Idiopathic scoliosis has been divided into Infantile (IIS), Juvenile (JIS), and Adolescent (AIS) forms. Recent researches into the early onset types of scoliosis (IIS and JIS) have pointed out that about twenty percent of these patients have neuro-axis anomalies which may contribute to the development of a curved spine. These types of curves in all patients under ten years of age may not actually be "idiopathic" in nature. For this reason, the natural history of these patients is different from the behavior of late onset scoliosis (AIS). Long term outcome studies of untreated patients with AIS have demonstrated that these curves will worsen when they are 50 degrees and more at maturity. Thoracic curves more than 80 degrees are associated with shortness of breath and risks of cor pulmonale and death. Patients with this degree of scoliosis will have more concern about their cosmetic appearance. Many patients with AIS have more pain but do not exhibit more disability than the general population. Depression does not seem to be more of a problem than in the general population. Patients with curves less than 45 degrees have lives with quality and length equal to those of control subjects. Both non-operative and operative treatments, therefore, aim toward keeping patients' curves under the important threshold of 50 degrees at maturity.

Non-operative treatment of scoliosis has been depicted as early as Hippocrates, in art and literature, using traction and lateral localizer straps. Modern bracing is said to have started with Blount and Schmidt in 1946, when they started using a brace developed for post-operative immobilization for non-operative treatment. This "Milwaukee Brace" used metal uprights to give a distraction effect to a sub-mandibular molded pad. Lateral straps and pads were placed over the apex of sclerotic curves to add lateral bending moments to the treatment, along with distraction. The brace was intended to stimulate the patient to pull away from the contact points thus using muscle power to correct the curve. Close observation indicated that those patients treated with the Milwaukee brace did not progress as often as those untreated. The standard treatment protocol became full-time wear for the duration of growth for all patients found to have scoliotic curves from around 20 degrees to 45 degrees. Physicians found that bracing did not generally change the natural history of scoliosis if the curves were greater than 45 degrees.

Patients apparently followed Dr. Blount’s instructions well, but others found the constraints of a rigid brace from the chin or throat to the pelvis uncomfortable and unsightly. Hall and Miller developed a more total contact brace that works as a sleeve while applying lateral pressure over the apices of curves. This low profile brace offered less conspicuous brace wear under clothing with the hope it would be more acceptable to
the patients and improve compliance. The outcome of the Boston Brace on the scoliosis progression was the same as the Milwaukee Brace.

Green\textsuperscript{18, 33} found that adolescents often did not wear their braces as long during each day as was prescribed. He suggested that it was possible to have the children wear their braces part-time and achieve the same control of curve progression. Variations of the treatment protocols for the Boston Brace were developed. The Charleston Bending Brace, Providence, and others, which were specifically built for nighttime wear.\textsuperscript{6,14,23} These braces bent patients out of their curves. Other mechanisms of treatment used electrical stimulation of trunk muscles to bend patient out of the curves\textsuperscript{2}. They suggested that a treatment period of nighttime or eight hours was adequate to keep scoliosis from progressing.

Manipulation and exercise therapies have been tried largely based on theory or anecdotal experience. There are no studies which prove or refute chiropractic treatment\textsuperscript{24}.

INDICATIONS FOR TREATMENT

Since adolescent idiopathic scoliosis progresses most often in patients who are growing and have curves which are above 20 degrees, this is the time to use a brace modality. Studies have shown that curves greater than 40 degrees are unlikely to respond to bracing. Treatment protocols may vary but closely resemble that shown in Fig. I\textsuperscript{63}

<table>
<thead>
<tr>
<th>RISSE R</th>
<th>CURVE</th>
<th>ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 1</td>
<td>0 - 20 degrees</td>
<td>Observe</td>
</tr>
<tr>
<td>0 - 1</td>
<td>20 - 40 degrees</td>
<td>Brace</td>
</tr>
<tr>
<td>2 - 3</td>
<td>0 - 30 degrees</td>
<td>Observe</td>
</tr>
<tr>
<td>2 - 3</td>
<td>30 – 40 degrees</td>
<td>Brace</td>
</tr>
<tr>
<td>0 - 3</td>
<td>40 – 50 degrees</td>
<td>Gray</td>
</tr>
<tr>
<td>0 - 4</td>
<td>50 degrees and higher</td>
<td>Surgery</td>
</tr>
</tbody>
</table>

ARE BRACES REALLY A VIABLE TREATMENT OPTION?

In 1993 Goldberg reviewed patients in Dublin who did not wear braces\textsuperscript{31}. She discovered that their clinic had the same number of surgeries for scoliosis when patients did not wear braces as they had while the authors were using the brace regimens. About the same time, series of patients treated with external electrical stimulators seemed to indicate that these patients had the same progression as might be expected from the natural history studies indicated\textsuperscript{9,20,29,62}. To answer these challenges, the Scoliosis Research Society commissioned a prospective, non-randomized, multi-center study to evaluate the effect of bracing and electrical stimulation on the natural history of
scoliosis. Researchers were given freedom to treat patients as they felt appropriate; that is to say they braced with their favorite brace or treated their patients with observation if they did not believe that bracing was effective. The overall results indicated that bracing did keep curves from getting larger compared to no treatment or treatment with lateral trunk electrical stimulation.

In 1995, the SRS Natural History and Prevalence Committee carried out a meta-analysis in order to determine from the English literature whether braces did keep idiopathic scoliosis from progressing. The committee also wanted to try to determine whether part-time bracing had the same effect as full-time bracing. A total of twenty studies were included in the meta-analysis studying 1,910 patients who had completed treatment. 1,459 had been braced, while 322 were treated with lateral electric stimulation (LESS) and 129 were treated by observation only.

The untreated patients did not progress (successful treatment) in forty-nine percent of the cases. Those treated with the LESS were successful thirty-nine percent and braced patients did not progress in ninety-two percent of the cases. The braced patients responded favorably significantly more than other forms of treatments reviewed.

The very young patients, especially juveniles, did not respond as well as adolescents and, of course, more mature patients who had little growth remaining. The reason for this is not clear from the meta-analysis, however literature since its publication has added precautions to the treatment of juvenile patients and boys. Karol has shown that boys only respond in twenty-five percent of the cases treated. Goldberg, et al, and Dobbs, et al. have shown that boys with scoliosis have a higher incidence of neuro-axis defects than the girls with adolescent idiopathic scoliosis. All children under the age of ten have been found to have an increased incidence of neuro-axis deformities. These findings may explain why braces are less effective in girls that are in the adolescent period.

Especially interesting, was the finding that there seemed to be a “dose response curve” related to the amount of time the braces were worn each day. While there was a trend that the patients prescribed part-time brace wear preformed better than observation, full-time bracing was significantly better (p=0.001). Furthermore, the Charleston brace which is worn eight hours was not statistically different then the TLSO’s worn for twelve hours, and both were not as successful as those braces worn full-time. The TLSO type of brace was not statistically different from the Milwaukee brace if both were worn full-time. These data were based on the length of time braces were prescribed to be worn. No timed data was available to confirm that patients were compliant with their prescriptions.

Literature since the meta-analysis has confirmed these findings. Katz and Durrani have also shown that a dose response curve exists for the length of time braces are worn daily and the control of curve progression. They did demonstrate that this time effect was more important for curves greater than 35 degrees. This makes treatment of smaller curves with part-time braces seem possible, further refining the treatment modalities the physician can offer patients and their families.
LONG TERM RESULTS OF BRACING

Danielsson and Nachemson\textsuperscript{15,16,17} have demonstrated in a long-term follow-up review of Swedish patients that the curve controlled by bracing seemed to keep the natural history of smaller untreated curves. That is to say curves kept under 45 degrees did not progress over a lifetime to a size likely to cause excessive concern about the cosmetic deformity, nor pulmonary functional loss. The average lifetime progression of curves that had been braced was 7.9 degrees compared to 23 degrees in the untreated population. They did show that there was a subgroup that progressed more than 10 degrees. This group could not be distinguished by demographic markers. Katz and Duranni \textsuperscript{42} also showed a group of braced patients that needed surgery after bracing in 36\% of the cases. These sub-groups need further study.

CONCLUSION

The literature supports that bracing for Adolescent Idiopathic Scoliosis is effective in controlling curve progression. The physician must be careful to evaluate all patients under ten years of age and all males before recommending this treatment. Boys do not respond well to brace treatment.

Part-time bracing may be effective for scoliosis with curves under 35 degrees. For curves greater than 35 degrees, full time bracing offers more predictable control of curve progression. Correction of scoliosis is unlikely using brace treatment. Bracing of curves over 40 degrees is not likely to effectively change the natural history.

Long-term studies show that the effects of bracing remain over a lifetime. Therefore, curves that are kept under 50 degrees at maturity are unlikely to progress over time to curves of 80 degrees or more, preventing pulmonary effects or shortened life expectancy. Patient body image satisfaction will likely be more positive with curves in the mild to moderate ranges.

It is our hope that the information in this manual will help physicians, patients and their families understand what bracing can do for their health and match their preferences and expectations to the treatments available.

All information in this manual represents the views of the authors and does not express the views of nor is it endorsed by \textit{THE SCOLIOSIS RESEARCH SOCIETY}.
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