Idiopathic scoliosis instrumentation using the Lea Plaza sublaminar frame

A preliminary report

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Summary. We reviewed 28 patients with idiopathic scoliosis operated on using the segmental sublaminar instrumentation devised by Lea Plaza. The results at 2 years show that the spine is rebalanced and normal alignment in the sagittal plane is obtained. The biplanar correction of double curves averaged 64% with a loss of 10% at 2 years. The upper and lower limits of the fusion area must be determined accurately in relation to the pattern of the curve. Combined anterior and posterior arthrodesis is advised in flexible or rigid curves of more than 60° in skeletally immature or mature patients respectively. In double curves overcorrection of the primary curve behind its flexibility index, and inclusion of the mobile transitional segments in the fusion area produce decompensation in the frontal plane. One case of total loosening of the frame occurred, but there was no protrusion of the frame, no fractures of the laminae, no sepsis, no pseudarthrosis and no permanent neural damage.

Résumé. Le but de la chirurgie de la scoliose idiopathique est l'obtention d'une colonne vertébrale rééquilibrée dans les 3 plans. Nous avons revu rétrospectivement 28 patients opérés de scoliose idiopathique, par l'instrumentation sous-laminaire de Lea Plaza qui est actuellement largement utilisée dans toute l'Amérique latine. Les résultats à court terme (2 ans) démontrent sa capacité de corriger le rachis tridimensionnellement et, en particulier, de rétablir l'équilibre du plan sa-

gittal. La correction biplanaire moyenne était de 64% avec une perte de 10% à 2 ans. La détermination de la zone de fusion dépend du type de courbe. L'arthrodèse combinée antérieure et postérieure associée à l'instrumentation postérieure est conseillée dans les courbes supérieures à 60 degrés qu'elles soient flexibles chez le patient immature (Risser <3), ou rigides chez l'adulte (Risser ≥3). L'hypercorrection de la courbe principale associée à l'extension de la zone de fusion aux segments mobiles de transition est responsable de la décompensation progressive dans le plan frontal, des courbes doubles majeures. Après l'opération nous n'avons eu à déplorer aucun déficit neurologique permanent, aucune saillie de l'instrumentation, aucune fracture des lames, aucune infection ni pseudarthrose. Un cas de démontage total de l'instrumentation est décrit.

Introduction

Harrington distraction rods were the first effective instrumentation developed for the treatment of idiopathic scoliosis, but had the disadvantage of producing flattening of the sagittal contour of the lumbar spine [13, 16]. Long term studies of these patients have revealed a high incidence of low back pain and a loss of sagittal balance, known as the flat back syndrome. There is controversy about the correlation of low back pain and the extent of fusion below the 3rd lumbar vertebra with the loss of normal lordosis [4, 13].

The need for correction of the scoliosis in three dimensions and the maintenance, or restoration, of sagittal balance is paramount [4, 7, 8, 14, 15].

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Table 1. Details of the 28 patients

Nr.	Age at surgery	Skeletal maturity (Risser)	Arthrodesis		Curve pattern	Measurement (degrees)	Pre op. with bending	Postop.	Follow-up (2 years)
			Anterior	Posterior					
1	18y 8m	V	No	T4-L3	Right thoracic T5-T11	FC	42°–30°	20°	25°
					Left lumbar T11-L3	CM	57°	–	43°
					Right thoracic T4-T11	FC	45°–16°	20°	24°
					Left lumbar T11-L4	CM	50°	–	34°
2	18y 1m	IV	No	T5-L3	Right thoracic T4-T11	FC	50°–28°	34°	34°
					Left lumbar T11-L4	CM	65°	–	39°
					Right thoracic T5-L1	FC	40°–6°	32°	25°
					Left lumbar T11-L4	CM	55°	–	45°
3	10y 11m	I	T5-T11	T4-L1	Right thoracic T5-L1	FC	75°–55°	12°	15°
					Left lumbar T11-L4	CM	89°	–	35°
4	14y 8m	IV	No	T6-L2	Right thoracic T7-L2	FC	41°–14°	14°	22°
					Left lumbar T11-L4	CM	49°	–	34°
5	16y 1m	IV	No	T3-L2	Right thoracic T4-T11	FC	44°–20°	9°	20°
					Left lumbar T11-L3	CM	44°	–	26°
					Right thoracic T6-T12	FC	33°–0°	12°	25°
					Left lumbar T11-L4	CM	40°	–	34°
6	12y 7m	0	No	T5-L3	Right thoracic T6-T12	FC	58°–23°	33°	34°
					Left lumbar T11-L4	CM	83°	–	44°
					Right thoracic T6-T11	FC	40°–15°	Not measured	20°
					Left lumbar T12-L4	CM	40°	–	24°
7	14y	III	T5-T11 L1-L3	T4-L3	Right thoracic T6-T11	FC	88°–56°	18°	20°
					Left lumbar T12-L4	CM	95°	20°	22°
					Right thoracic T8-L2	FC	70°–25°	13°	15°
					Left lumbar T12-L4	CM	77°	16°	18°
8	13y 4m	0	T8-T12	T6-L3	Left thoracolumbar T8-L2	FC	45°–25°	–	15°
					Right thoracic T5-L2	CM	55°	–	25°
9	17y 10m	V	No	T3-L3	Right thoracic T5-L2	FC	35°–13°	6°	8°
					Left thoracic T2-T5	CM	38°	–	23°
					Right thoracic T6-T11	FC	25°–13°	10°	14°
					Left lumbar T12-L4	CM	28°	–	45°
10	15y	III	No	T5-L3	Right thoracic T6-T11	FC	42°–20°	25°	36°
					Left lumbar T12-L4	CM	46°	–	46°
					Right thoracic T6-L1	FC	46°–10°	32°	38°
					Left lumbar T12-L4	CM	61°	–	41°
11	17y 2m	III	No	T5-L3	Right thoracic T6-L1	FC	36°–22°	25°	14°
					Left lumbar T12-L4	CM	46°	32°	18°
12	15y 9m	IV	No	T6-L4	Right thoracolumbar T8-L2	FC	50°–16°	8°	13°
					Left lumbar T12-L4	CM	55°	–	29°
13	12y 11m	IV	No	T3-L2	Right thoracic T5-L1	FC	40°–13°	7°	8°
					Left lumbar T12-L4	CM	40°	–	8°
					Right thoracic T5-L1	FC	25°–0°	2°	2°
					Left lumbar T12-L4	CM	45°	–	15°
14	14y 9m	III	No	T3-L2	Right thoracic T5-T11	FC	40°–18°	6°	10°
					Left lumbar T12-L3	CM	52°	–	13°
					Right thoracic T5-T11	FC	20°–3°	2°	2°
					Left lumbar T11-L4	CM	53°	–	7°
15	13y	IV	No	T4-L3	Right thoracic T5-T11	FC	45°–40°	20°	27°
					Left lumbar T11-L4	CM	45°	–	47°
					Right thoracic T6-T11	FC	46°–20°	18°	30°
					Left lumbar T12-L4	CM	63°	–	55°
16	14y 6m	0	T6-T11 T12-L3	T6-L4	Right thoracic T6-T11	FC	90°–70°	50°	56°
					Left lumbar T12-L4	CM	94°	–	56°
					Right thoracic T5-L1	FC	90°–50°	30°	30°
					Left lumbar T12-L4	CM	99°	–	57°
17	13y 5m	IV	No	T5-L2	Right thoracic T5-L1	FC	45°–25°	18°	19°
					Left lumbar T12-L4	CM	50°	–	21°
					Right thoracic T5-L1	FC	18°–3°	–	–
					Left lumbar T12-L4	CM	18°	–	–
18	14y 10m	IV	No	T10-L4	Left lumbar T12-L4	FC	40°–4°	17°	17°
					Right thoracic T5-L1	CM	57°	–	42°

Table 1. Continued

Nr.	Age at surgery	Skeletal maturity (Risser)	Arthrodesis		Curve pattern	Measurement (degrees)	Pre op. with bending	Postop.	Follow-up (2 years)
			Anterior	Posterior					
19	21y	V	No	T5-L3	Right lumbar	FC	34°–16°	26°	26°
					T11-L4	CM	39°	–	26°
					Left thoracic	FC	49°–30°	16°	16°
					T6-T11	CM	49°	–	30°
20	14y 10m	IV	No	T10-L4	Left lumbar	FC	45°–16°	10°	20°
					T12-L3	CM	50°	–	30°
21	19y	V	No	T5-L3	Right thoracic	FC	38°–17°	8°	10°
					T4-T11	CM	46°	–	10°
					Left lumbar	FC	42°–4°	4°	10°
					T12-L3	CM	47°	–	15°
22	13y 10m	IV	No	T5-L3	Right thoracic	FC	42°–12°	14°	16°
					T5-T11	CM	46°	–	24°
					Left lumbar	FC	35°–10°	12°	10°
					T12-L4	CM	38°	–	15°
23	17y 5m	V	No	T4-L2	Right thoracic	FC	40°–3°	10°	10°
					T5-T12	CM	40°	–	18°
24	16y 7m	IV	No	T3-L3	Right thoracic	FC	44°–23°	20°	26°
					T5-T11	CM	59°	–	36°
					Left lumbar	FC	26°–0°	7°	12°
					T11-L3	CM	31°	–	14°
25	17h	V	No	T4-L3	Right thoracic	FC	41°	12°	14°
					T5-T10	CM	51°	–	16°
					Left lumbar	FC	44°	12°	14°
					T11-L3	CM	49°	–	19°
26	22y	V	T5-T10	T4-L3	Right thoracic	FC	62°–52°	34°	38°
					T5-T10	CM	64°	–	43°
					Left lumbar	FC	62°–35°	22°	26°
					T11-L3	CM	69°	–	31°
27	16y 5m	II	T6-T12	T3-L3	Right thoracic	FC	86°–42°	13°	14°
					T6-T12	CM	96°	–	24°
					Left lumbar	FC	40°–80°	8°	8°
					L1-L4	CM	43°	–	23°
28	14y 6m	V	T6-T11	T4-L3	Right thoracic	FC	80°–48°	20°	22°
					T6-L1	CM	95°	–	27°
					Left lumbar	FC	35°–0°	5°	5°
					L1-L4	CM	45°	–	10°

This paper assesses the restitution of normal sagittal curves with arthrodesis and the use of the Lea Plaza frame in idiopathic scoliosis.

Materials and methods

The Lea Plaza frame is a rigid rectangular device bridged by connecting bars [7, 8]. It is bent in the sagittal plane to the desired amount of kyphosis or lordosis, and is fixed to the spine by segmental sublaminar wires. Pedicle screws can be used in the lumbar spine.

We carried out a retrospective review of the medical records and radiographs of 28 patients treated in the Hospital San Juan de Dios, Caracas, between April 1992 and April 1994. There were 27 females and one male with an average age at operation of 15 years 6 months (range 12 to 22 years).

The diagnosis was idiopathic scoliosis, adolescent in 26 and juvenile in 2. The curves were: right thoracic in 23 (18 King II, 4 King III and 1 King V); left thoracic 1; lumbar 2, and thoracolumbar 2. The Risser sign was: 0 in 3 patients: I in 1, II in 1; III in 4; IV in 11; V in 8 (Table 1).

The frontal Cobb angle (FC) and the composite measurement (CM) in the frontal plane were used to describe the scoliotic deformity and the results of treatment. Sagittal alignment was measured from T3 to T12 and from L1 to 5.

The CM was calculated by adding the FC to the deviation from normal in the sagittal plane: 30° was used as the normal thoracic kyphosis and 45° as the normal lumbar lordosis [16]. The formulae used for the calculations were

- (1) Thoracic with decreased kyphosis: $CM = FC + 30^\circ - \text{actual kyphosis}$
- (2) Thoracic with increased or normal kyphosis: $CM = FC + \text{actual kyphosis} - 30^\circ$.
- (3) Lumbar with decreased lordosis: $CM = FC + 45^\circ - \text{actual lordosis}$.
- (4) Lumbar with increased or normal lordosis: $CM = FC + \text{actual lordosis} - 45^\circ$.

Balance was assessed clinically by using a plumb line to measure the deviation of C7 from the median sacral line, and on the anteroposterior radiographs. Shoulder elevation was the distance between the highest point of each shoulder. Acceptable balance was defined as translation and shoulder elevation of less than 10 mm [15, 20].

The classification of right thoracic curves was according to King [6], but this was not applied to the fusion area.

In patients with normal trunk balance before operation, the criterion of the stable vertebra, that most closely bisected by the central sacral line, was used to determine the lower limit of the fusion. The sacral line was always based on a horizontal pelvis [6].

In patients whose trunk was not balanced over the pelvis, the criterion was that the neutral vertebra and the underlying disc must open equally on both lateral bending radiographs.

The upper limit for fusion and instrumentation was the first vertebra in which the upper end plate was parallel to the pelvis.

The fused area must be delineated by normal intervertebral discs and must include the abnormal sagittal curves shown on a standing lateral radiograph. In the type II King curve, the fusion was always extended to the lumbar region because of the high incidence of thoracolumbar kyphosis and progressive decompensation of the trunk after instrumentation limited to the thoracic curve [10, 15, 17, 32].

Results

The average number of levels fused averaged 10.4 (range 4 to 1). The average estimated blood loss was 450 ml and average operating time was 4 hours.

The mean preoperative thoracic deformity was 50° (range 25° to 90°) by FC and 59° (range 40° to 108°) by CM. The mean preoperative lumbar or thoracolumbar deformity was 42° (range 18° to 90°) by FC and 40° (range 18° to 99°) by CM.

The correction of thoracic curves after operation averaged 62% by FC measurement. The follow up showed 52% correction by FC and CM at 2 years. Correction of thoracolumbar and lumbar curves after operation was 66.6% by FC. Follow up showed correction by 52.3% by FC compared with 47% by CM at 2 years.

Anterior spinal arthrodesis at the apex of the curve was carried out in 7 patients before posterior operation to obtain better flexibility in rigid curves of >60° (cases 7, 16), and avoid the crankshaft effect in flexible curves >60° and Risser <3 (cases 3, 26) [2].

A Risser orthosis was required after operation in 13 patients who were either decompensated before operation, or who were very active and had large curves and a long fusion area. The thoracolumbar brace was used to improve coronal balance or to prevent the patient being too active.

No permanent neurological damage was found in any patient at the final follow up.

One frame became loose because of a technical error where the surgeon did not tighten the connecting bars (case 15). Fatigue failure of one sublaminar wire at the upper limit of instrumentation occurred in one patient where the fusion area was too short (case 10).

One patient developed progressive decompensation in the coronal plane after thoracolumbar fusion of a King type II curve (case 27) (Table 1).

Discussion

Treatment of scoliosis should maintain or restore the sagittal alignment of the spine, rebalance the trunk and stabilise progression of the curves.

The importance of sagittal correction has been stressed and composite measurement makes its evaluation possible since normality is restored when the FC and CM percentages of correction are equal [16]. Axial deformity should ideally be assessed by CT scan of the apex of the curves, but high cost prevents this from being used routinely [16].

Equal percentages of derotation of the spine have been reported after Cotrell-Dubousset instrumentation (CDI) and segmental sublaminar wiring [7, 8, 9, 17, 20]. On the other hand, Wood described axial plane decompensation in King type III curves after CDI [20]. This procedure does not consistently derotate the thoracic apex relative to the pelvis, especially in single thoracic curves, and only correction in the coronal plane may be apparent due to transmitted torque and rotation of the entire spine-pelvis axis [20]. Moens, using CT scanning to evaluate apical derotation after CDI, concluded that there was no significant increase or decrease [12].

Posterior spine fusion with any type of instrumentation fails to improve rotation when there is a rib hump which needs to be dealt with by costectomy [1, 9].

Restoration of normal lumbar lordosis is important to prevent low back pain [15], to rebalance the trunk and to avoid the flat back syndrome [4, 18]. Translation of a frontal plane deformity to normal sagittal alignment, rather than derotation of the apical vertebrae, is the main principle of surgical correction [8, 9].

In CDI, strategic vertebrae are selected and forces to produce kyphosis and lordosis are applied respectively to the thoracic and lumbar segment of the same rod [4, 9, 14, 18, 28]. With the Lea Plaza, frame each segment is derotated and pulled up to the median line. At the end of the operation, the spinous processes are mostly realigned in the middle of the frame [7, 8]. In both cases the rods are previously bent in the sagittal plane into the normal thoracic kyphosis and lumbar lordosis.

We use the standard posterior subperiosteal approach with excision of the facets. The arthrodesis is carried out by decortication of the la-

Fig. 1. 14-year old female with a rigid right thoracic curve pattern type King II

Fig. 2. The sagittal XR showed a hypokyphotic trunk

Fig. 3. An anterior arthrodesis from T₅ to T₁₁ allows 56% correction of the right thoracic curve

Figs. 4, 5. Final result after a combined anterior release (L₁ to L₃) and a posterior arthrodesis from T₄ to L₃. The spine is rebalanced and the sagittal alignment is restored since the percentage correction is equal in the FC and CM measurements: – right thoracic curve 18° (FC) and 20° (CM) with left lumbar curve 13° (FC) and 16° (CM)

minae and autologous iliac grafting. Each segment is instrumented. The wires must be kept taut against the undersurface of the laminae to prevent contusion of the cord or roots.

The fusion area is selected according to the curve pattern; the curves must not be overcorrected beyond their flexibility as determined by lateral bending radiographs. We used Thompson's parameters to evaluate the magnitude of correction on balance, and the flexibility/correction ratios were calculated for the major and minor curves [17]. Richards observed that postoperative correction of 10% more than that on lateral bending radiographs was responsible for large torsional forces across the uninstrumented spine resulting in progressive decompensation [10]. The inclusion of

mobile transitional segments in the fusion reduced the spontaneous correction of the instrumented curves.

We first instrument the concavity of each curve and, in double curves, the primary scoliosis before the secondary, in order to rebalance the trunk. The fusion is extended to L₃ in King type II scoliosis. A Risser brace is worn for 3 to 6 months after the fusion when the trunk is unbalanced before the operation.

Lea Plaza reported 70% correction of single curves and 66% in double curves with a loss of 1% at one year, the sagittal plane being preserved in all cases [7, 8]. In our cases the frontal correction averaged 64% with a loss of 10% at 2 years. The sagittal alignment is restored since the percentage

correction is equal in the FC and CM measurements [16]. Thoracic kyphosis is increased slightly since we found 52% of thoracic biplanar correction compared with 47% in the lumbar region. Lenke reported the same results with CDI [9].

The high incidence of skeletally immature patients (Risser <3, no menarche) with large curves in our series led us to select those who needed anterior fusion of the apex of the curve in order to avoid the crankshaft phenomenon [2]. The association of thoracic hyperkyphosis and a curve greater than 60° is a priority. In all other cases, posterior fusion and instrumentation are carried out first, and anterior fusion added when the deformity progresses greater than 5°. Other indications for anterior fusion in skeletally mature patients are curves greater than 60°, when there is less than 50% correction on lateral bending, an ugly hump and an unbalanced trunk. Anterior fusion provides better stability and avoids fusion below L3 (Figures 1 to 5); older patients are more likely to develop degenerative disc changes below this level [9, 13].

Double wires are used to improve rigidity of the frame at the apex of the thoracic and lumbar curves in active patients with a large curve and a long fusion. There is a choice between wires and pedicle screws in the lumbar spine.

Even when the wake-up test during operation shows normal function, a careful watch must be made to detect any neurological abnormality during the first week after operation. Sensory disturbance is the most common complication and is caused by continued epidural bleeding or oedema from a mild dural contusion [5, 19]. Lea Plaza reported hyperaesthesia in 3% of his patients; our incidence of 8% may be because all the operations were done by residents. Treatment with intravenous corticosteroids results in recovery in 8 days [8]. No permanent neurological damage occurred with this procedure since there is a minimal invasion of the spinal canal and there is no danger of the implant penetrating deeply into the canal as may occur with CDI [8, 14]. The risk of damage associated with pedicle screw fixation, reported at 27.4% [3], is also avoided.

We had no case of deep infection, no laminar fracture during instrumentation and no pseudarthrosis associated with metal breakage, except for a sublaminar wire in one patient where the fusion was too short.

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