Juvenile idiopathic scoliosis (JIS) has been reported to occur in 8% to 21% of idiopathic scoliosis patients and presents between the ages of 3 and 10 years.¹⁻⁶ The clinical history of JIS includes a rapid increase in deformity during the adolescent growth spurt. JIS is felt to represent a gradual transition from infantile to adolescent scoliosis.³ The difference in prognosis and outcome warrants consideration of JIS and AIS as distinct clinical entities.³ Despite these differences, there are presently very few studies with long-term follow-up of JIS and even fewer looking specifically at bracing in this group.⁵⁻⁸

The adverse long-term effects on personality development and self-esteem in adolescent patients treated with full-time bracing have been shown.⁹⁻¹¹ Although part-time bracing has been successful in adolescents (AIS), to date, there are no reports of its use specifically for JIS.

The purpose of this study was to determine the effectiveness of part-time bracing for JIS with patients followed to skeletal maturity.

Materials and Methods

All patients prescribed a Charleston nighttime bending brace between 1990 and 2004 at the Children’s Hospital of Eastern Ontario were identified. To be included in the study all patients had to be diagnosed with juvenile idiopathic scoliosis, curves >20° at the initiation of bracing, Risser sign of 0 at initiation of bracing, brace wear >12 months, completion of brace wear, at least 1 follow-up examination after discontinuation of brace-wear, have reached skeletal maturity defined by Risser >4, and have adequate records and radiographs available for analysis.

All braces were made by the same certified orthotist (G.M.). In patients with double curves, the higher magnitude curve was placed in the bending position, while an attempt was made to bring the lower magnitude curve to neutral by placing pads in the appropriate position. The patients were instructed to wear the brace at night while they slept for at least 8 hours per a 24-hour period. There were no strict hospital guidelines pertaining to the indication for bracing or the time of discontinuing the brace. There was no standard weaning protocol as 4 different staff physicians were involved in the study.

The patient’s charts were reviewed to obtain: sex, age of diagnosis, age at brace fitting, menarchal status, history of prior treatment with another brace, time in brace, length of follow-up and compliance. Five patients were previously braced with a Boston TLSO brace of which 4 were noted to have poor compliance, wearing the brace at night or not at all. These 4 patients had progressed >5° since the initiation of the Boston brace. One patient switched brace treatment to a Charleston brace at Risser 0 as the brace was becoming too small and the curve had progressed 7° in 6 months. All 5 patients with previous history were later prescribed a Charleston brace, completed treatment and were included in the analysis. Patients were deemed noncompliant after reviewing the charts for any clinical note indicating suspicion of noncompliance. Four patients were deemed noncompliant but were included in the study.

All radiographs and charts were reviewed by 1 author (S.G.) to limit interobserver error. Curve magnitude using the Cobb
method and Risser sign were recorded for 5 separate radiographs: initial diagnosis, prebrace, best correction in-brace, discontinuation of the brace and at last follow-up. All radiographs were standing AP views taken out-of-brace, except for the best correction in-brace which was done supine in the brace and taken within 3 weeks of brace fitting.

Curves were classified according to the Scoliosis Research Society into thoracic, thoracolumbar, lumbar, double major and triple curves. With double and triple curves, all major and secondary curves were measured. Patients were divided into 3 groups for analysis based on prebrace and last follow-up visit curve magnitude:

1. Success: curves progressing 5° or less.
2. Progression: major curve or secondary curve progressing more than 5° but achieving curve stabilization at skeletal maturity and not requiring surgery.
3. Surgery: Continuing curve progression to >45° with failure of conservative management during skeletal immaturity.

## Results

Between 1990 and 2004, a total of 34 patients with JIS were prescribed a Charleston Bending Brace. Three patients were still wearing their brace at the time of the review, 3 patients wore the brace for less than 12 months, 2 patients were lost to follow-up, and 3 patients were later diagnosed with chromosome abnormalities and were excluded. In total, 11 patients were excluded leaving 23 patients completing brace treatment.

Seven males and 16 females were included providing a total of 37 curves for analysis. Average age at referral was 8.3 years (range, 5.5–9.9) with males and females presenting with an average age of 8.5 and 8.2 respectively. Average age at initiation of bracing was 10.3 years. Nineteen patients had documented progression before the start of bracing and the remaining 4 patients presented with curves large enough to necessitate bracing. The average length of brace wear was 3.7 years (1–7.5 years). All patients then returned for a follow-up examination at an average of 2.5 years postbrace completion.

There were 9 right thoracic curves, 12 double major curves, 1 left thoracolumbar curve, and 1 triple curve, thus totaling 23 major curves. This was comprised of 23 single thoracic curves, 3 thoracolumbar curves, and 11 lumbar curves to give a total of 37 major and secondary curves. The average curve magnitude at referral was 22° (range, 7–35°) with average curve immediately before bracing at 30° (20–43°). At the end of brace-wear, including patients scheduled for surgery, the average curve magnitude was 35° (7–60°).

In patients presenting with 1 or more curves, progression of any 1 curve, whether it was a major or secondary curve, was considered progression and brace treatment failure for the patient. Thus, treatment was considered a failure if any curve progressed >5° or if the patient required surgery. Nine (39%) patients were deemed a success with a <5° curve magnitude change at final visit. Seven (30%) patients demonstrated curve progression of >5° at final visit. Of the 7 patients that progressed, 3 patients had mild progression of <10° but less than or equal to 10°. Thus, 12 (52%) of the 23 patients finished treatment with <10° of curve progression. Surgical intervention was required in 7 (30%) of the patients. The average curve for the surgical group at brace discontinuation and at preoperation was 54° (45–60°) and 57° (52–64°), respectively.

Analysis of all individual curves at the end of brace treatment showed 19 (51%) of the curves had a successful outcome. Of the 23 single thoracic curves, only 10 (43%) were successful compared with 6 of 11 (55%) lumbar curves and all 3 (100%) of thoracolumbar curves. Of the 7 patients who had surgery, 6 had a thoracic curve while 1 had a lumbar curve.

Table 1 demonstrates that initial curve magnitude at time of bracing was not related to success or outcome.

### Table 1. Relation of Curve Magnitude at Initiation of Bracing With Eventual Outcome

<table>
<thead>
<tr>
<th>Prebrace Curve Magnitude</th>
<th>Total No. Curves</th>
<th>Success ≥5°</th>
<th>Progression 6–10°</th>
<th>≥11 degrees</th>
<th>Surgery &gt;45°</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right thoracic (9) and left thoracolumbar (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20–29°</td>
<td>4</td>
<td>3</td>
<td>–</td>
<td>–</td>
<td>1</td>
</tr>
<tr>
<td>30–39°</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>10</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Double major (12), triple (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20–29°</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>30–39°</td>
<td>7</td>
<td>3</td>
<td>–</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>13</td>
<td>5</td>
<td>–</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>All patients (23)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20–29°</td>
<td>10</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>30–39°</td>
<td>13</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>23</td>
<td>9</td>
<td>–</td>
<td>7</td>
<td>7</td>
</tr>
</tbody>
</table>

Results based on major curve types.
With curves measuring 20 to 29° (10 patients), 5 curves were a success, 3 curves progressed, and 2 patients ultimately had surgery. Thirteen patients had major curves measuring between 30 and 39° with 1 curve measuring 43° eventually resulting in surgery. The remaining 12 patients showed equal results with 4 patients in each category of success, progression, and surgery.

Table 2 shows the average curve magnitudes for each outcome group. The surgery group had larger average referral and before-fit curves compared with the success and progression groups. The change in curve magnitude from brace discontinuation to last visit was not significant and did not result in any differences with respect to patient outcomes.

Correction in brace was calculated as:

\[
(\text{before-fit curve} - \text{best in-brace curve}) \\
\times 100/\text{before-fit curve}.
\]

A higher best in-brace correction correlated with a successful result. The success group had an average best in-brace correction of 102% (59%–148%), followed by 71% (0%–100%) for the progression group, and 73% (31%–100%) for the surgery group.

There was a difference in best in-brace correction depending on the type of curve. Patients presenting with a single major curve (9 right thoracic and 1 left thoraco-lumbar) had a best in-brace correction of 94% (69%–148%). In the 12 double major curves and the 1 triple curve, using the curve that determined the final outcome for the patient, the average best in-brace correction was 76% (0%–123%). Of the 12 double major curves, the in-brace correction for the major curves was 85% (59%–123%) and only 42% (0%–68%) for the secondary curves. Three double major curves fell into the progression group, and in 2 patients the secondary curve was responsible for the progression while the primary curve was stable.

Discussion

The concept of part-time bracing in JIS has many potential psychosocial and compliance benefits if one considers the length of treatment needed. Excellent tolerance and low psychosocial stress associated with the Charleston nighttime brace has already been documented with AIS patients. Of the 16 patients in our study that did not require surgery, the average length of brace wear was 4.2 years with 1 patient being braced for a total of 7.5 years.

A study by Kahanovitz et al. showed that part-time Milwaukee brace treatment was effective for curves <35° and rib vertebral angle difference <20° at onset of treatment. Although the amount of time for part-time bracing ranged from full-time wear except for school to every other night, Kahanovitz et al. based the time duration on curve magnitude, stability, and amount of curve improvement.

A study by Tolo and Gillespie included 42 JIS patients treated with a Milwaukee brace, with the brace being discarded for 4 hours or more daily once the curve had apparently stabilized. This option of a modified part-time bracing technique resulted in only 8 (19%) patients needing surgery. Although this study found the Milwaukee brace as an effective device once progression is proven, the majority of these patients in the study were still braced and not skeletally mature at the end of the study. Robinson and McMaster followed 89 of 109 JIS patients to skeletal maturity. Their study included 88 patients that were braced full-time with a Milwaukee or Boston or part-time (20 hours/day) and 77 of the 89 (87%) progressed to spinal fusion. Figueriedo and James reported on 55 of 98 JIS patients requiring spinal fusion. In their study, 45 patients were previously treated with a full-time Edinburgh brace resulting in progression to surgery in 28 (62%) cases. Mannherz et al. reviewed 31 JIS patients treated with a Milwaukee brace and reported 12 patients progressing >5° with 13 (42%) eventually requiring surgery and the remainder either improved or unchanged. This study is comparable to our report with average age at brace wear being 9 years (5–12 years) and 30 of the 31 patients having curves less than 45° at onset of treatment. A review by Masso et al. of 34 JIS patients using full-time and part-time (18 hours/day) wear of an underarm brace resulted in 17 (50%) of these patients requiring surgery. They also found that of the 17 patients treated with orthosis only, the mean overall progression was 6° (range, −25–23°). This patient sample is similar to ours with initial age of bracing at 10.1 year (range, 5.8–14 years) and average length of treatment of 3.9 years (range, 0.7–7.5 years).

Table 3 summarizes the historical bracing results. However, it is difficult to compare these studies, since they involve different patient characteristics such as age and sex, definition of treatment outcomes, initial curves and curve types. Furthermore, indications for surgery and the patient characteristics for the surgery group are not standard.

Early reports on the effectiveness of part-time bracing for idiopathic scoliosis have focused mainly on the adolescent population. More recent publications have stated...
that the Charleston Bending brace improves on the natural history of AIS and is as effective as other bracing options with success rates from 60% to 85%. However, these studies had many differences for inclusion criteria with regards to gender, curve type, compliance, and completion of treatment. Reports by Katz et al and Howard et al both found the Boston TLSO brace to be more effective than the Charleston brace in AIS patients with the exception of the treatment of single thoracolumbar and single lumbar curves. Gepstein et al found that the Charleston and Boston TLSO were equally successful for treatment of single major curves regardless of initial curve magnitude, type of curve, or Risser stage at the start of therapy. These reports were based on adolescent idiopathic scoliosis patients and are not comparable to JIS patients who make up a distinct and different clinical group of scoliosis patients.15,20

Because our patient sample included only 23 patients, with 21 presenting with right thoracic and double major curves, our sample size was too small to demonstrate any specific curve type to be more effectively braced. Similarly, it was not possible to discern any consistent factors leading to brace failure.

Patients with more than 1 curve did not fare any worse than patients with only single curves in our study. Success rates for multiple curve patients and single curve patients were 38% (5 of 13) and 40% (4 of 10), respectively. Price et al warned of the difficulty in treating double major curves with poor response related to the difficulty in “unbending” 2 opposing curves in AIS Charleston braced patients. We did, however, find discrepancies in the average in-brace correction for the double major curves and, indeed, 2 patients in the double major curve category were placed in the progression group based solely on changes in their secondary curves. It should also be noted that no patient had different treatment outcomes if the final curve was measured at brace discontinuation or at final follow-up visit. For the 7 patients that demonstrated progression during treatment, the average curve only progressed 1° (range, −2–4°) after brace discontinuation. We feel that there is more time for curves to stabilize in part-time bracing, accounting for the decrease in postbracing progression. In the surgery group, the decision for surgical management was made before discontinuing the brace.

A statistically significant association was noted with success and best in-brace correction. Patients who achieved a best correction in-brace >100% had a significant association with a successful outcome compared with correction <100% (significant at the 0.05 level). This association has been documented in previous studies of AIS patients.11,19,22 The success group had an average correction of 102% compared with 71% and 73% for the progression and surgery groups, respectively.

In a review of 115 untreated scoliosis patients, Pehrsen et al found that mortality was significantly increased in the infantile and juvenile populations but not for adolescents. The natural history of JIS has demonstrated a higher proportion progress and require spinal fusion compared with AIS. Few studies have reported data on the natural history of curve progression in JIS patients. In a review of 727 patients with scoliosis, Lonstein and Carlson found that in patients under the age of 10 with curves between 20 and 29° 100% progressed more than 5°, but this only included 10 patients. They also found that 38 (45%) JIS patients with curves 5 to 19° progressed more than 10°. Other small studies have shown that small curves under 20° can be observed without treatment with minimal progression.

Although they were designed for adolescent idiopathic scoliosis, this study follows the new Scoliosis Research Society Committee on Bracing and Nonoperative Management inclusion and assessment criteria for brace studies. However, it is difficult to compare our results with those using other bracing options for JIS because of the different curve and patient characteristics, indications for bracing and for surgery. Our results are favorable even though we used very strict criteria for curve progression and brace failure. We specifically considered a patient to have progressed if only 1 curve of a double major pattern progressed by more than 5° (including all secondary curves). We also included all patients in the study despite issues of noncompliance.

Given the long course of treatment in JIS, we feel these patients may benefit the most from part-time bracing due to a decrease in the psychological stress associated with full-time bracing. In this situation, with attention to detail, it appears that part-time bracing can be successful and is better than the natural history. Nonetheless, these results highlight the necessity for a larger, multicenter randomized study of bracing in this enigmatic condition.

### Key Points
- The effectiveness of part-time bracing for juvenile idiopathic scoliosis has not previously been reported.
- Twenty-three patients with 37 curves were assessed.
- Part-time bracing was effective for JIS.
References