SURGICAL TREATMENT OF
LATE-ONSET IDIOPATHIC THORACIC SCOLIOSIS

THE LEEDS PROCEDURE

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Late-onset idiopathic scoliosis is associated with a rib hump in the thoracic region, and surgery is indicated when this deformity becomes unacceptable. Fifty patients with this deformity were treated by the Leeds procedure, which consists of segmental wiring to a kyphotically-contoured square-ended Harrington rod; this procedure not only derotates the spine but restores the natural thoracic kyphosis, thus avoiding subsequent buckling. All patients were followed up for a minimum of two years. Forty-two of these, who had a pre-operative Cobb angle of less than 60°, were treated by one-stage instrumentation and fusion, while the remaining eight with greater curves underwent preliminary anterior multiple discectomy to provide flexibility with shortening. Postoperative loss of correction was not observed and there were no neurological complications.

There are two varieties of idiopathic scoliosis: early and late onset (Ponseti and Friedman 1950; Dickson 1985). The uncommon, progressive early-onset type is associated with severe deformity and with cardiopulmonary morbidity (Nachemson 1968), while the more prevalent late-onset form is the source of deformity only, there being no organic consequences to the patient (Davies and Reid 1971; Branthwaite, personal communication 1985); the deformity is, however, important, and the greater it is, the more the patient suffers social and psychological deprivation (Bengtsson et al. 1974).

While the early-onset progressive case may be treated conservatively (Mehta and Morel 1979), late-onset idiopathic scoliosis can only be treated effectively by surgery (Miller, Nachemson and Schultz 1984; Dickson 1985). Patients present with asymmetry of the torso, usually in the form of an unacceptable rotational prominence. It is this which the patient wishes to have corrected, and it is remarkable how unsuccessful standard surgical treatment is in achieving this correction. Harrington instrumentation is no more corrective than previous casting methods (Moe and Valuska 1966), and for thoracic curves the average correction is 50% in the coronal plane and little or nothing in the transverse plane, the rib hump remaining unchanged (Schultz and Hirsch 1973; Aaro and Dahlborn 1982). Posterior segmental wiring systems (Resina and Alves 1977; Luque and Cardoso 1977) are no better (Leatherman et al. 1984) and do not provide effective derotation (Wenger and Carollo 1984). This, together with an unacceptably high complication rate (King 1984), has led to the widely held view that there is no place for two rods and sets of wires in idiopathic scoliosis, and that for patients with this deformity a single Harrington rod and one set of segmental wires is preferable (Leatherman et al. 1984).

That structural scoliosis is as resistant to correction by instrumentation as it was to earlier methods is entirely attributable to its three-dimensional nature. The essential lesion is a lordosis which buckles to the side (Adams 1865; Somerville 1952; Roaf 1966; Dickson et al. 1984). Segmental wiring attached to straight rods, or to rods favouring the coronal-plane component of the deformity, exert their effect behind the axis of the lordosis; such wiring cannot be expected to improve the rotational prominence and may in fact make it worse. Moreover, the tethering effect of posterior surgery in the presence of a lordosis (Roaf 1966) is such that the deformity continues to progress, sometimes at a faster rate than before (Hefti and McMaster 1983).

If the deformity is to be effectively corrected, the pull on the vertebrae in the curve should be backwards rather than to one side; in the thoracic region the
kyphosis is thereby restored so that the spine is once again in its correct position in relation to the axis of spinal rotation. Subsequent rotational progression is mitigated (Dickson, Lawton and Buttt 1984). Sagittal-profile segmental wiring to a Harrington distraction rod is thus the basis of the Leeds technique, which was first performed in November 1982. We report here the results of the first 50 cases of late-onset idiopathic scoliosis treated by this procedure.

PATIENTS AND METHODS

There were 40 females and 10 males with a mean age of 12.5 years (range 9 to 22). Before operation, 42 had a Cobb angle of less than 60° and were treated by a one-stage procedure; the remaining eight with a Cobb angle of between 60° and 90° had a two-stage operation. The deformity was assessed radiographically by measuring the Cobb angle and the angle of apical vertebral rotation (Perdriolle 1979) from erect postero-anterior radiographs obtained just before operation, two weeks thereafter and then at follow-up (average 2 years 3 months; range 2 years to 3 years 3 months).

Operation. The basis of the technique is a standard midline posterior approach to the spine from at least the neutral vertebra above the deformity to the neutral vertebra below; this is followed by the passage of concave sublaminar wires and the insertion of a Harrington distraction rod.

Certain parts of this procedure are critical. For thoracic curves the rod must be bent into at least 20° of kyphosis, held in that position by a square-ended hook–rod relationship. For a particularly rigid curve, the rod may also require bending in the coronal plane (manual pressure medially and downwards over the rib hump determines whether this is necessary). When the rod is inserted it is not distracted until the segmental wires have been tightened. If the rod is distracted first, as in the standard Harrington method, then the whole three-dimensional deformity will become rigid in tension; then either the segmental wires will not achieve their desired aim or the contents of the spinal canal will be put under undue tension. If the rod is still slack at the end of wire-tightening, then and only then is it distracted maximally.

The order of tightening the wires also is critical. The upper and lower ends of the rod are first restrained by local wire-tightening; this also secures the hooks. A rod extending above and below neutral vertebrae is thus preferable. Next, the wires under the apical two vertebrae are tightened, aided by manual pressure downwards and not sideways on to the rotational prominence. This is extremely important in order to achieve maximal derotation, as it is only the apical two vertebrae which are maximally rotated (Dickson et al. 1984). If the wires were tightened above and below the apex before the apical wires, then a significant amount of the rotational deformity would be "left behind".

The remainder of the wires are then tightened and a posterolateral fusion is performed by interdigitating flaps of bone lifted from the posterolateral elements out to the tips of the transverse processes. Upon this bed, matchsticks of allograft cancellous bone are applied. Unless there is a shortage of bank bone, it is not necessary to use bone from the patient’s iliac crest, which necessitates a much longer incision and greater postoperative discomfort. For patients with thoracic curves whose rotational prominence still appears obvious, the apical six ribs on the convex side are divided just distal to the transverse process and the lateral end is tucked anterior to the medial; the rib hump is thereby markedly flattened. A postoperative EDF (elongation-derotation-flexion), polyurethane cast with a zip fastener (NeoFract; Johnson & Johnson) is applied 10 days after operation and retained for six months.

The above regimen applies to the typical flexible adolescent idiopathic curve, that is, to those patients with a pre-operative Cobb angle of less than 60° (Figs 1 to 4). For those with bigger, and thus more rigid, deformities (curves between 60° and 90°), a satisfactory correction cannot be achieved by a one-stage posterior procedure, and there is, moreover, a real risk of neurological damage due to tension if such an attempt is made. The deformity needs to be shortened as well as straightened; this is achieved by a preliminary anterior removal of the apical five or six discs and end-plates, thus making considerable space available for the deformity to be "pulled through". Enhanced correction without undue tension is thus obtainable. Two to three weeks later, the procedure of posterior instrumentation described above is then performed (Figs 5 to 8). For curves greater than 90°, and for those previously treated by posterior fusion, we favour a two-stage wedge resection of the spine (Leatherman and Dickson 1979).

RESULTS

The results are shown in Table I, from which it can be seen that, overall, a 65.5% correction of the Cobb angle was achieved; more importantly, however, a 50% correction in rotation was also achieved.

Measurements from radiographs taken two weeks after operation were compared with those at follow-up and indicated that the very small losses of correction had occurred within the first few weeks. There were no neurological complications, no deaths and no infections in this series. Two rod breakages were observed. One occurred in a 15-year-old girl with a 50° curve who, in order to exercise on a trampoline, removed her EDF cast three weeks after operation; the metal implants were taken out and a simple Harrington distraction rod inserted without wires and there have been no further problems. The second rod breakage, in a girl of similar
A postero-anterior radiograph of a 12-year-old girl (Fig. 1); there is a right thoracic idiopathic scoliosis with 30° of apical rotation, and a right rib hump is clearly seen when she bends forward (Fig. 2). Two years after operation, the apical rotation now measures 10° (Fig. 3), and forward bending shows that good correction of her rib hump has been maintained (Fig. 4).
A postero-anterior radiograph of a 13-year-old girl who has a right thoracic curve with 40° of apical rotation (Fig. 5). Before treatment by a two-stage procedure, forward bending showed a significant rib hump (Fig. 6). Two years later (Fig. 7) apical rotation measured only 20°, and forward bending revealed good correction of the rotational deformity (Fig. 8).
age with a similar curve, was seen in the radiograph taken at two years after the operation; it was not present in the film taken at one year and the patient's initial good correction was sustained and still is. Both breaks occurred at the ratchet–solid rod junction and, because this was associated with a large number of ratchets below the upper hook (an unfavourable mechanical situation), we would recommend keeping the number of ratchets between hooks to a minimum.

**DISCUSSION**

The indications for operation in late-onset idiopathic scoliosis have become clearer over the past 10 years. Reports that untreated individuals with idiopathic scoliosis have a significant morbidity and mortality from cardiopulmonary compromise (Nachemson 1968; Nilsonne and Lundgren 1968; Collins and Ponseti 1969) have been misinterpreted, suggesting that when curves exceed 60° operative treatment is required to prevent chest complications. However, this applies only to early-onset cases (Davies and Reid 1971; Branthwaite, personal communication 1985) and these are now rare. Far more common is late-onset idiopathic scoliosis and, in this variety, once the deformity has become unacceptable, the objective must be to make it acceptable and to keep it so until the risk of subsequent progression has passed. There are thus two important aspects to be considered: correction and maintenance of the correction.

Before the era of spinal instrumentation pioneers in scoliosis surgery obtained their corrections by the use of casts (Risser et al. 1953). While the addition of Harrington instrumentation reduced the rate of pseudarthrosis, there was no improvement in correction (Moe and Valuska 1966), although very few tension neurological complications were observed in the idiopathic case (MacEwen, Bunnell and Sriram 1975). More powerful posterior segmental instrumentation techniques not only failed to produce improved corrections (Kahn 1984; Leatherman et al. 1984) but were associated initially with a neurological complication rate as high as 17% (Luque 1984); even with further not inconsiderable experience, this rate had dropped to only 4% (King 1984).

The failure to achieve correction of rotation and the perilously high rate of neurological complications are both readily explained by the three-dimensional nature of structural scoliosis. Before the advent of radiographs, the buckled lordosis of the deformity was quite clear to those who studied it (Dick 1864; Adams 1865). The taking of radiographs, however, while enabling the bony spinal column to be visualised, artificially highlighted the lateral spinal curvature; despite the occasional warning (Somerville 1952; Roaf 1966), this aspect of the deformity thereafter attracted all the attention and therapeutic effort.

The futility of longitudinal distraction in correcting rotation has long been known (Schultz and Hirsch 1973) and it would thus appear superficially tempting to pull each vertebra horizontally to the midline by segmental wiring in an effort to improve correction. However, the lordotic apex of the deformity lies in front of the axis of spinal rotation and therefore not only can the rotational deformity not be improved but may in fact be made worse. Only by segmentally pulling the deformity posteriorly in relation to the axis of spinal column rotation can derotation by achieved and, for thoracic curves, the restoration of kyphosis is an integral part of the derotation process. This has nothing to do with the preservation of physiological sagittal curves, often adduced as the reason for slightly bending the longitudinal rods (Luque 1984), but is the essential manoeuvre in producing true derotation (Dickson et al. 1984).

Understanding the nature of the apical rigidity helps to clarify the necessary process of correction and what must be done if rigidity is excessive. The thoracic facet joints are obliquely disposed and favour segmental rotation about an axis in the vertebral body anteriorly. In the presence of a thoracic lordosis, however, the axis of rotation is situated posteriorly, at about the level of the facet joints whose oblique disposition resists segmental rotation to produce a local rigid area. As the apical region is drawn backwards, the axis of rotation comes to lie more and more in front of the facets with rigidity becoming progressively less. Thus recreation of the thoracic kyphosis positively enhances correctability.

As curve size increases, so the ability of posterior surgery alone to correct the curve diminishes, and a more aggressive approach becomes necessary. Our clinical experience suggests that a figure of 60° is appropriate as a threshold above which an anterior space-making procedure is necessary; for a curve of up to 90° this can be performed at disc level. Neurological problems are produced, not by the sublaminar site of the wires, but by the fact that they may actually increase the deformity if

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Table I. Results in 50 patients with late-onset idiopathic scoliosis treated by the Leeds procedure

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<thead>
<tr>
<th></th>
<th>Cobb angle &lt; 60° (42 patients)</th>
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<th>Cobb angle 60°–90° (8 patients)*</th>
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<tbody>
<tr>
<td></td>
<td>Before operation</td>
<td>At follow-up</td>
<td>Correction (%)</td>
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<tr>
<td>Mean Cobb angle</td>
<td>54°</td>
<td>18°</td>
<td>66</td>
</tr>
<tr>
<td>Mean apical rotation</td>
<td>31°</td>
<td>15°</td>
<td>51</td>
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* Two-stage procedure (see text)
no anterior first-stage procedure is performed.

It can thus be seen that the Leeds procedure is really applicable to curves not in excess of 90°. The 50% correction of the rotational component obtained in our series is most rewarding, and such a figure has not hitherto been achieved. The ingenious method of Dubousset and his colleagues achieves a correction of rotation of 40°; their patients all had mild flexible curves (Dubousset et al. 1986). While this procedure also specifically addresses the sagittal plane, the spine is only derotated where the hooks are sited and thus the apical region is "left behind". As the apical region is the area of greatest rotation, ideally it should be tackled by the instrumentation and, indeed, should be tackled first.

With late-onset idiopathic scoliosis the risk of subsequent rotational progression is less than with the early-onset type, there being less time for the spine to deform before maturity. A posterolateral spinal fusion is therefore performed at the time of posterior instrumentation. The spine does not stop growing until, on average, 10 years after the rest of the skeleton (Haas 1939; Bernick and Cailliet 1982), and a fused thoracic kyphosis is a much safer sagittal profile than a persistently tethered lordosis. With rod and wires in the spine, the available surface area for producing fusion is correspondingly reduced. The addition of bone graft material is thus advisable, although it does not matter whether this is allograft or autograft (Aurori et al. 1985).

It is the three-dimensional nature of the deformity of idiopathic scoliosis which holds the key to successful correction. In particular it is the rigid apical lordosis which has to be unravelled: if deformity is to be rendered acceptable without the risk of neurological damage, then bigger curves do need more aggressive surgery. With such curves a planned and staged treatment programme is safer than a one-stage posterior operation.

REFERENCES


