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OPTIMAL THREE-DIMENSIONAL CORRECTION OF IDIOPATHIC SCOLIOSIS

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We have reviewed the standing position antero-posterior and lateral radiographs of 64 children operated on for juvenile or adolescent idiopathic scoliosis. Twenty five patients had Cotrel-Dubousset posterior instrumentation, twenty one were corrected with Pouliquen anterior plate and twenty one with Harrington distraction rod. The transversal plane of the spine was visualised by computer reconstruction using sonic digitizer GP-9 and the programme Rachis. The following parameters were compared : Cobb angle, Perdriolle angle of vertebral rotation, apical vertebra transposition. Transversal plane reconstruction images were also compared. The results showed better 3-D correction in Cotrel-Dubousset technique over the Harrington technique. This concerned Cobb angle and apical vertebra transposition but not the vertebral rotation. The anterior instrumentation gave the best correction in each of the three planes. In particular, the vertebral rotation was significantly diminished with anterior technique. The results were also confirmed by computer reconstruction of the transversal plane of the spine. The authors conclude that vertebral derotation can hardly be achieved with posterior spinal techniques, regardless of the type of instrumentation applied. Following the biomechanical analysis of the spatial displacement of each vertebra of the scoliotic curve after operation, a complex movement of the corrected spine can be evaluated.

1. Introduction

Idiopathic scoliosis concerns 2.0% – 4.0% of the population of children and adolescents [9]. The etiology remains unknown in spite of the efforts of scientists and physicians. The non-operative treatment may be effective in scoliosis with Cobb angle [1] value below 40 degrees. In major spinal curvatures the operative treatment is necessary. Every year up to one thousand children with scoliosis are operated on in Poland.

The operation consists of the implantation of spinal implants (plates, screws, rods, hooks etc.) allowing the correcting manoeuvres on the spine. Afterwards the operation is completed with spinal fusion of the exposed area. The purpose of the hardware is to achieve an optimal correction of scoliosis. It means that all components of the three-dimensional deformity are to be corrected: lateral curvatures, saggittal curvatures and vertebral rotation [2].

Spinal systems designated to perform the surgical correction of scoliotic deformity can be evaluated in relation to: 1) the point of fixation on the vertebra that signifies the point of applying the corrective force – it can be anterior (vertebral body) or posterior (vertebral laminae and processes), 2) the number of implants that determines the value of the corrective force, and 3) the direction of the corrective force that can be parallel or perpendicular to the long axis of the spine [7].

The optimal correction of scoliosis is the maximal, safe and durable correction. The operative correction cannot be complete because the long term adaptation of the bony structures of the spine and rib cage (according to the so-called Wolff's law [8]) cause the irreversible deformation of the shape of vertebrae. The central nervous system and the peripheral nerves must be protected from any rapid modification of the shape and the dimension of the spinal canal which can take place during the operation of scoliosis.

2. Material

We have evaluated radiographs of 64 patients. 25 patients underwent COTREL-DUBOUSSET posterior instrumentation (CD) [2], 21 patients had the anterior plate of POULIQUEN [6] and 21 patients were treated with HARRINGTON distraction rod [3].

The curves with similar localisation, magnitude and reductibility were selected.

3. Methods

Standing radiographs including the spine and pelvis were analysed. The radiographs were digitised with a sonic digitizer and PC computer. The data were analysed using the programme RACHIS [4]. In this paper the analysis of the following parameters is presented: COBB angle [1], apical vertebra transposition (AVT) and apical vertebra rotation (AVR). The vertebral rotation was estimated using the PERDRIOLLE method [5].

4. Results

The initial Cobb angle varied from 45 to 65 degrees. Before the operation, the three groups of patients were similar in all measured radiological parameters.

The mean correction of the Cobb angle was 69.7% for Cotrel-Dubousset instrumentation, 82.8% for anterior instrumentation, and 36.0% for Harrington instrumentation (Table 1).

Table 1. Cobb angle before and after operation (in degrees).

method	N	before operation	after operation
Cotrel-Dubousset	25	53.6 ± 7.03	16.2 ± 6.5
Pouliquen	21	49.5 ± 6.71	8.5 ± 4.2
Harrington	21	60.4 ± 6.98	38.3 ± 9.0

The mean correction of apical vertebra transposition was 90.5% for Cotrel-Dubousset method, 101% for anterior plate and 52.6% for Harrington rod (Table 2).

Table 2. Apical vertebra transposition before and after operation (in mm).

method	N	before operation	after operation
Cotrel-Dubousset	25	50.4 ± 16.5	4.6 ± 12.6
Pouliquen	21	42.2 ± 15.4	-0.5 ± 7.0
Harrington	21	64.0 ± 13.4	30.3 ± 12.1

The mean correction of apical vertebra rotation was 8.7% for Cotrel-Dubousset instrumentation, 70.5% for anterior method and 8.8% for Harrington rod (Table 3).

Table 3. Apical vertebra rotation before and after operation (in degrees).

method	N	before operation	after operation
Cotrel-Dubousset	25	21.4 ± 6.3	19.6 ± 5.8
Pouliquen	21	18.0 ± 5.5	5.3 ± 4.4
Harrington	21	27.3 ± 3.8	25.1 ± 4.0

5. Discussion

The Cotrel-Dubousset instrumentation is a multilevel (segmental) posterior instrumentation in which the direction of the correcting force is transversal to the spine. Pouliquen instrumentation is a multilevel, segmental, anterior instrumentation acting with transversal forces. Harrington instrumentation is a two-point fixation posterior system that applies longitudinal force (distraction).

The operative correction of the Cobb angle was similar with the CD and the anterior technique. Both methods gave results markedly superior to the Harrington procedure. The same observation is valid for the apical vertebra transposition.

The significant vertebral derotation was found only after anterior instrumentation. In this technique the derotation was achieved by pushing the lateral convex part of vertebral bodies with the plate. Contrary, the rotation of the CD rod did not result in vertebral derotation. The effectiveness of the CD instrumentation in the correction of vertebral rotation hardly exceeded that of the

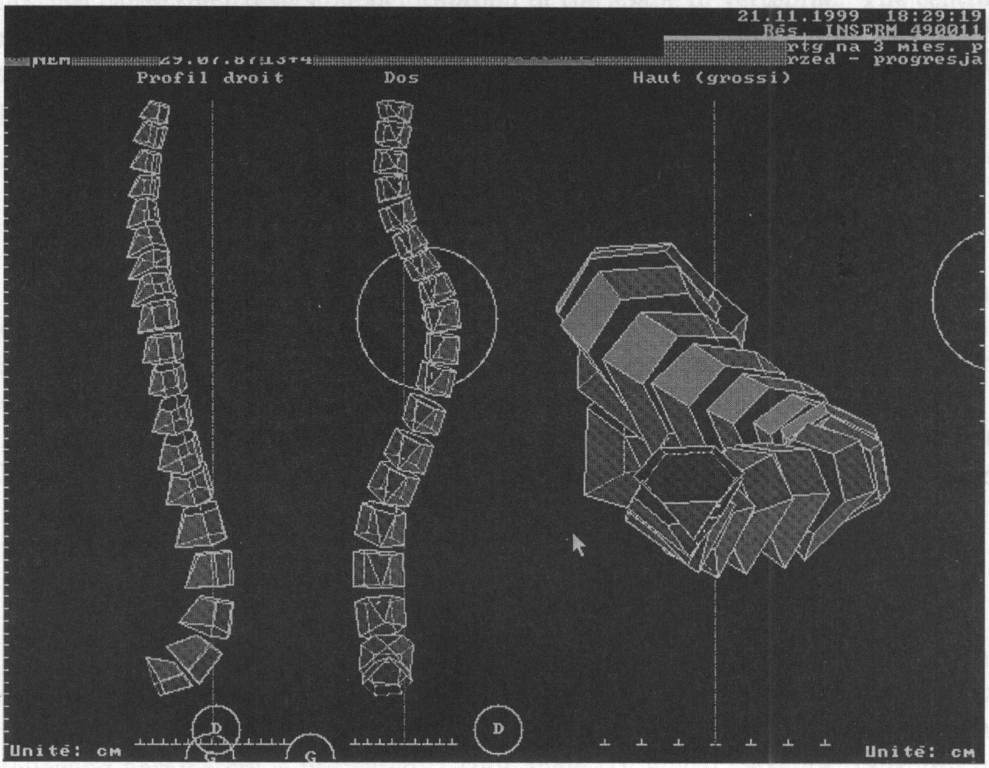

FIG. 1a. Single right thoracic scoliosis before operation. Lateral view, posterior view and top view. The corresponding surfaces of the vertebrae are marked by the same colour.

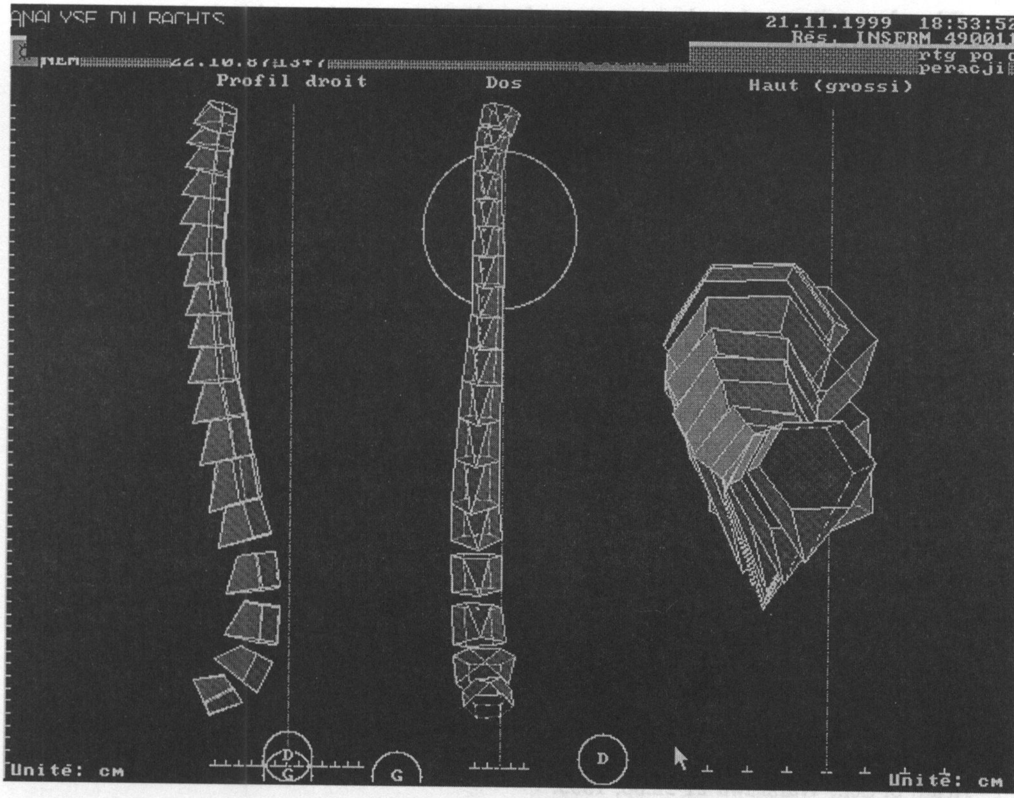

FIG. 1b. The same scoliosis after operative treatment. The top view shows vertebral derotation in the apical zone of scoliosis, achieved by anterior technique.

Harrington rod. Thus the translation of the apex of the curve to the midline seems to be the major effect of CD technique. The Harrington rod had a small effect on this translation and on the correction of the AVT. The true vertebral derotation after anterior instrumentation was best demonstrated on the transverse reconstruction of the spine made with programme RACHIS (Fig. 1).

6. CONCLUSIONS

Segmental spinal instrumentation provided better correction of scoliosis than two-point instrumentation.

Transversal forces were more effective in correction of scoliosis than the longitudinal forces.

Fixation on the anterior elements of vertebra provided better correction than fixation on posterior elements.

The three-dimensional correction of scoliosis was achieved only by the anterior method.

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