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Nighttime Bracing for Adolescent Idiopathic Scoliosis with the Charleston Bending Brace

Preliminary Report

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The authors report their preliminary experience with the Charleston bending brace for the treatment of adolescent idiopathic scoliosis. This brace holds the patient in the position of maximum side bend correction and is worn only at night.

Patients in this prospective multicentered study met all the following criteria: skeletal immaturity (Risser 0, 1+, or 2+), curvature greater than 25° before bracing, no prior treatment, and greater than 1-year follow-up since initiation of treatment. There were 191 structural curves in the 139 patients. One hundred fifteen patients (83%) showed improvement or less than 5° change in curvature. Twenty-four patients (17%) demonstrated an increase in curvature greater than 5°. Based on these preliminary results, continued use of bending brace treatment at nighttime only is justified for adolescent idiopathic scoliosis. Patients with double curves should be observed closely for increase in compensatory curves. [Key words: scoliosis, bracing, orthosis, nonoperative treatment, idiopathic]

SIDE BENDING AS a nonoperative treatment for scoliosis is not a new concept.[2] In 1931, Hibbs et al[13] reported the use of a Risser turnbuckle corrective cast, which used bending forces as a means of curve treatment. In 1936, Barr and Buschenfeldt[3] described the use of a brace that actively corrected scoliosis through a system of levers and corrective pads that applied bending forces to the body. Several braces designed in the 19th century by German orthotists Heine et al[10] bear striking similarities to the Barr-Buschenfeldt design. Predating them, the Kalibis-type splint or spiral bandage was used for the correction of scoliosis.[10] During the 1970s, Brown[5] used bending and righting forces in a brace that was used in a full-time brace-wearing program.

In 1978, Ralph Hooper, CPO, began fabricating a side-bending orthosis for Frederick Reed, MD, of Charleston, SC (Figure 1). The Charleston bending brace is used only at nighttime because ambulation is difficult in the bent position. Originally, the brace was used on patients who had failed other types of orthotic management. It was also used for patients who were almost skeletally mature but continued to demonstrate curve progression. In some early cases, the Charleston bending brace was used for patients who refused other treatment options. In these situations, time-modified bracewear was believed to be preferable to no treatment. Early results indicated success with the lateral bending brace at nighttime only. This prompted the initiation of a prospective multicenter investigational study in 1984.

In this article, we report our preliminary experience with the Charleston bending brace for nighttime treatment of adolescent idiopathic scoliosis.

ORTHOTIC DESIGN AND FABRICATION

The Charleston bending brace is a custom fabricated orthosis that begins as a negative plaster model of the patient. The patient is casted while in the supine position using radiographs as a blueprint. The orthotist maintains a pushing pressure at the apex of the curvature while applying an unbending force above the curve at the axilla in the opposite direction of the push. Stabilizing forces are placed on the trochanters or lumbar spinal area (Figure 2).

After the negative mold is completed, it is sent to a central fabrication lab (Dobi Symplex, Apopka, FL), where a positive plaster model is created. The positive plaster model is modified to meet established guidelines that will ensure maximum in-brace correction.

After the positive mold is completed, a soft foam padding material is placed on the mold in areas of maximum pressure. A cool, polymer plastic sheet is heated and then draped by hand over each of the lateral halves of the mold. The two lateral halves overlap in the front and the back approximately 3". The back overlap is fastened with rivets, while the front remains free to open and is pulled snug with three Velcro straps.

After fabrication, the patient is fitted in a supine position. An anteroposterior radiograph of the spine is obtained in the brace. Our current recommendation is to accept no brace that has less than a 50% in-brace correction or that has any increase in a compensatory curvature. After an initial adjustment period, the brace is worn a minimum of 8 hours each night.

MATERIALS AND METHODS

To be included in this study, patients met all of the following criteria: idiopathic scoliosis, skeletal immaturity (Risser 0, 1, or 2), and curvature of 25 to 49° before bracing, age 10 years or older when the brace was applied, no prior treatment, and more than 1 year of follow-up since initiation of treatment. Specific contraindications were not defined. Thus, hypokyphotic patients and patients with an apex as high as T2 were included in the study.

From 1984 through 1988, 152 patients met these criteria. Thirteen patients were lost to follow-up before 1 year, leaving 139 patients as the basis for this report. Noncompliant patients were included in the final analysis as were patients who required surgery early in the course of bracing. There were 15 males and 124 females. Average age at the initiation of treatment was 12 years, 6 months (range, 10 years to 16 years 6 months). Fifty-six patients had documented progression before bracing. Follow-up averaged 1 year 7 months since initiation of treatment (range, 12 months to 4 years 4 months). Forty-four patients have completed treatment.

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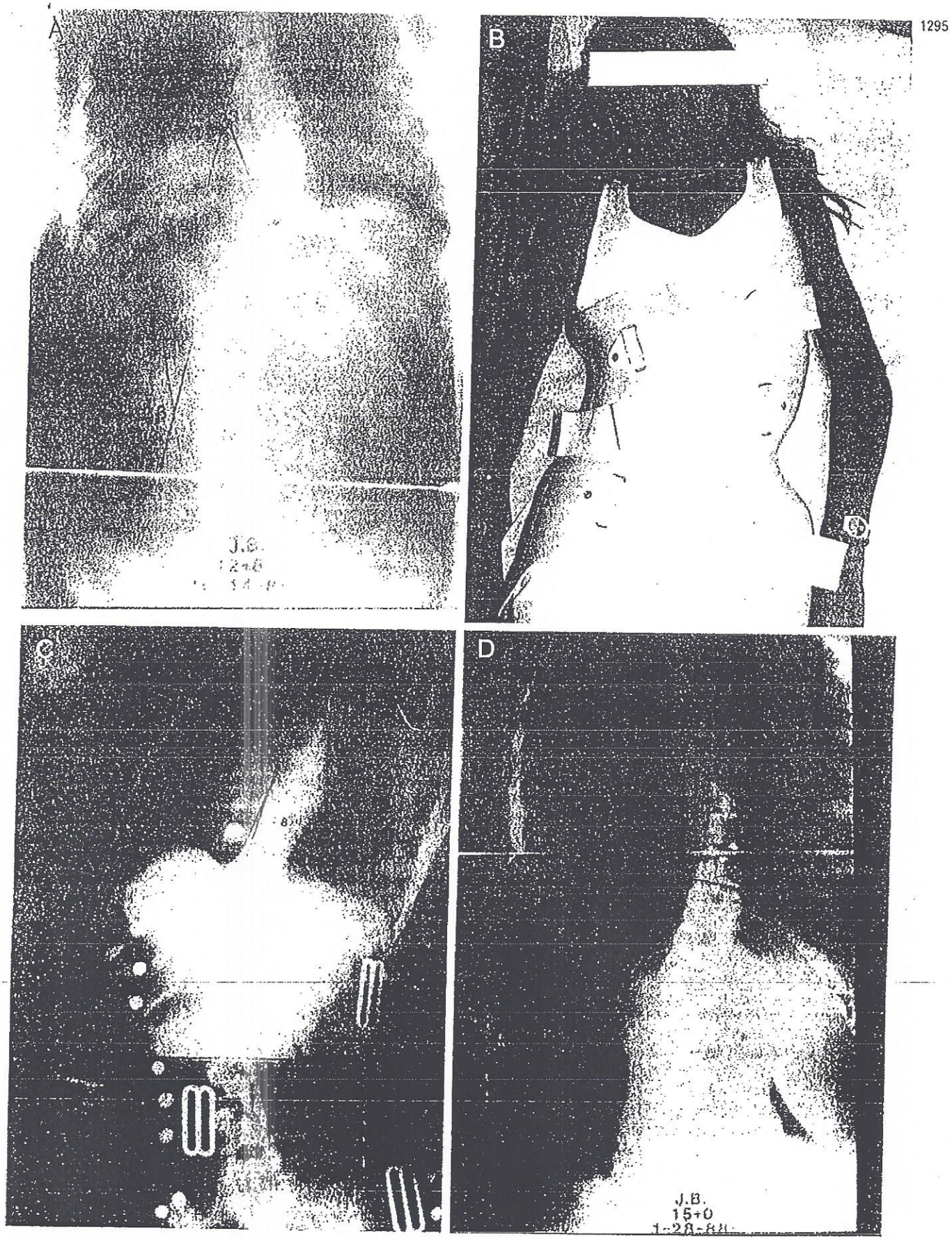


Fig 1. A, A 12-year, 8-month-old girl with 34° right thoracic scoliosis, which had progressed from 27° during 4 months of observation. B, Initial scoliograph. C, Initial x-ray in Charleston bending brace. D, Scoliosis measures 37° 6 months after completion of brace treatment.

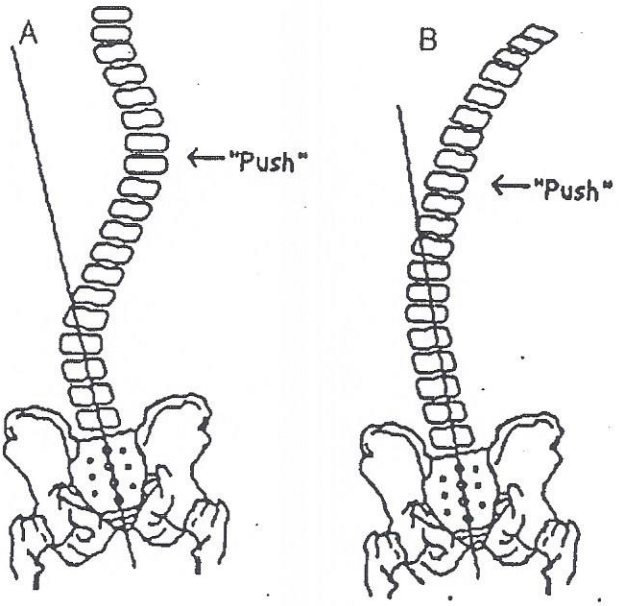


Fig 2. Correction technique for right thoracic curvature with compensatory lumbar curve. A, In the supine position the pelvis is tilted to align the distal portion of the compensatory curve. B, Pushing pressure is applied at the apex of the thoracic curve while applying unbending force above the curve in the opposite direction of the push.

According to the classification system recommended by the Scoliosis Research Society, there were 34 single thoracic curves (24%), 32 thoracolumbar curves (23%), 21 lumbar curves (15%), and 52 double curves (37%). Six of the double curves were double thoracic. Thus, there was a total of 191 structural curves in 139 patients. Average curvature immediately before bracing was 33° (range, 25 to 49°).

Results were analyzed according to the total number of curves, each curve type, and total number of patients. Treatment was considered successful if there was improvement or no more than 5° progression at the time of follow-up. Failure was defined as progression greater than 5°. All patients who required surgery had progressed more than 5° and were considered brace failures. For the patient analysis, individual patients were considered failures if any curvature, including the compensatory curves, increased more than 5°.

A supine anteroposterior radiograph was obtained in the brace each time a new brace was applied in order to evaluate the effectiveness of the brace. All other radiographs were obtained standing out of the brace. A weaning period was not employed. Bracing was usually discontinued 6 to 8 months after a Risser sign of 4 was noted for females and 12 to 18 months after a Risser sign of 4 was noted for males.

RESULTS

Scoliosis curvature averaged 28° at follow-up (for surgical patients, the value of the scoliosis curvature was that immediately before surgery). One hundred fifteen patients (83%) showed improvement greater than 5° or no more than 5° change in curvature at follow-up. Twenty-four (17%) patients demonstrated progression of curvature greater than 5° and were considered brace failures. Eleven of these 24 patients were counted as failures because of an increase in what was thought to be the compensatory curve of a double major curve even though the primary curve remained unchanged. These 11 "compensatory curves," which increased progressed an average amount of 11° (range, 6 to 27°) and the curves averaged 35° at follow-up (range, 23 to 53°). Two patients required surgery because of an increase in compensatory curve alone. Thus, 13 patients (9.4%) have had progression of the major curvature. Nine of these patients have required surgery. Thirty-five patients have completed brace treatment without requiring surgery. Twenty-eight percent of patients with double major curves demonstrated progression of at least one curve. Fifteen percent of patients with single thoracic curves progressed. Eleven percent of those with lumbar curves and nine percent of those with thoracolumbar curves progressed greater than 5°.

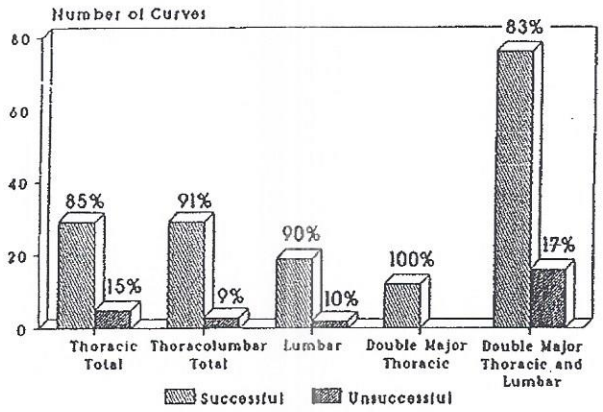
Analysis with regard to individual curves indicates that 166 (87%) of the 191 structural curves showed improvement or change of 5° or less in curvature at follow-up. In brace curve correction averaged 73%.

Table 1 and Graph 1 subdivide results by major curve type. Individual curves in a double structural curve pattern had a 14% incidence of progression. Single thoracic curves had a 15% incidence of progression. Incidence of progression was 9% for single thoracolumbar and 10% for single lumbar curves.

Table 2 indicates results for all curves in the thoracic spine according to curve apex.

Table 1. Results Subdivided by Major Curve Type

Curve type	*No. of curves*	*Stayed same or corrected >5° (%)*		*Increased >5% and/or surgery (%)*	
Thoracic total					
<30°	13	11 (85%)		2 (15%)	
30-39°	19	17 (89%)	85%	2 (11%)	15%
40-49°	2	1 (50%)		1 (50%)	
Thoracolumbar total					
<30°	17	15 (88%)		2 (12%)	
30-39°	12	11 (92%)	91%	1 (8%)	9%
40-49°	3	3 (100%)		0 (0%)	
Lumbar					
<30°	8	8 (100%)		0 (0%)	
30-39°	11	10 (91%)	90%	1 (9%)	10%
40-49°	2	1 (50%)		1 (50%)	
Double major thoracic	12	12 }100%		0 }0%	
Double major thoracic and lumbar					
<30°	46	35 (76%)		11 (24%)	
30-39°	40	35 (87.5%)	83%	5 (12.5%)	17%
40-49°	6	6 (100%)		0 (0%)	



Graph 1. Results subdivided by major curve type.

Table 2. Results for All Curves in the Thoracic Spine According to Curve Apex

Apex	No. of patients	Stayed same or improved >5° (%)	Increased >5°- and/or surgery (%)
T2, 3, 4	6	6 (100%)	0 (0%)
T5, 6	3	3 (100%)	0 (0%)
T7, 8	36	28 (78%)	8 (23%)
T9, 10, 11	47	44 (94%)	3 (6%)

Compliance with brace wear was difficult to evaluate. Nine patients were known to be partially or completely noncompliant. Three of these progressed greater than 5° and two of the three required surgery.

There were three complications related to brace wear. One patient developed transient neuropathy from axillary pressure, which was relieved by trimming the brace. Two patients developed local skin erythema but there were no cases of skin breakdown.

Only 13% of curvatures increased greater than 5° during the period of this study. Reports of the natural history of scoliosis indicate that 60–80% of patients in this study would have increased more than 5° without treatment.[6,15,16,18,19]

DISCUSSION

The results of this preliminary study suggests that 8 hours of nighttime treatment with the Charleston bending brace may be as effective as other methods of orthotic management for scoliosis. Bassett et al[4] reported that the Wilmington brace was effective in 72% of patients. Emans et al[11] reported that approximately 80% of patients with scoliosis were controlled or corrected by the Boston bracing system. They noted similar success rates between those patients who were fully compliant and those who were partially compliant. Thus, Emans et al suggested that part-time bracewear might be as effective as full-time bracewear. Green,[12] using criteria for brace treatment similar to the current study, noted an 89% success rate with part-time bracewear 16 hours each day. Other authors have used less rigid criteria for treatment or have excluded noncompliant patients from analysis.[8,9,14] Thus, the 87% success rate of this preliminary study is encouraging. But, final

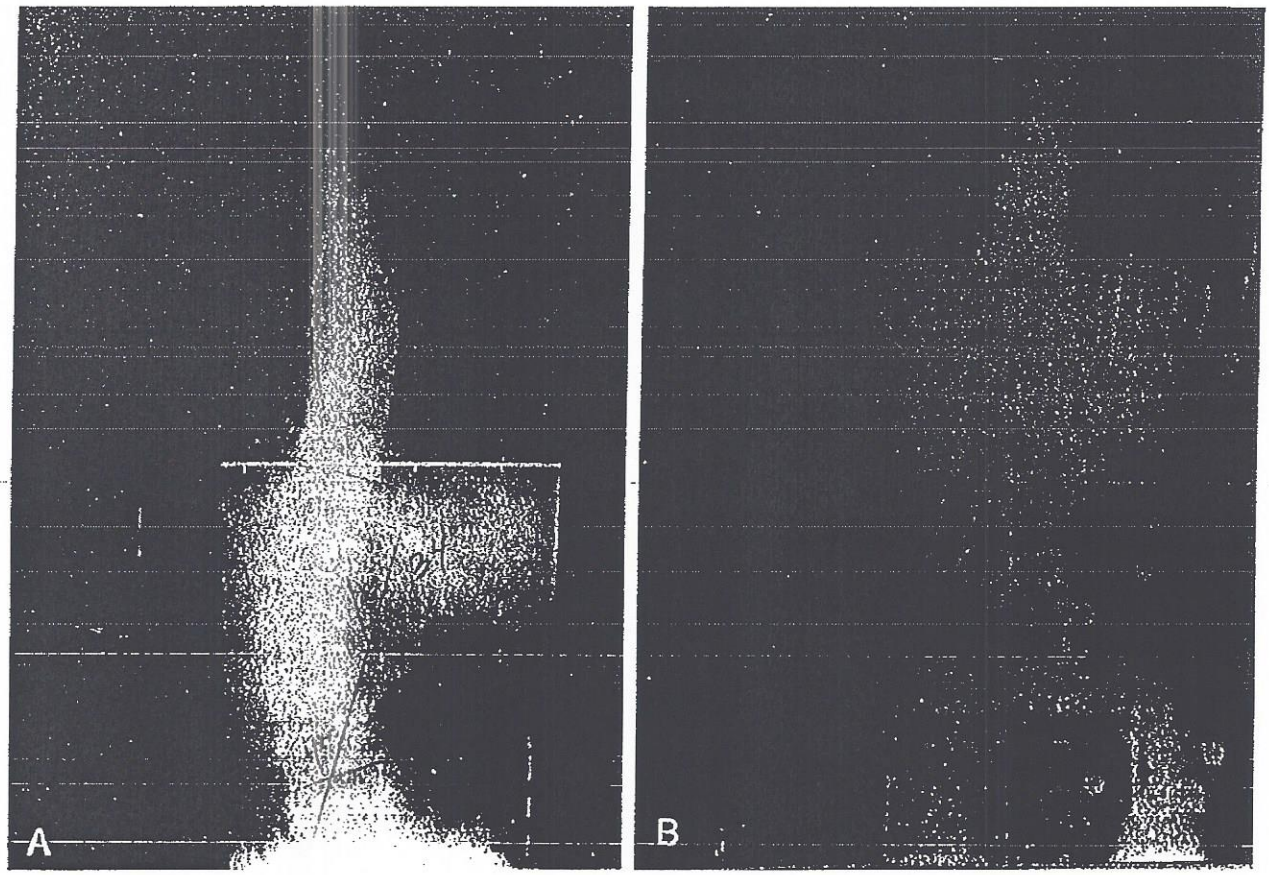


Fig 3. Double curves can be corrected in the brace: **A**, A 10-year, 9-month-old girl with double major scoliosis prior to bracing. **B**, Radiograph obtained in Charleston bending brace showing significant correction of both curvatures.

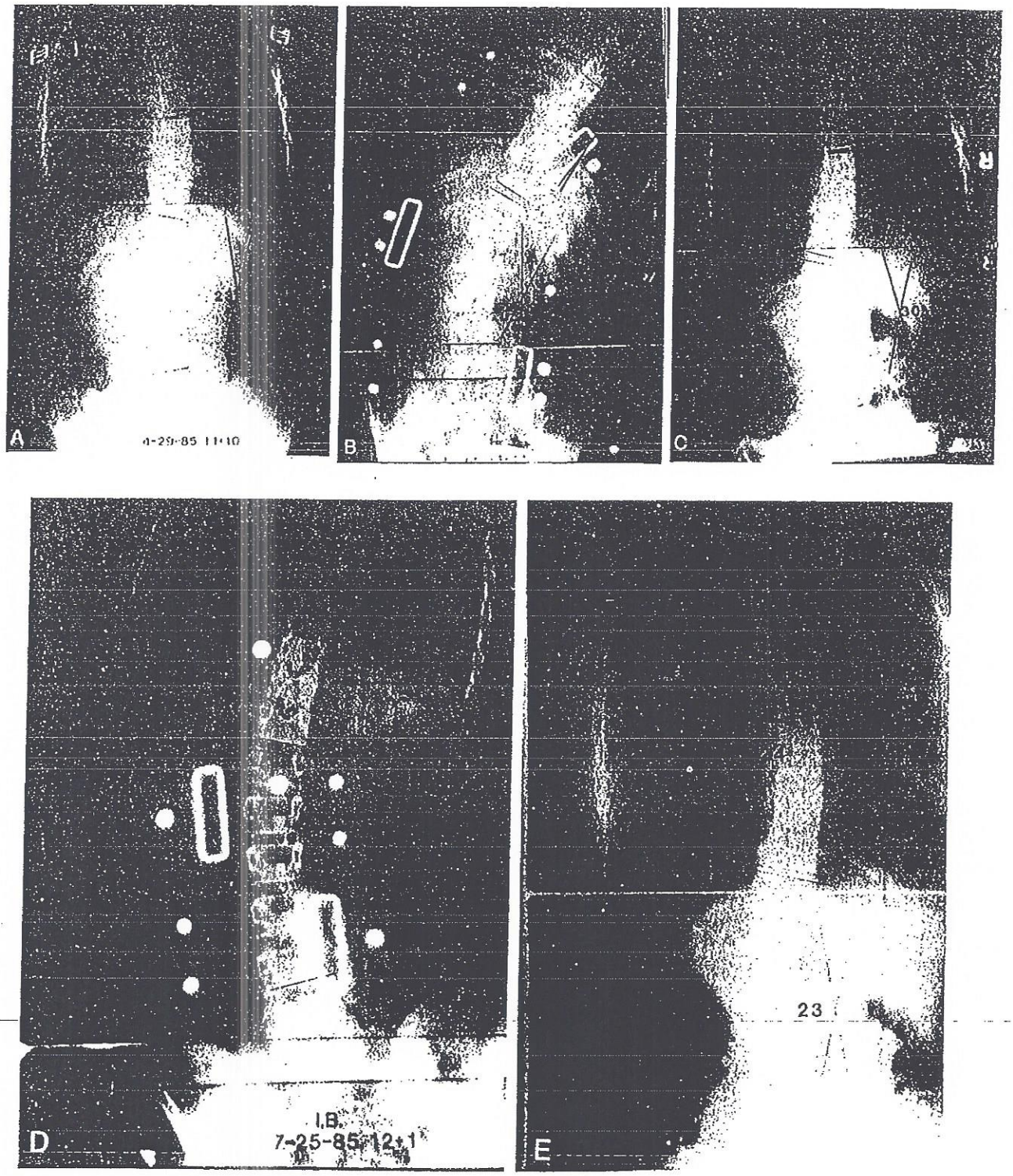


Fig 4. Compensatory curves may be increased by poor bracing technique: A, 11-year, 10-month-old girl with 25° right thoracic scoliosis, which had progressed from 17°. Compensatory lumbar curve measures 23°. B, Radiograph in initial Charleston bending brace. Note that the compensatory curve is increased to 30° in the brace. C, Out of brace radiograph 2 months later demonstrates progression of lumbar curvature. D, Radiograph in new orthosis demonstrates correction of both curvatures. Thoracic curve measures 0°. Lumbar curve measures 23°. E, Eight months after completion of brace treatment the thoracic curve measures 24° and the lumbar curve measures 23°.

results of this study will not be known until all patients have passed skeletal maturity.

During the period of this study, 44 patients have completed treatment. Thirty-five of these patients did not require surgery while 9 patients (20%) have required surgery. This 20% incidence of surgery in the completed treatment group may be misleading because curves that are "malignant" or truly progressive often require early surgery. Successful brace patients do not complete treatment for several years, so it is possible that the percentage figure for patients requiring surgery may decrease as longer follow-up is obtained.

In this study, double major curves had the poorest response to brace treatment. Perhaps this is due to difficulty achieving significant bending correction over two opposing segments. However, careful attention to brace fabrication technique can produce satisfactory in-brace correction (Figure 3). Other authors have also noted that double major curve patterns tend to have a less satisfactory response to brace treatment.[1,11,17] It is our opinion that patients with a double curve pattern should be observed closely and other forms of bracing should be considered if satisfactory correction cannot be achieved in the Charleston bending brace. Patients should also be observed for progression of compensatory curves. If this occurs the brace should be changed or modified (Figure 4).

It is valid to question whether other forms of bracing would also be effective when used at nighttime only. The answer to this question is not known, but several authors have emphasized the need to obtain maximum correction in the brace.[7,8,11] Emans et al[11] noted a strong correlation between initial in-brace correction and correction at follow-up. We noted average initial correction of 73% for all curves treated with the Charleston bending brace. This is considerably better in-brace correction than reported with other bracing techniques.[7,11,17] Perhaps this improved correction is adequate to allow treatment at nighttime only. The psychosocial advantages of nighttime treatment are readily apparent to physicians, parents, and patients, but caution is advised until long-term results are available from several different centers.

In conclusion, these preliminary results of nighttime treatment of scoliosis with the Charleston bending brace are encouraging and justify continued investigation.

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