TREATMENT OF SCOLIOSIS BY POSTERIOR FUSION, HARRINGTON INSTRUMENTATION AND EARLY WALKING

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One hundred and three patients with scoliosis treated by posterior fusion and Harrington instrumentation are reviewed. The fusion technique described does not require added bone. Walking in a localiser plaster is encouraged as soon as the wound is healed, usually two weeks after operation. The results compare satisfactorily with others published. It is concluded that added bone is not necessary unless neural arch defects are present, and that early walking is advantageous and without risk to the correction.

In 1962 Harrington described a method of internal fixation for scoliosis which, combined with posterior fusion, has probably become the most widely practised operation for this deformity. Techniques of fusion and instrumentation, and pre-operative and post-operative management vary considerably. The regime described here is based on the following considerations. 1) The Harrington distraction rod and hook system is most stable under longitudinal compression, which locks the hooks more securely on the rod, provided there is strong bone at the hook seatings. It may be disturbed however by rotation of the spine, which may dislodge the upper hook from the bone, or by repeated bending in any direction—forward, backward or sideways—which may either dislodge the hooks or fracture the rod at the junction of barrel and ratchet. A localiser plaster (Risser 1961) prevents these movements (Fig. 1) and thus the combination of instrumentation and plaster should be stable in all positions and make post-operative recumbency unnecessary. 2) Exploration of a fusion mass usually reveals a flat sheet of cortical bone: deep to this may be a cancellous area with a further cortical sheet in front of that, forming the posterior wall of the neural canal. Clearly much remodelling of bone has occurred, and it may be that the final state of the fusion mass depends more on its post-operative mechanical and environmental history than on the volume of bone added at the time of operation. 3) Fusion will be facilitated by achieving the largest possible area of contact between adjacent neural arches, and for this reason the posterior aspects of the transverse processes are included in the fusion area. Use of the transverse processes in this way excludes the insertion of a Harrington compression assembly.

Thus, a programme was evolved comprising: 1) pre-operotive correction by various methods; 2) a fusion technique aimed at maximum direct bony contact between adjacent levels, but without added bone unless to bridge congenital defects of the neural arches; 3) insertion of a Harrington distraction rod and hooks; 4) recumbency for the minimum period required for comfortable recovery from operation, followed by walking in a pelvi-occipito-mental plaster ("localiser"). This paper reports all patients so treated at the Royal Orthopaedic Hospital, Birmingham, from May 1966 when the regime was introduced, to June 1972.

METHOD

Pre-operative correction—At first, in mild curves pre-operative correction was not attempted because distraction at the time of rod insertion was believed to be sufficient. It was found, however, that considerable further

Fig. 1
A pelvi-occipito-mental plaster ("localiser") prevents any movement of the lumbar and thoracic spine.

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remains recumbent until operation. The plaster is bivalved before operation and the resulting anterior and posterior shells are used after operation. More severe curves, especially paralytic ones, can usually be corrected a great deal by two to three weeks corset-halter traction before operation. A localiser plaster is then applied and is bivalved before operation. A few very rigid or severe curves were subjected to halo-femoral skeletal traction, though since the period covered by this paper the halo-pelvic hoop apparatus has been preferred for these difficult problems.

Operation—With the patient lying on a “Toronto” frame (Relton and Hall 1967) a subperiosteal exposure is made of all neural arches in the fusion area. Beds are cut for the upper and lower hooks (Figs. 2 and 3) as described by Harrington (1962), and the fusion is then performed, as shown in Figures 4 and 5. First, the surfaces of the zygo-apophysial joints are excised as completely as possible without opening the spinal canal. The denuded surface of the caudal facet, with adjacent bone from the transverse process, is elevated and impacted into the joint space. In the lumbar region a sliver raised from the lateral part of the lamina of the caudal vertebra is also turned into the remains of the joint space; this is unnecessary at thoracic levels. The spinous process and remaining part of the lamina are split into four parts (right and left cephalic and caudal), and these are turned up and down to interweave with the corresponding slivers from adjacent vertebrae while still retaining an attachment to the parent neural arch. At completion of fusion the hooks and rod are inserted and the ratchet distracted, usually until the rod just begins to bend, though the safe limit of distraction in each case is a nice decision, based mainly on bone texture and rigidity of the curve. The

![Fig. 2](image)
The seating for the upper hook is at the junction of inferior articular facet, transverse process and pedicle; for the lower hook in the strongest part of the lamina, usually near its junction with the inferior articular facet.

![Fig. 3](image)

![Fig. 4](image)

**Fig. 4**
Technique of fusion at thoracic levels. The heavy broken line in each figure shows where the gouge will be applied to elevate the next bone sliver; dotted areas represent exposed cancellous bone on the underside of a turned-in sliver, or in the bed from which it was cut.

![Fig. 5](image)

**Fig. 5**
Fusion at lumbar levels. Broken lines and stippling as in Figure 4.
upper hook is finally locked into position by a wire twisted round the ratchet immediately caudal to the hook. This locking wire is essential: in a few early instances when it was omitted the upper hook subsequently slipped back several notches on the ratchet, and a significant degree of correction was lost. In severe deformities placement of the rod may have to be facilitated by bending it to fit a kyphosis or less commonly a lordosis, or, when it bridges the soft tissues on the concave side, by elevating the erector spinae from the transverse processes, or by resecting rib prominences so that it is well buried beneath muscle. It should never project into the subcutaneous tissues; in one early case in which this occurred extensive skin sloughing ensued.

**Post-operative management**—The patient is nursed in anterior and posterior plaster shells made from the bi-valved plaster, and remains completely recumbent until two weeks after operation, when a new localiser plaster is applied. She then begins walking, returning home and to school as soon as confidence is regained, usually about one week later. Only minor modifications to school routine are required, and all physical activities consistent with the bulk of the plaster are encouraged. Six months after operation the plaster is replaced by one that leaves the head and neck free. This is removed three months later. These periods of immobilisation are probably too long, and currently have been reduced to five months in a localiser plaster and two months in a body plaster.

**MATERIAL**

Nearly all scoliotic children in the greater Birmingham area are treated in one clinic, which thus receives a largely unselected sample of cases. Instrumentation and fusion are usually offered when a curve is cosmetically unacceptable or may be expected to become so, in a patient who is skeletally mature enough for fusion to be reliable, usually twelve years of age or more in girls, and thirteen or over in boys. On occasion, because of curve progression uncontrolled by bracing, fusion has been done earlier, down to ten years of age.

This report includes all patients submitted to the operation described at the Royal Orthopaedic Hospital, Birmingham, between May 1966 when the regime was introduced, and June 1972. It was 100 per cent complete at April 1973; many patients have been seen again after that date and there have been no significant changes from the findings presented here.

There were 103 cases, ten with double curves; thus the total number of curves treated was 113. The age at operation is shown in Figure 6, and the severity, level and aetiology of the curvature in Figure 7 and Table I. The period of follow-up from operation to the last radiographic measurement ranged from ten months to 5-3 years with an average of two years. It is appreciated that this is a relatively short-term review, but as all patients have completed their period of post-operative immobilisation it allows adequate assessment of its efficiency, which is one of the principal objects of this study: further, as growth had certainly ceased at the time of review in sixty-eight cases (seventy-five curves), and had probably done so in several more, it is likely that the final results will not differ much from those recorded here.

**RESULTS**

The corrections obtained and subsequent losses are summarised in Table II.

**Initial correction**—This is the difference between the last erect radiograph before pre-operative correction, and the first post-operative recumbent film, usually on the day after operation. Most of the correction was obtained

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**TABLE I**

<table>
<thead>
<tr>
<th>Aetiology and Levels of 113 Curves</th>
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</thead>
<tbody>
<tr>
<td>Idiopathic 88 (in 79 patients)</td>
</tr>
<tr>
<td>Congenital 15 (in 15 patients)</td>
</tr>
<tr>
<td>Neurogenic 10 (in 9 patients)</td>
</tr>
</tbody>
</table>

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**FIG. 6**

Histogram showing the age distribution of patients at the time of operation. Seventy-one were female, thirty-two male.

**FIG. 7**

Histogram showing the distribution of curve angles before correction, measured by the method of Cobb (1948).
before operation, only the last few degrees resulting from instrumentation.

**Loss of correction in post-operative plaster**—This is the difference between the first post-operative recumbent radiograph and the erect film taken after final removal of plaster. Measurement of standardised radiographs is probably accurate to 5 degrees, and thus a change of more than 10 degrees may be considered significant; this has occurred in thirteen curves. In two of these, with losses of 11 and 13 degrees respectively, no adequate explanation could be found, but in the remaining eleven there were recognisable technical errors: nine were early

**Loss of correction after removal of plaster**—This is the difference in degrees between the first erect radiograph after removal of plaster and the final follow-up radiograph. It was significant—more than 10 degrees—in only three curves, which were in the group already described as showing significant loss in the post-operative plaster through recognisable technical errors. If these three curves are removed, we find the average loss for the remainder in this period is 1.8 degrees only, and no curve showed significant loss of correction after removal of plaster unless it had already done so in the post-operative immobilisation period.

**TABLE II**

**RESULTS IN 113 CURVES**

<table>
<thead>
<tr>
<th>Degrees</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial correction</td>
<td>2</td>
<td>78</td>
<td>26</td>
</tr>
<tr>
<td>Loss in post-operative cast</td>
<td>0</td>
<td>30</td>
<td>5.3</td>
</tr>
<tr>
<td>Loss after removal of cast</td>
<td>0</td>
<td>21</td>
<td>2.3</td>
</tr>
<tr>
<td>Total loss</td>
<td>0</td>
<td>40</td>
<td>7.6</td>
</tr>
<tr>
<td>Final maintained correction</td>
<td>10</td>
<td>67</td>
<td>19.1</td>
</tr>
</tbody>
</table>

**TABLE III**

**DURATION OF HOSPITALISATION AND RECUMBENCY**

<table>
<thead>
<tr>
<th>Time in days</th>
<th>All patients (103)</th>
<th>Patients with scoliosis only (85)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimum</td>
<td>Maximum</td>
</tr>
<tr>
<td>Total in-patient stay</td>
<td>28</td>
<td>338</td>
</tr>
<tr>
<td>Post-operative in-patient stay</td>
<td>15</td>
<td>320</td>
</tr>
<tr>
<td>Post-operative recumbency</td>
<td>14</td>
<td>193</td>
</tr>
</tbody>
</table>

in the series when the upper hook was not locked and was displaced one or more notches on the ratchet; one had the rod removed three months after operation because of sepsis, and in one the upper hook rotated out of the pedicle and came to rest under the transverse process. If we take out these eleven cases with known and avoidable technical error we find the average loss of correction during post-operative immobilisation is 4 degrees. In most cases erect radiographs were taken in the first few days of post-operative ambulation and these usually showed a few degrees loss due to the hooks "bedding in". It thus appears that provided the upper hook is properly locked there will be a few degrees loss of correction on resumption of the upright position, but thereafter significant loss will not occur except in the rare cases of "instrument failure" through incorrect hook seating, or from sepsis.

**Total loss of correction**—This is the difference between the post-operative recumbent radiographs and the erect film at final follow-up. It represents of course the sum of the losses just described in the two previous paragraphs, twenty-two curves showing significant loss. This figure is greater than the combined figures given above because of summation of individual losses in the two periods. Most of them however are marginal and only the three cases already mentioned in the last paragraph have shown serious continuous loss of correction.

**Final maintained correction**—This is the difference between the pre-operative and the final erect radiographs.

No significant correlation could be found between total or percentage initial correction and pre-operative curve measurement or aetiology, nor between loss in plaster and total initial correction, percentage initial correction, or operative correction, but there were strong
suggestions that congenital curves are more difficult to correct than others and that the frequency of significant loss increases with the amount of initial correction.

**Length of stay in hospital**—A great advantage of this regime is the short period in hospital. The times shown in Table III are at first sight disappointing, but often the scoliosis did not account for the entire stay in hospital, which was prolonged in eight cases by operation for other conditions, in two by coincidental illness, in two by unsatisfactory home conditions, and in five by complications of the operation. If we consider the remaining eighty-five cases in which the whole period of hospitalisation was for uncomplicated treatment of scoliosis the figures are more encouraging.

**Complications**—There were no deaths attributable to operation, but three patients died later from other causes. Two of them committed suicide—one after an unhappy love affair, the other while taking narcotic drugs; it is not known whether residual deformity, which was moderate in both, was in any way responsible. The third, a girl of fifteen, died five months after operation from acute peritonitis. Necropsy failed to reveal the primary site of infection; the spinal fusion was soundly united at all levels and free from infection.

During the period covered by this study the author operated on four patients with paralytic curves and severe respiratory impairment in the cardio-respiratory unit at the Birmingham Children's Hospital, because of anticipated respiratory difficulty after operation. They are not included in this report because pre-operative and post-operative management, especially in relation to plaster and ambulation, varied considerably from the standard, though in three cases the final results did not vary from those described here. It must however be recorded that the fourth child died during operation from unexplained cardiac arrest; towards the end of an uneventful fusion the heart action weakened suddenly and then stopped.

Attempts to restart it failed, and neither surgeon, anaesthetist, nor pathologist could find any satisfactory explanation.

Seventy-eight patients were completely free of any kind of complication, and a further fourteen had only minor non-specific problems not in any way affecting the outcome or requiring any change in management. Thirteen major complications developed in the remaining eleven patients, and are summarised in Table IV. The three cases of hook displacement occurred in severe curves where great correction had been obtained. In all three the curve was re-explored, the fusion masses were divided, and the instruments were replaced. Excellent correction was obtained. The findings at re-exploration were of considerable interest; in one case there was a solid fusion mass without defect; in another a linear fibrous defect extended only two-thirds of the way across the mass, and in one there was a complete transverse defect with demonstrable mobility. Thus major loss of correction was not necessarily associated with a complete fibrous defect at the time of re-exploration, and for this reason the term "pseudarthrosis" has been avoided.

**DISCUSSION**

Comparison with other published results is of limited value because so many variables are involved, but there is no doubt that the initial and final maintained corrections recorded here are not as good as those of Moe and Valuska (1966) and of Goldstein (1969). These two reports however were of idiopathic cases only; the results with congenital curves reported by Winter, Moe and Eilers (1968) were not so good. In the present series results improved considerably in later cases because of greater attention to pre-operative correction, more vigorous operative correction as confidence in the instrumentation increased, and secure hook locking. It is probable

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**TABLE IV**

**Thirteen Major Complications in Eleven Patients**

<table>
<thead>
<tr>
<th>Complication</th>
<th>Number of cases</th>
<th>Comment</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infection</td>
<td>5</td>
<td>All before institution of regular suction drainage</td>
<td>Four resolved. One had early removal of instruments with complete relapse</td>
</tr>
<tr>
<td>Skin slough</td>
<td>1</td>
<td>Rod too superficial across the concavity</td>
<td>Early removal of instruments with complete relapse</td>
</tr>
<tr>
<td>Adventitious bursa</td>
<td>2</td>
<td>Upper end of rod projecting too far beyond the hook</td>
<td>Late removal of rod; no effect on result</td>
</tr>
<tr>
<td>Deep vein thrombosis</td>
<td>1</td>
<td>Girl aged 15</td>
<td>Minimal persistent oedema</td>
</tr>
<tr>
<td>Pneumothorax</td>
<td>1</td>
<td>Small, asymptomatic</td>
<td>Spontaneous resolution</td>
</tr>
<tr>
<td>Lower hook cutting out</td>
<td>1</td>
<td></td>
<td>Severe relapse. Osteotomy of fusion mass and reinsertion of the rods gave good results</td>
</tr>
<tr>
<td>Upper hook slipping</td>
<td>2</td>
<td>Omission of locking wire allowed slip along ratchet</td>
<td></td>
</tr>
</tbody>
</table>

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that the correction obtained and maintained in curves treated at the end of the period covered by this report are not significantly inferior to those of other regimes (Fig. 8).

![Fig. 8](image_url)

**Fig. 8**

Result in a 15-year-old girl.

Comparisons of incidences of pseudarthrosis are singularly misleading because of varying definitions: only one complete fibrous defect has been seen, but if we accept "significant continuous loss of correction" as equivalent to the "pseudarthrosis" of many reports, then the present incidence of 3.5 per cent is comparatively very low.

Few authors have accurately stated the duration of recumbency after operation: it is believed that the periods recorded here ("routine" sixteen days, overall average twenty-one days) are shorter than in any other report, but undoubtedly there is a general trend towards earlier walking. It is thus important to establish, by comparison with regimes involving several months of recumbency after operation, whether earlier resumption of the upright position increases the post-operative loss of correction. The total average loss of 7-6 degrees between operation and final follow-up in the present series is not so good as the corresponding 3-2 degrees recorded by Goldstein (1969), but the average loss of 5-3 degrees in the post-operative plaster compares favourably with the corresponding 12 degrees of Moe and Valuska (1966). It thus appears that prolonged recumbency offers little if any advantage in this respect: its social disadvantages are obvious, and a long period in hospital and away from school, often at a critical stage of education, have in the past weighed against surgical treatment of scoliosis. With these problems reduced, operation can be offered, and is usually accepted, before the curve becomes too severe for a good result to be obtained. There is moreover a strong suggestion that early walking gives a purely technical advantage by avoiding osteoporosis, thus giving a stronger fusion mass when the post-operative plaster is removed. This is supported by the very low incidence of major relapse, and the excellent state of the mass on the few occasions when the opportunity has arisen to inspect it.

It is a pleasure to acknowledge the kindness of many colleagues who have referred patients, and to thank Mr. Norman Gill and Mr. Douglas Northam for the illustrations.

REFERENCES


