Orthopaedics & Traumatology: Surgery & Research 100 (2014) 37–41

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Special Vol. 100

A new technic for segmental spinal osteosynthesis using the posterior approach☆

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ARTICLE INFO

Keywords:
Spine
Scoliosis
Posterior approach
Instrumentation
Cotrel-Dubousset

ABSTRACT

The authors have designed a new method of instrumentation aimed at obtaining surgical fixation of the scoliotic curve without any postoperative external immobilisation. It is particularly strong and rigid and allows adequate reduction of the curve. This technique avoids the sublaminar space and thus prevents excessive blood loss and diminishes the danger of cord damage. The instrumentation is made of two parallel rough cylindrical rods inserted independently in the convexity and concavity of the curve. If necessary, they can be bent pre-operatively. They are attached to hooks placed on the laminae or pedicles, which are locked by bolts, thus allowing progressive straightening of the curve. They are joined by two transverse bars, one above and one below, to provide better rigidity to the device and to allow correction of rotation. The parts of the vertebrae left free by the device are denuded to allow the addition of grafts. Laboratory tests have demonstrated that this type of fixator is more rigid than the Harrington or Luque rods. Fifteen patients, either idiopathic or paralytic cases, were operated on without any neurological impairment. No loss of correction was observed since the hooks have been locked.

1. Introduction

Increased stability of extensive spinal instrumentations, particularly those designed for scoliosis and kyphosis, has been obtained by improving the fixation points of the Harrington instrumentation system [1] (rods and square-ended hooks, addition of a transverse traction device connecting the concave and convex rods). Further improvement was achieved by segmental sub-laminar fixation of each vertebra to the rods using the system designed by Luque [2].

However, this last technique carries an increased risk of bleeding and neurological compromise. We therefore developed a new technique for posterior segmental instrumentation that considerably decreases the risk of bleeding and neurological compromise, as none of the fixation components is entirely located within the sub-laminar space. We have used this new technique in 15 patients.

Although follow-up is short (6 months), the good quality of the immediate results in terms of deformity reduction and maintenance of reduction stability (without casting or bracing), functional outcomes (immediate resumption of walking and of other physical activities such as swimming), patient comfort, and return to normal everyday activities within 10 to 15 days postoperatively warrants the present publication.

2. Principles

The goals are to achieve the best possible correction and, above all, the stiffest possible fixation of a spinal segment of variable length (depending on the length of the deformity), while allowing arthrodesis if needed. These goals are achieved by distributing the vertebral purchase points so that each vertebra included in the segment of interest is instrumented and therefore secured on at least one side, with the other side left free for arthrodesis. The vertebrae are connected by two parallel rods that can be contoured to replicate the physiological antero-posterior curvatures. These two parallel rods are connected to each other by several transverse systems, giving the overall assembly a rigid frame configuration.

3. Material

a – Two types of *hooks attached to the spine* are used.

– *Classical closed hooks*: the rod is top-loaded through the barrel then secured by directly tightening a hexagon-head bolt onto the rod.

These hooks are used at one end of the assembly, for both distraction and compression, and can be placed either under the lamina or under the transverse process. The tip of the hook is blunt

☆ Technical note. For citation, use not the present reference but that of the original publication: Cotrel Y, Dubousset J. [A new technic for segmental spinal osteosynthesis using the posterior approach]. Rev Chir Orthop Reparatrice Appar Mot 1984;70(6):489–94.

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1877-0568/$ – see front matter © 2013 Published by Elsevier Masson SAS.
http://dx.doi.org/10.1016/j.otsr.2013.12.009

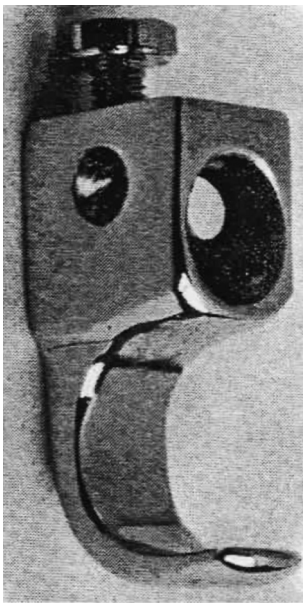

Fig. 1. Closed hook placed under the lamina or transverse process.

to prevent injury to the epidural space or intertransverse space (Fig. 1).

– *Open hooks* allow passage of the rod (Fig. 2). The contour of the opening is conical at the upper half and cylindrical at the lower half. The rod is secured to the hook using a cylindrical-conical set screw that fits into the opening in the hook; an upper projection of the set screw has a square cross-section that locks the rod onto the hook in the desired position by means of a hexagon-head bolt. The square cross-section prevents rotational movements.

Open hooks have two different tip configurations:

- *the pedicular hook* (Fig. 2) has a bevelled upper edge with a midline anterior notch; this notch ensures firm support on the lower edge of the pedicle by directly embracing the pedicle, thus conferring resistance not only to compression and distraction forces, but also to transverse and rotational forces;

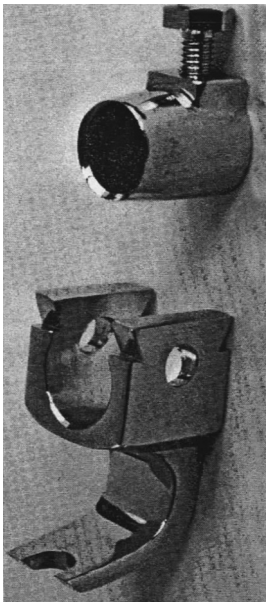

Fig. 2. Open hook for placement in a pedicle, with the cylindrical-conical set screw. Note the square cross-section of the upper projection of the set screw.

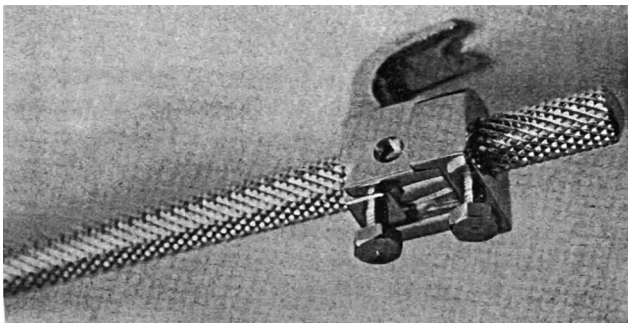

Fig. 3. Hook secured onto the knurled rod by the hexagon-head bolt, and safety locking system for the uppermost concave hook.

- *the laminar hook* has a blunt, rounded, upper edge to avoid injuring the peri-dural space. Two types are available: for the lumbar spine, the anterior aspect of the hook body is straight (Fig. 1); whereas for the thoracic spine, the anterior aspect is oblique superiorly and anteriorly to ensure that the hook moves backward as it is driven under the lamina.

The uppermost hook of the distraction assembly is always a pedicular hook. Strong fixation of this hook is crucial to preclude loosening, particularly when the non-instrumented spinal segment above the assembly is placed in kyphosis. This hook is therefore secured using a *safety locking system* that fits exactly over its upper aspect and is held in place by a hexagon-head bolt (Fig. 3).

b – *The rods have been considerably simplified* and now exist as a single type.

They measure 7 mm in diameter and are entirely covered by 1-mm diamond-shaped knurls (Fig. 4) that allow hook fixation using a hexagon-head bolt at any level of the rod (*knurled rod*, Figs. 4 and 5).

The rod can be contoured according to the desired antero-posterior spinal curvatures, either before or during implantation. Rod contouring allows passage of the set screw up to a radius of 6 cm (Fig. 6). If needed, the rod can be cut after implantation, using a standard rod-cutting tool.

Several rod lengths are available. The rods no longer have a top and a bottom or a front and a back, which simplifies ordering, stock management, storing, classification and, above all, use, as any rod can serve for distraction, compression, or rotation, by virtue of the firm fixation of the hooks bolted onto the rod in the desired position (Fig. 6).

c – *Device for transverse traction*

The two parallel rods are connected to each other at the top and bottom of the assembly by two transverse traction systems. The throats of the hooks on the transverse systems are shaped to fit exactly onto the diamond pattern of the knurled rods (Fig. 7). This feature allows direct de-rotation on the rod if needed.

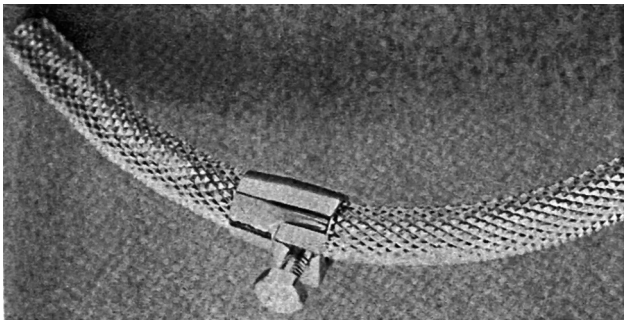

Fig. 4. The rod can be bent, even to a considerable extent, without hindering the passage of the blocked cursor.

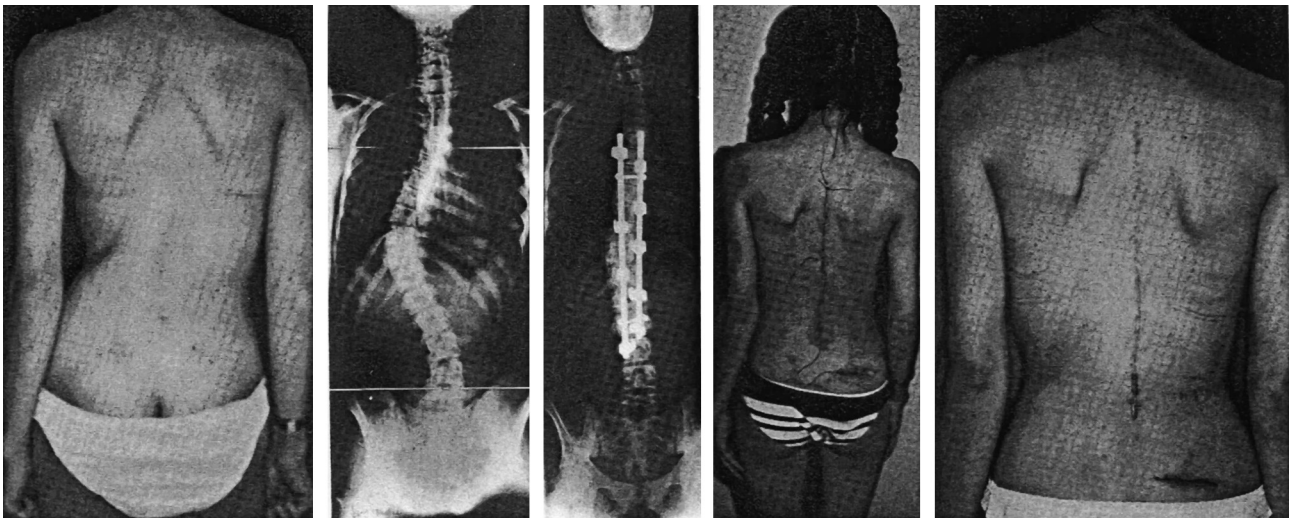

Fig. 5. Child D.N. A and B. 50° right-sided idiopathic scoliosis in the thoracic spine. C. 18° correction and arthrodesis maintained after 6 months with no bracing. D. Appearance in the standing position on the fifth postoperative day. E. Final appearance.

Biomechanical studies have established that the rigidity of the quadrilateral frame-like configuration is increased by applying a distraction force to transverse bars positioned between the two vertical rods, at the top and bottom of the assembly. The same system is used, with the hook throats facing in opposite directions.

The strength of materials studies were conducted at the Laboratoire National d'Essai and the biomechanical studies at the Laboratoire de Biomécanique de Montpellier headed by Prof. F. Bonnel, to whom we extend our deepest gratitude for his help.

4. Technique

Example: common form of scoliosis.

The patient is placed on a special table designed for spinal surgery. The traction on the head should not exceed 15 to 20 kg. If needed, pressure can be put on the side of the chest and the neck can be flexed. The periosteum is then carefully and completely removed from the neural arches, to the tips of the transverse processes.

a – *The first step is implantation of the hooks*.

- *distraction is applied to the concave side*: support at the caudal end is on the vertebra, and the lower boundary is a closed hook straddling the supra-jacent lamina and facing caudally:
  - the immediately supra-jacent vertebra is left free to allow arthrodesis,
  - the second supra-jacent vertebra is instrumented, using either an open pedicular hook facing cranially at the thoracic segment or an open laminar hook facing caudally at the lumbar spine; T12 is treated as a lumbar vertebra, given the shape of its articular processes,
  - the third supra-jacent vertebra is left free for arthrodesis. This sequence is continued up to the vertebra at the top of the assembly, in which a pedicular hook is implanted as usual, through a small opening cut in the inferior articular process, so that it faces cranially;
- *compression is applied to the convex side*: the caudad-most support point on the lowest vertebra in the construct is a closed hook that faces cranially and is placed on the lower edge of the lamina. The immediately supra-jacent vertebra is left free for arthrodesis, and the sequence is continued up to the topmost vertebra in the assembly. Support on this last vertebra is via an open laminar hook that faces caudally and is placed on the upper edge of the transverse process, in the costo-transverse arch. The resulting staggered arrangement of the hooks allows continuous arthrodesis.

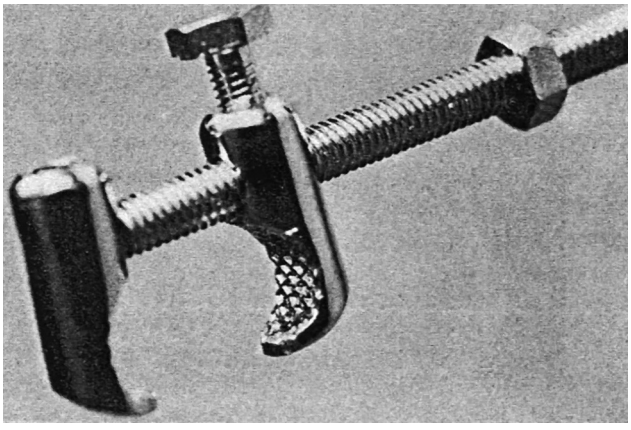

Fig. 6. Device for transverse traction (DDT) fashioned so that it fits perfectly onto the diamond pattern of the rod, thus reliably blocking the assembly.

b – *Then, the two rods are selected*. The rod on the convex side must be long enough to allow compression. The rods are first *bent to match the desired spinal contour*, which should resemble the normal spinal curvature as closely as possible.

The rods can be contoured before starting the surgical procedure, based on the radiographs obtained with the scoliosis corrected; or during surgery, using a phantom rod made of highly flexible steel that is easy to shape. Decortication of the non-instrumented articular processes is then performed as usual, and intra-articular grafts are implanted.

c – *Implantation of the rods*

First, the concave rod is implanted between the top and bottom hooks to distract and further reduce the curvature in the longitudinal direction (the intervening hooks are removed temporarily for this step).

The convex rod is then implanted, using the rod pusher if needed and alternating pressure and a lever manoeuvre. Implantation of the concave rod begins to de-rotate the vertebrae by exerting direct pressure on the convex side. In addition, this rod ensures partial

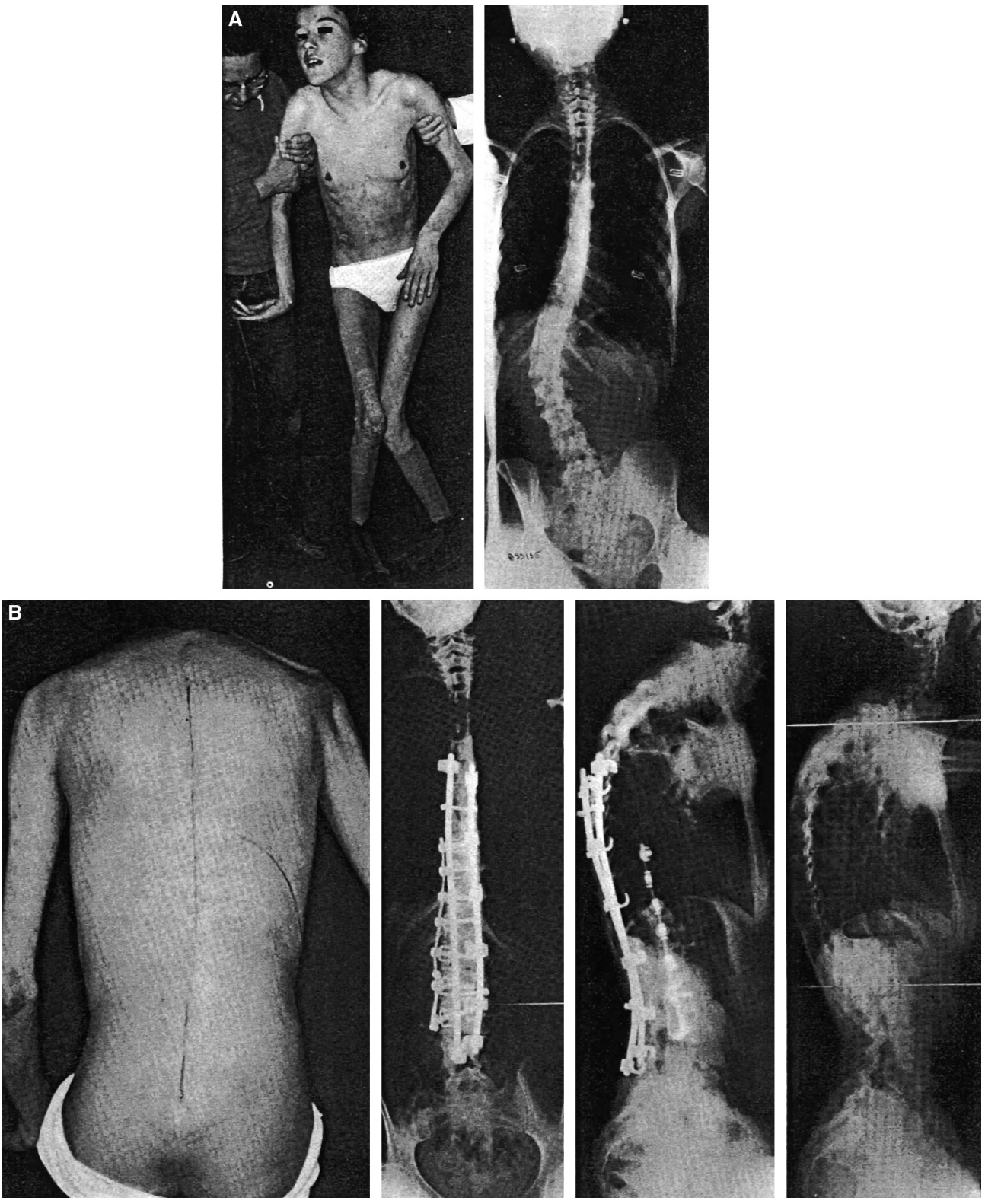

Fig. 7. Child CL.F. A. Paralytic scoliosis complicating cerebral palsy with moderate pelvic obliquity. B. Anterior and posterior correction and arthrodesis. No bracing. Note the maintenance of the good correction of the pelvic obliquity.

transverse correction by pushing the topmost vertebra toward the concave side. This convex rod is therefore fixed provisionally.

The concave rod is removed and the intermediate hooks returned to their positions. These intermediate hooks are usually well aligned at this stage. The concave rod is re-implanted and all the locks are tightened provisionally.

d – The fourth step is the *application of force to the rods using distraction on the concave side and compression on the convex side*,

alternately, returning to each hook several times, to ensure that correction is both as gradual and as complete as possible.

Decortication and arthrodesis of the non-instrumented spinal levels (spinous processes and laminae) is then performed, taking care not to weaken the bone.

e – *The last step is the application of force to the two transverse traction devices, at the top and bottom of the assembly, respectively*, which connect the two sides. *If needed, distraction can be applied to an additional transverse system in the middle of the assembly*, in order to increase rigidity. Spinal cord function is then assessed by intraoperative arousal, and antero-posterior and lateral radiographs are obtained. Wound closure is performed.

The seated position without support and ambulation are resumed as soon as allowed by the child's general condition, usually as early as postoperative day 2 or 3. No casting or bracing is used.

The child is discharged on day 10, after removal of the sutures. Swimming is allowed as soon as the wound is healed.

5. Preliminary results

Between January and September, we used the above-described material in 15 patients.

• *Causes*: Of the 15 patients, 6 had idiopathic scoliosis and 9 paralytic scoliosis related to Friedreich's ataxia ($n = 3$), poliomyelitis ($n = 2$), Werdnig-Hoffmann disease ($n = 1$), athetoid cerebral palsy ($n = 1$), Duchenne muscular dystrophy ($n = 1$), or Marfan syndrome $n = 1$).

• *Age* at surgery ranged from 11 to 21 years.

• *The location of the deformity varied widely*: thoracic, thoracolumbar, lumbar, double major.

• *The angle of the curvature* ranged from 40° to 80°.

It should be pointed out that, in 1 patient, the posterior instrumentation procedure was performed 10 days after correction by anterior arthrodesis with Dwyer instrumentation. Another patient with severe pelvic obliquity had a support point on the sacrum and arthrodesis down to the sacral level.

• *Mean operative time* was 1 hour longer than the time usually needed for simple Harrington instrumentation. As a result, the amount of blood lost was increased by about 0.5 L.

None of the patients wore a cast or brace after the procedure, even among those with impaired trunk control. The patients with paralytic scoliosis were able to resume walking or sitting between days 4 and 10.

• *Complications*

No immediate complications were recorded. In particular, there was no neurological compromise.

In the first 5 patients, the upper safety locking system was not used. After 1 month, more or less complete loosening of the rod and upper hook was noted with loss of correction and pain, which required re-operation in only 2 patients. No adverse mechanical events were noted after the addition of the safety locking system.

• *The angle correction* was consistently equal to or about 10° greater than the passive correction angle recorded during the bending test.

• *Postoperative loss of angle correction*

– *In the patients with paralytic scoliosis*, from 0° to < 5° in 5 patients, from 3° to 8° in 3 cases, and > 10° in 1 case after the maximal follow-up of 6 months. The marked loss of correction occurred in the patient with loosening of the hook.

– *In the patients with idiopathic scoliosis*, 0° to < 5° in 4 patients and > 10° in the remaining 2 patients (11° and 16°, respectively).

Importantly, in all the patients who experienced loss of angle correction, a marked difference was noted between the supine radiograph taken at departure from the operating room and the standing or seated radiograph taken on day 8, prior to hospital discharge. This fact suggests inadequate tension of the assembly. With accumulating experience, this problem was resolved, and the most recently treated patients had little or no angle loss. Furthermore, when the assembly was well adjusted with no loss of angle correction between the supine radiograph and the subsequent erect radiograph, no loss of angle correction occurred (at least during the first 6 months, which was the duration of follow-up).

Some measure of de-rotation was noted, as shown by the greater than 50% decrease in hump prominence.

Longer follow-ups are needed, in particular to determine the risk of non-union. Every effort is made to prevent non-union by carefully decorticating the articular processes and the bone structures that are not directly in contact with the material.

All the children and their parents were extremely pleased with the procedure and appreciated the fact that they no longer needed to wear a brace or cast. On average, they returned to their preoperative level of activities (e.g., school and swimming) 1 month after surgery.

Since writing this article, we have treated about 80 patients, who will be the focus of a subsequent paper.

Disclosure of interest

Authors' disclosure of conflict of interest was not requested when the article was originally published.

References

[1] Harrington PR. Correction and internal fixation by spine instrumentation. J Bone Joint Surg (Am Vol) 1962;44:591.
[2] Luque ER. The anatomic basis and development of segmental spinal instrumentation. Spine 1982;7:256–9.