INTRODUCTION

In adolescent idiopathic scoliosis, prevention of major deformity is possible by the early detection and control of minor curves. The two available methods of control are bracing and electro spinal stimulation. Each has certain disadvantages. A brace is required to be worn continuously for the major part of the day and at night through the growing years until skeletal maturity is reached. The duration of treatment could be as long as three years or more. Although the Milwaukee brace (1) has largely been replaced by the cosmetically less obtrusive braces constructed on the Boston pattern (2), the prospect of long-term brace-wearing to an otherwise healthy adolescent is bleak.

Nightly electro spinal stimulation by surface electrodes with freedom during the day is a more attractive alternative. However, problems such as skin irritation in some cases, frequent monitoring of electrode placements, and regular maintenance of the equipment have not encouraged its wider acceptance. Braces remain the mainstay of conservative treatment.

In view of the drawbacks associated with these methods, an alternative form of treatment is needed that should impose no external constraint by day or night, be minimally inconvenient, and yet be capable of obtaining results at least as good as those obtained by the existing methods. These requirements are met by the method of active autocorrection by side-shift. It has been tried for four years, and this is a preliminary report on its application to 35 children with early adolescent idiopathic scoliosis.

The Background

The principle of active correction in scoliosis by shifting the trunk sideways over the pelvis is not new. Steindler (3) used it in his compensatory treatment of scoliosis. It has a prominent place in the exercise program of the Milwaukee brace treatment (2). In addition, some patients with untreated and decompensated thoracolumbar scoliosis have discovered for themselves a way of improving their appearance by shifting the trunk toward the prominent hip.

The realization that the frequent repetition of this maneuver by itself can stabilize and even correct an early idiopathic scoliosis came about by chance when, with the intention of improving her appearance, I recommended the side-shift to a girl of 15 with a 28° thoracolumbar curve and Risser grade 4. She returned six months later with a curve of 23° and has maintained that improvement over a four-year follow-up period. The side-shift was then prescribed on a trial basis to two other girls of similar age with similar curves; both returned at follow-up with a small reduction in the curves. Thereafter, at first tentatively and later with increasing confidence derived from results in the older children, I extended the method to the treatment of curves in younger children with Risser grades 0-3.

In the last four years active autocorrection by side-shift has, in my practice, replaced the brace as the elective method of treatment. In certain situations, however, a modified Boston-type brace with a large rib molding pad is used for night wear only as an adjunct to the side-shift during the day. These situations are, first, in curves of over 30° with a large rib hump where the purpose of the brace is to reduce the hump by passive pressure molding, and, second, in very fast growing young children with Risser grade 0 where some measure of control at night of the curve itself is considered to be prudent.

The Method

The side-shift is taught in the clinic and is easily learned. Most children become adept in a matter of seconds with the aid of visual feedback provided by a full-length mirror, and gentle fingertip pressure applied laterally to the convex side of the rib cage and the contralateral hip (Figure 10.1). The child is taught to shift the trunk away from the curve convexity as far as the spine will allow, to hold this position for about ten seconds and then relax into the
senting the choice of alternative treatment by bracing—a Boston-type brace sits permanently on a shelf in the clinic. But early enthusiasm does wane after some months; parental reminders are regarded as nagging; and some other means of ensuring that the shift is done often enough has to be devised (see "Discussion"). Despite these difficulties, the results so far have been encouraging.

MATERIAL

Children from three London boroughs with early idiopathic scoliosis detected by school doctors are seen at the Scoliosis Screening Clinic of the Royal National Orthopaedic Hospital, Stanmore. Because of financial constraints the children are screened for scoliosis only twice in the course of routine school medical examinations, at about the age of 12 on changing from junior to middle school, and at 15 or 16 before leaving school. This referral pattern explains the age distribution and curve magnitude in the children reported in this paper.

Only those children who have been on the side-shift treatment for at least a year are being considered. The one exception is a girl (case 4, Table 10.1), who, by extraordinary effort, overcorrected her curve in four months (discussed below). The children number 35 (33 girls and 2 boys). Their mean age at the beginning of treatment was 14.1 years; 14 children were aged between 10 and 13 years, and the remaining were between 14 and 17 years. Nine of the girls were premenarchal. The curve pattern was 19 thoracolumbar, 6 lumbar, 7 right thoracic/left lumbar, and 3 thoracic.

The convexity was predominantly to the right, with the exception of lumbar curves where the ratio of left to right convex was 2:1. The Cobb angle in the 35 children (42 curves) ranged from 15° to 42° with a mean of 22.4°; 32 curves were between 15° and 30° and 10 were in excess of 30°, of which 3 measured 40° and more.

To define the deformity and to evaluate treatment in greater detail, two parameters were used in addition to the Cobb angle. They are apical vertebral rotation and lower vertebral tilt, or LVT. Both are measured from standard AP or PA radiographs. Rotation is measured by the Lawhon-Bunnell method (4). The tilt of the lower-end vertebra is measured against the horizontal plane. Rotation ranged from 2° to 24° with a mean of 9.2°. The LVT ranged from 5° to 24° with a mean of 12.4°.

The Risser sign was 0 in 10 children, 2–3 in 10, and 4 in the remaining 15 (Table 10.1).

Correction by Side-shift

A modified Boston brace, made to cast in the corrected side-shift position, was given to eight children for night wear only. Four
of the children were in group 1, two in group 2, and two in group 3 (see "Results"). All with rib humps that were disproportionately large compared with the size of the curve, and in all but two the curve pattern was thoracic or right thoracic/left lumbar. The two exceptions were thoracolumbar curves of 28° and 40° with a large apical rotation of 15° and Risser 4.

RESULTS

The period between the beginning of treatment and the last examination extended from one to four years and averaged 1.9 years, during which an average increase in the standing height of 3.4 cm (range 0-24.5 cm) was recorded, and eight of the nine premenarchal girls started menstruating. At the last examination, only 5 children were in Risser grade 0 to 3 compared with 20 at the beginning of treatment (Table 10.1).

Table 10.1 Risser Grading in the 35 Treated Children

<table>
<thead>
<tr>
<th>Risser Grade</th>
<th>0</th>
<th>1</th>
<th>2-3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of children in grade at the start of treatment</td>
<td>10</td>
<td>0</td>
<td>10</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>Number of children in grade at the last examination</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>25</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 10.2 Results of Treatment of 35 Children

<table>
<thead>
<tr>
<th>Average Age</th>
<th>Average Cobb Angle</th>
<th>Average Rotation</th>
<th>Average LVT</th>
</tr>
</thead>
<tbody>
<tr>
<td>At start of treatment</td>
<td>14.1</td>
<td>23.5° (15°-35°)</td>
<td>9.2° (2°-24°)</td>
</tr>
<tr>
<td>At last examination</td>
<td>16</td>
<td>24.8° (-3°-39°)</td>
<td>9.8° (0°-24°)</td>
</tr>
<tr>
<td>Change</td>
<td>1.9</td>
<td>+1.0°</td>
<td>+0.6°</td>
</tr>
</tbody>
</table>

Note: Mean period was 1.9 years. The plus sign indicates worsening.

Correction by Side-shift

During this period of 1.9 years the overall results showed, on average, an increase in all three parameters amounting to 1° in Cobb angle, 0.6° in rotation, and 0.4° in LVT (Table 10.2). We evaluated the curves individually—there were 42 curves in 35 children—by the criteria used in electrosynaptic treatment, namely, a reduction of 5° or more is considered improved, an increase of 5° or more is worsened, and either a reduction or an increase of up to 4° is unchanged (5). The results were as follows. Nine curves (21.4 percent) had improved and 21 (50 percent) were unchanged, making a total of 71.42 percent. The remaining 12 curves (28.57 percent) became worse. The curves worsened on average by 7.1° (range 5°-11°) and improved by 9.6° (range 5°-23°); the unchanged group showed an average increase of 1.7° (range -2° to +4°).

By averaging the results of the whole group the figures may appear to be better than they might if differences in age, skeletal maturity, and curve magnitude were taken into account and analyzed separately. It was therefore decided to divide the children into three groups according to the risk of their developing progressive deformity. Ten children considered to be most at risk because they were young, with a mean age of 12.1 years; premenarchal; and showing no ossification of the iliac apophyses, Risser 0, were placed in group 1. In group 2 were a further ten children, also at risk but less so, because they were postmenarchal, with a mean age of 14.2 years, and Risser 2-3. In group 3, the least at risk, were the remaining 15 children with a mean age of 15.4 years and Risser 4.

Table 10.3 Results of Treatment of Ten Children Most at Risk: Group 1

<table>
<thead>
<tr>
<th>Average Age</th>
<th>Average Cobb Angle</th>
<th>Average Rotation</th>
<th>Average LVT</th>
</tr>
</thead>
<tbody>
<tr>
<td>At start of treatment</td>
<td>12.1</td>
<td>22.4° (15°-35°)</td>
<td>8.3° (3°-14°)</td>
</tr>
<tr>
<td>At last examination</td>
<td>14.2</td>
<td>24.4° (-3°-39°)</td>
<td>9.0° (0°-15°)</td>
</tr>
<tr>
<td>Change</td>
<td>2.1</td>
<td>+2.0°</td>
<td>+0.7°</td>
</tr>
</tbody>
</table>

Note: Nine of the children were female, all premenarche. The male was 11.1 years old. Risser was 0 for all. Mean period was 2.1 years. A night brace was prescribed in four cases (see text). The plus sign indicates worsening.
Table 10.4 Results of Treatment of Ten Children at Risk: Group 2

<table>
<thead>
<tr>
<th></th>
<th>Average Age</th>
<th>Average Cobb Angle</th>
<th>Average Rotation</th>
<th>Average LVT</th>
</tr>
</thead>
<tbody>
<tr>
<td>At start of treatment</td>
<td>14.2</td>
<td>24.0°</td>
<td>8.4°</td>
<td>12.9°</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(15°-41°)</td>
<td>(4°-17°)</td>
<td>(6°-24°)</td>
</tr>
<tr>
<td>At last examination</td>
<td>15.7</td>
<td>26.1°</td>
<td>10.0°</td>
<td>15.1°</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(13°-40°)</td>
<td>(4°-18°)</td>
<td>(3°-24°)</td>
</tr>
<tr>
<td>Change</td>
<td>1.5</td>
<td>+2.1°</td>
<td>+1.6°</td>
<td>+1.2°</td>
</tr>
</tbody>
</table>

Note: All ten children were postmenarche females, Risser 2-3. Two girls with curves of 41° and 35° were given a night brace. The plus sign indicates worsening.

The results, presented as the average in each of the three groups, are shown in Tables 10.3, 10.4, and 10.5. The mean Cobb angle at the start of treatment was lower in group 1, being 22.4° compared with 24° and 25° in groups 2 and 3. Groups 1 and 2 showed a small increase in Cobb angle, rotation, and LVT during treatment (Tables 10.3 and 10.4), but group 3 showed a slight improvement (Table 10.5).

Since the interval between treatment and the last examination was 2.1 years in groups 1 and 3 and only 1.5 years in group 2, a better way of comparing the intergroup results is to express them as change in degrees per year, as in Table 10.6. This table shows that the Cobb angle increased on average by 1° and 1.4° a year in groups 1 and 2 and improved by 0.5° in group 3. Changes of this order, particularly in children in the high-risk group 1, may reasonably be regarded as insignificant. They indicate that the treatment does influence the natural history of the early curves by slowing down their rate of progression during a time of rapid growth.

Table 10.7 has been compiled to show individually the effect of treatment on the ten children in group 1. Some cases need further comment. The presence of a major idiopathic scoliosis in case 3’s mother and case 4’s two older sisters demanded early treatment. It also gave the children a good reason for working hard at the side-shift, with remarkable effect. Case 3’s curve became fully corrected within 6 months and has remained so over a 12-month follow-up period. Case 4 was even more diligent and overcorrected her curve by 3° in four months. Her treatment has been stopped for fear of further overcorrection. Case 5, conscientious at first, reduced her scoliosis from 17° to 12° (Risser 0) in eight months but thereafter became bored by it all and would shift only sporadically. Her curve increase in the following months to 28° (Risser 3) (see “Discussion”). Case 7, an 11-year-old girl, presented with a 20° right thoracic curve that increased to 26° in four months. She was adamantly opposed to any form of brace, so the side-shift was prescribed. Her determination to avoid a brace gave her the necessary self-discipline to persevere with the shift program for three years. At the age of 14, and Risser 4, her curve measured 33°—an increase of 7° in three years. A brace for night wear was given to cases 6, 8, 9, and 10 for remodeling of rib hump and additional control of the thoracic curves, which measured 20° or more. Case 6 was an erratic brace wearer.

Table 10.5 Results of Treatment of 15 Children Least at Risk: Group 3

<table>
<thead>
<tr>
<th></th>
<th>Average Age</th>
<th>Average Cobb Angle</th>
<th>Average Rotation</th>
<th>Average LVT</th>
</tr>
</thead>
<tbody>
<tr>
<td>At start of treatment</td>
<td>15.4</td>
<td>25.0°</td>
<td>10.4°</td>
<td>12.4°</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(15°-42°)</td>
<td>(2°-24°)</td>
<td>(5°-22°)</td>
</tr>
<tr>
<td>At last examination</td>
<td>17.5</td>
<td>24.0°</td>
<td>10.2°</td>
<td>11.4°</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(13°-42°)</td>
<td>(4°-23°)</td>
<td>(0°-22°)</td>
</tr>
<tr>
<td>Change</td>
<td>2.1</td>
<td>-1°</td>
<td>-0.2°</td>
<td>-1°</td>
</tr>
</tbody>
</table>

Note: One child was male, 14 were female, all Risser 4. Two girls with curves of 28° and 40° were given a night brace. The minus sign indicates improvement.
Table 10.8: Group 1: Most at Risk

<table>
<thead>
<tr>
<th>Number</th>
<th>Name</th>
<th>Curve Pattern</th>
<th>At Treatment</th>
<th>At Last Examination</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Age (years)</td>
<td>Risser</td>
</tr>
<tr>
<td>1</td>
<td>B M</td>
<td>L. Lum.</td>
<td>11.4</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>K R</td>
<td>L. Lum.</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>E O</td>
<td>R. Th-L</td>
<td>10.8</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>J N</td>
<td>R. Th-L</td>
<td>13.9</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>D D</td>
<td>R. Th-L</td>
<td>13.8</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>*L G</td>
<td>R. Th</td>
<td>11.1</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>M S</td>
<td>R. Th</td>
<td>11.1</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>*J B</td>
<td>R. Th</td>
<td>11.1</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>*J D</td>
<td>R. Th/L. Lum.</td>
<td>11.9</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>*B K</td>
<td>R. Th/L. Lum.</td>
<td>11.4</td>
<td>0</td>
</tr>
</tbody>
</table>

Note: Individual results in ten children on the side-shift treatment. The four who were given a night-time brace are indicated by an asterisk.

Since there are no absolute criteria for discriminating at an early stage between progressive and nonprogressive scoliosis, the decision to start treatment is deferred until a curve has been seen to increase to an arbitrary limit. Experience has shown that, in general, a curve is contained at the level at which treatment is started, and that any correction obtained during treatment is lost after it is discontinued (6, 7). Michel (8) therefore recommends that "to obtain a reliably stable curve of less than 30° in adulthood it is necessary to undertake treatment of a curve of less than 30°.

but fairly difficult with the side-shift. Case 9 (Table 10.8) illustrates particularly the effect of the side-shift in controlling progression and the reluctance, so far, to treat smaller curves. It could be argued, however, that containment in the early days and I took the wrong decision to stop the side-shift after a year's treatment for fear of control. Since there are no absolute criteria for discriminating at an early stage between progressive and nonprogressive scoliosis, the decision to start treatment is deferred until a curve has been seen to increase to an arbitrary limit. Experience has shown that, in general, a curve is contained at the level at which treatment is started, and that any correction obtained during treatment is lost after it is discontinued (6, 7). Michel (8) therefore recommends that "to obtain a reliably stable curve of less than 30° in adulthood it is necessary to undertake treatment of a curve of less than 30°.

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Experience has shown that the fear is unjustified (see "Discussion"), but fairly difficult with the side-shift. Case 9 (Table 10.8) illustrates particularly the effect of the side-shift in controlling progression and the reluctance, so far, to treat smaller curves. It could be argued, however, that containment in the early days and I took the wrong decision to stop the side-shift after a year's treatment for fear of control.

Since the side-shift treatment does not put any way
restrict the child's daily activities or interfere with sleep, it be­
comes ethically justifiable to begin treatment sooner.

The possibilities of earlier treatment and more ready accept­
ance by the patient are important considerations, but they are not in
themselves sufficient reasons for recommending a method unless
the results it obtains are at least as good as those had by the existing
methods. The short-term results in the 35 children (Tables 10.2
to 10.7) appear to indicate that they are comparable with those re­
ported by braces (6-10) or electrospinal stimulation (11,12). How­
ever, it could be argued that since this report includes the treatment
of some curves of less than 25° and also of children with Risser
grade 4, the results are not strictly comparable. Excluding, there­
fore, the results in the Risser 4 group and taking into account only
those relating to the skeletally immature children in groups 1 and 2,
with a mean annual increase of 1° and 1.4° during treatment, it can
be said that the level of containment of progressive deformity by
the side-shift is about the same as by the other methods.

The inability to ensure that the side-shift is done often enough
and to its full limit is the main and only drawback. As a rule the
children cooperate fully in the first six months or so, but thereafter
they, not unnaturally, slacken in their effort. The exception to this
general pattern is children who maintain a high level of compliance
throughout because of either the example of a family member with
scoliosis or a passionate determination to avoid the alternative treat­
ment by brace. The older girls also comply better because they are
more aware of their body image and wish to improve it.

A small electronic-battery-powered reminder device to be
worn under the clothing has recently been developed. It is designed,
during the active phase of a preset cycle, to deliver a small elec­
trical signal that can only be switched off
by
the child's shifting into
the maximally corrected position. With this device it should be pos­
sible not only to ensure a uniformly consistent level of compliance
but also to work out how many hours the device should be worn to
correct the deformity as opposed to keeping it contained.

The size of the curve, the curve pattern, and the degree of
compliance with treatment all contribute to the outcome of treatment
by the side-shift or any other method. Thoracolumbar and low tho­
racic curves respond best to the side-shift, lumbar curves less so,
particularly when there is an acute take-off at L5. For the right
thoracic/left lumbar pattern the side-shift away from the thoracic
curve convexity is used. Although in theory this should aggravate
the lumbar curve, in practice both curves are equally contained (see
Tables 10.7 and 10.8).

Table 10.7 shows that correction and even overcorrection can
be obtained when all three conditions are favorable, as in cases 3
and 4 where both girls with thoracolumbar curves of 15° and 20°
were motivated to work hard at the side-shift because each had a
close relative with scoliosis. The 11-year-old in case 7, equally
determined and conscientious, was unable to correct her curve be­
cause of its pattern and size, which was 26° thoracic. She did suc­
cceed, however, in considerably slowing down the rate of progression
to a 7° increase in three years compared with a 6° increase in four
months before treatment was started. Cases 1 and 2, also with 15°
and 20° curves but of the lumbar pattern, increased. Two factors
seem to have contributed to this: first, the curve pattern itself, and,
second, the fact that since lumbar curves do not show as much hip
asymmetry as do thoracolumbar, neither the children nor their
parents saw a compelling reason for adhering to the treatment re­

Figure 10.2 On the left is a standing radiograph of the girl in Fig­
ure 10.1, taken in the relaxed position. The first and second lumbar
vertebrae form an oblique stack. On the right, a standing radiograph
taken in the side-shift position shows the correction of the stack to
the vertical and consequent reduction of the curve.
tenance therapy to prevent progression in adult life. Five girls who are now skeletally mature (Risser 5) are maintaining their curves constant by a brief period of 15-30 minutes of side-shift daily.

How does the side-shift work? To answer this, a brief description of what happens when a curvature develops from a normal spine is necessary. On the rare occasion when serial radiographs showing this are available, the first hint of incipient imbalance in the frontal plane in the straight column is a slight tilting of a lumbar vertebra. Later, with the development of a lateral curve, the tilted vertebra becomes the lower-end vertebra and forms the base of an oblique stack of two or three vertebrae at the lower end of the curve. The oblique stack seems to be the target zone for the deforming forces to create imbalance and produce a scoliosis. It also plays an important part in the dynamics of the lateral curvature; the stack moves en bloc, and the direction of its movement controls the size of the curve. Progressive inclination of the stack toward the convexity, indicated by an increase in the degree of LVT, increases the curve. Movement of the stack in the opposite direction, toward the midline, reduces the curve (Figure 10.2); if that movement is carried past the midline, the curve becomes overcorrected (Figure 10.3).

The side-shift works by opposing the deforming forces at their point of action, which is the oblique stack, by a counterforce generated by the child's own muscles, to move the stack back toward the midline vertical. This principle of active correction is quite different from the passive correction by brace where the main thrust of the three-point pressure system is directed at the apex of the curve.

The side-shift is not an exercise program to be learned or performed in physiotherapy departments. It is an autocorrective treatment and perhaps more effective than either the Boston brace or electrical stimulation for these reasons. The design of the brace actually restricts the full lateral trunk displacement that is essential for full correction, but the side-shift has the power to reverse the tilt of the oblique stack and overcorrect the curve. Spinal stimulation by implanted or surface electrodes is restricted to one or two muscle groups. The side-shift activates a number of muscles to work synchronously: the paraspinals and abdominals to move the spin, and the deep spinal muscles to hold it in the corrected position.

Prevention has hitherto been aimed at keeping small curves small. The side-shift, by allowing the treatment of smaller curves, may extend the scope of prevention to complete correction in some cases.
REFERENCES


KINDER-HARRINGTON RODDING

J. Polster, J. Heine, and D. Strick-Lutterman

Posterior spinal fusion for scoliosis is rarely indicated in children under the age of ten since progressive deformity is usually controllable by conservative means such as the Milwaukee (1), Boston (2), or Cheneau (3) brace. The posterior vertebral elements are sufficiently large and strong to withstand the distractive forces exerted by the Harrington instrumentation system (4), and the problem of creating a stunted trunk is avoided when spinal fusion is delayed until after the age of ten.

In a few patients, however, early fusion becomes necessary because of severe deformity, as for example in infantile or juvenile scoliosis with marked vertebral rotation or in rapidly progressive curves associated with neurofibromatosis, Marfan’s syndrome, or diastrophic dwarfism, in which conditions an additional complicating factor is the poor quality of bone. The absence of the posterior vertebral elements as in congenital scoliosis with spinal dysraphism or from extensive laminectomy for the resection of spinal tumors adds to the operative difficulties of stabilizing the spine in young patients; consequently, past attempts at securing a sound posterior fusion without using internal fixation were frequently followed by significant loss of correction in the postoperative years from plastic deformation of the fused mass.

For these reasons it is questioned whether spinal fusion in the young child could be made more effective by the use of an internal fixation device similar to that designed by Harrington. The original Harrington instruments in use since 1968 for adolescent and adult patients are not, or are only rarely, suitable for children under ten years of age. The inside diameter of the standard hooks is too large for the small neural arches in young children, and there is a danger of their protruding into the canal and causing cord compression. The distraction rods likewise are too long and too thick for comfortable