schultz A B, Belytschko T B, Dewald R. Milwaukee brace correction of idiopathic scoliosis. A biomechanical analysis and a retrospective study. J Bone Joint Surg (Am) 1976; 58 (6): 806-15.

Carr W A, Moe J H, Winter R B, Lonstein J E. Treatment of idiopathic scoliosis in the Milwaukee brace. J Bone Joint Surg (Am) 1980; 62 (4): 599-612.

Emans J B, Kaelin A, Bancel P, Hall J E, Miller M E. The Boston bracing system for idiopathic scoliosis. Follow-up results in 295 patients. Spine 1986; 11 (8): 792-801.

Hueter C. Anatomische Studien an dem Extremitätengelenken neugebornener und erwachsener. Virchow Arch Path Anat 1862; 25:5 72-99.

Kalen V, Conklin M. The behavior of the unfused lumbar curve following selective thoracic fusion for idiopathic scoliosis. Spine 1990; 15 (4): 271-4.

King H A, Moe J H, Bradford D S, Winter R B. The selection of fusion levels in thoracic idiopathic scoliosis. J Bone Joint Surg (Am) 1983; 65 (9): 1302-13.

Knapp D R, Price C T, Jones E T, Coonrad R W, Flynn J C. Choosing fusion levels in progressive thoracic idiopathic scoliosis. Spine 1992; 17 (10): 1159-65.

Large D F, Doig W G, Dickens D R, Torode I P, Cole W G. Surgical treatment of double major scoliosis. Improvement of the lumbar curve after fusion of the thoracic curve. J Bone Joint Surg (Br) 1991; 73 (1): 121-4.

Lonstein J E, Winter R B. The Milwaukee brace for the treatment of adolescent idiopathic scoliosis. A review of one thousand and twenty patients. J Bone Joint Surg (Am) 1994; 76 (8): 1207-21.

Nachemson A L, Peterson L E. Effectiveness of treatment with a brace in girls who have adolescent idiopathic scoliosis. A prospective, controlled study based on data from the Brace Study of the Scoliosis Research Society. J Bone Joint Surg (Am) 1995; 77 (6): 815-22.

Perdriolle R, Vidal J. A study of scoliotic curve. The importance of extension and vertebral rotation. Rev Chir Orthop Reparatrice Appar Mot 1981; 67 (1): 25-34.

Richards B S. Lumbar curve response in type II idiopathic scoliosis after posterior instrumentation of the thoracic curve. Spine (Suppl 8)1992; 17: S282-6.

Rowe D E, Bernstein S M, Riddick M F, Adler F, Emans J B, Gardner-Bonneau D. A meta-analysis of the efficacy of non-operative treatments for idiopathic scoliosis. J Bone Joint Surg (Am) 1997; 79 (5): 664-74.

Styblo K. Conservative treatment of juvenile and adolescent idiopathic scoliosis. Thesis, University of Leiden, The Netherlands 1991.