SAGITTAL AND TRANSVERSE PLANE ANALYSIS OF IDIOPATHIC SCOLIOSIS PATIENTS WHOM CONTREL-DUBOUSSET INSTRUMENTATION IS USED

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Vertebral rotation in the axial plane is thought to be the primary deformity in the pathogenesis of idiopathic scoliosis. In this study 62 patients with idiopathic scoliosis treated by Cotrel-Dubousset Instrumentation at the 1st Orthopaedics and Traumatology Clinic of Ankara Social Security Hospital from December 1988 to June 1991 were evaluated. Preoperative and postoperative rotation degrees of the apical, intermediate and end-neutral vertebrae of the hpatients were measured by computed tomography. The maximum amount of correction at the apical vertebra was obtained in King Type III curves in which a derotation manoeuvre had been performed and RAsag, RAml and RAdev angles were corrected by 24.8 ± 16,9 %, 25.8 ± 18,4 % and 26,5 ± 20,8 % respectively. This group was followed by King Type IV and Type II curves. Derotational effect was minimal in the lumbar region in King Type I and Type II curves. The highest amount of derotation occurred in the apical vertebrae followed by the intermediate vertebrae and was almost zero at the end vertebrae. It was concluded that the derotational force affected mainly the scoliotic curve and was not carried segmentally to the distal or proximal parts of the vertebral clomn and did not cause decompensation.

Key words: *Idiopathic Scoliosis, Computed Tomography, Cotrel-Dubousset Instrumentation*

INDRODUCTION

Scoliosis is a spinal deformity characterized by lateral curve in frontal plane, deterioration in physiological sagittal contours and vertebral rotation. As a rule, vertebral bodies which are in the curve rotate to convex side of the curve. The apical vertebra is the most rotated one (Leatherman and Dickson, 1988 (13); Mot and Byrd, 1987 (17); Stagnara, 1988 (22); Tachdjian, 1990 (23)).

In the last 25 years, important devolopments in the correction of lateral curvature has occurred in the surgical treatment of idiopathic scoliosis. However, most of the techniques have minimal effect on correction of vertebral rotation. The traditional Harrington system achieves correction in the frontal plane by distractive and compressive forces but has minimal effect on rotational deformity (Aaro, 1982 (3); Akbarnia et. al., 1988 '4); Benson, 1977 (5)).

In sublaminar wiring techniques such as Luque and Drummond, the curve can be corrected in the frontal plane and rigid fixation can be provided, but as corrective moment affects mainly the concave side, significant derotation can't be expected (Herring and Wenger, 1982 (10); Hullin et. al., 1991 (11); Luque, 1982 (14)).

There are various reports suggesting that with multiple hooks placed in strategic vertebrae, double rods and a Dispositif de Traction Transversale (DTT) system, Cotrel-Dubousset Instrumentation builds a rigid frame and provides high correction rates in all the three planes. It has also been reported that especially in flexible thoracal curves, this system corrects rib hump deformity by the derotation manouevre and improves pulmonary functions by increasing the radius of the ches (Akbarnia et. al., 1988 (4); Bridwell et. al., 1988 (6); Michel and Michel, 1988 516); Nagata et. al., 1987 (18); Paterson et. al., 1988 (20); Pérez-Grueso et. al., 1988 (21)).

In the recent years, it has been suggested that Cotrel-dubousset sytem's derotational effect in the lumbar region and in rigid curves is minimal and neutral segments and neutral segments and secondary curves are also rotated (Transfeldt et. al., 1988 (24); Transfeldt et. al., 1988 (25); Wood et. al., 1991 (26)).

In this study the effect of Cotrel-Dubousset Instrumentation on the rotational deformity and whether it was influenced by the type of the curve and the amount of sagittal contour angle was evaluated. The effect of the derotation manoeuvre on the neutral segments which were not in the curve was examined.

MATERIAL and METHODS

From December 1988 to June 1991, 62 patients with idiopathic scoliosis were treated surgically by

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Cotrel-Dubousset Instrumentation (CDI) at the 1st Orthopaedic and Traumatology Clinic of Ankara Social Security Hospital. Mean follow-up period was 26.0 (10-42) months. Twenty-seven of the patients were female and 35 were male.

After routine clinical and laboratory examinations, patients were grouped according to the classification of King (King, 1988 (12)). Preoperative and postoperative rib hump deformity of the patients were measured and their correction rates were determined.

Derotation manoeuvre was only performed in King Type III and Type IV curves. In rigid curves, Double rods were used at the concave side and correction was obtained by using distraction-compression and transverse traction forces. Posterior fusion was done in all patients by using autologous bone grafts. No postoperative external support was used. The patients were turned to right and left side during the first day and were seated on the second day. Generally on the third day most of the patients were encourged to walk (58 patients (93.5 %)). On the phostoperative 10-15th day sutures were removed and patients were discharged from the hospital. The postoperative controls were done in the 1., 3., 6., 12., 18., 24 and 36th months.

Preoperative and postoperative Cobb angles of the hpatients were measured and the amounts and percentages of correction were determined. In the lateral radiograms sagittal plane contours and the amount of postoperative correction was evaluated. During the follow-up period antero-posterior radiograms were taken with the patients standing and any correction loss was noted.

By preoperative and postoperative computed tomography; the apical, intermediate and neutral-end vertebral rotations were measured with the methods of Aaro and Dahlborn (Aaro and Dahlborn, 1981 (1); Aora and Dalhborn, 1981 (2)). The mid point of the sternum, center of the posterior neural arc and vertebral axis were determined and using these reference points, Rotation Angle midline (RAml), rotation angle-sagittal (RAsag) and rotation angle deviation (RAdev) were measured. RAml is the angle between the midline and the vertebral axis. RAsag is the angle between the vertebral axis and the line drawn vertical to the table which the patient lies. RAdev is the angle between the midline and sagittal vertebral line. The sum of RAsag and RAdev shows RAml. In the follow-up period computed tomographies of the patients were taken and correction loss was searched for.

Cotrel-Dubousset System's derotational effect on different curve types was evaluated. For this purpose, rotation angles of the apical vertebra in the major curve were measured, in which this system claims to have the maximum effect. Statistical correlation between the rib hump deformitty and the rotation angle was also exmined, Apart from the apical vertebra, the effect of derotation on the intermediate and neutral vertebrae was also evaluated in flexible thoracal curves. During the follow-up period, the evolution or if already present the decompensation of the secondary curves was investigated.

Lastly the correlation bletween preoperative values of the sagittal plane contour and the amount of correction achieved by the derotation manoeuvre was analyzed. For this purpose two groups were formed. Patients who had a thoracal kyphosis angle below 15° and patients with had the thoracal kyphosis angle between 15°-30°.

The statistical evaluation was done using the the "Difference Between Means for Paired Observations" test and the "Kruskall-Wallis Analysis of Variance" test and "Correlation Matrix" test.

RESULTS:

Preoperatively 39 (62.9 %) patients had a single classical thoracal flexible curve and 17 (27.4 %) patients had thoracolumber curves. According to the bending radiograms 5 (8.1 %) patients had Type I, 12 (19.4 %) patients had Type II, 39 562.9 %) had Type III, 6 (9.7 %) had Type IV curves. None of the patients had a Type V curve.

When the rib hump deformities of the patients were measured clinically, 20 (32,3 %) patients had a rib hump less 3 cm, 25 (40,3 %) patients had a rib hump between 3-6 cm and 17 (27,4 %) had greater than 6 cm. Preoperative and postoperative rib hump values according to different curve types and their correction percentages are seen in Table I. In Type III curves in which a derotation manoeuvre had been performed, the highest correction was achieved with 76.0 ± 20.6 %. This group was followed by Type IV curves with 51.3 ± 25.6. Except Type I curves, there were statistically significant differences between preoperative and postoperative rib hump values in all curves ($P < 0.05$).

When the position of center of gravity in relation to the intergluteal crease was evaluted, 22 (35,5 %) patients had balanced curves, 23 (37,1 %) patients had less than 3 cm, 16 (25,8 %) patients had 3-6 cm and only one (1,6 %) patients had more than 6 cm devia-

Table 1: Preoperative and postoperative values, amount of the correction values and percentages of correction, hight of rib hump deformites of the patients according to various curves
(PR: Preoperative, PO: Postoperative, PC: Percentage of correction, n: number of cases, A: Average, Sd: Standart deviation) (Numbers are cm at the column of PR, PO and AC)

Curve Types	PR	PO	PC	t p
Type I n = 5	2,5 ± 1,6	1,5 ± 1,1	33,6 ± 21,4	3,65 > 0,05
Type II Lordotic n = 7	7,9 ± 1,4	4,7 ± 1,3	41,5 ± 8,9	17,42 < 0,05
Type II Kyphotic n = 5	7,8 ± 1,4	5,9 ± 1,9	25,8 ± 10,2	7,75 < 0,05
Type III n = 39	3,9 ± 1,9	1,2 ± 1,1	76,0 ± 20,6	13,56 < 0,05
Type IV n = 6	3,3 ± 1,2	1,8 ± 1,8	51,3 ± 25,6	8,22 < 0,05
Total n = 62	4,5 ± 3,4	2,0 ± 1,9	62,3 ± 26,9	15,8 < 0,05

Table 2: Preoperative and postoperative average Cobb angles and the percentage of correction in the frontal plane according to different curve types. (T: Thoracal curve, L: Lumbar curve, TL: Thoracolumbar curve, m: major curves, n: number of the patients, A: Average, Sd: Standart deviation)

Type of the curve		Preoperative A ± Sd	Postoperative A ± Sd	Percentage of Correction A ± Sd	t p
King Type I n = 5	T	44,0° ± 8,6°	26,4° ± 12,7°	42,2° ± 15,9°	7,67 < 0,05
	L	62,0° ± 13,0°	42,0° ± 12,6°	32,5° ± 13,5°	5,65 < 0,05
King Type II (Lordotic) n = 7	T	61,3° ± 11,5°	35,4° ± 16,2°	41,8° ± 7,4°	8,70 < 0,05
	L	28,3° ± 10,2°	22,3° ± 8,5°	21,7° ± 4,1°	7,34 < 0,05
King Type II (Kyphotic) n = 5	T	65,6° ± 16,7°	41,2° ± 13,4°	38,0° ± 4,8°	14,96 < 0,05
	L	31,2° ± 10,3°	24,0° ± 9,2°	22,8° ± 12,2°4,81 < 0,05	
King Type III n = 39	T	49,9° ± 4,6°	17,0° ± 8,5°	67,4° ± 14,3°	33,71 < 0,05
King Type IV n = 6	TL	48,8° ± 6,9°	25,2° ± 12,3°	53,8° ± 23,2°	6,42 < 0,05
Total n = 62	M	53,2° ± 9,7°	23,5° ± 13,4°	57,6° ± 19,1°	29,13 < 0,05

tion. Gravity line came to the intergluteal crease in 35 (62.9 %) patients. There was 0-3 cm deviation in 21 (33.9 %) and more than 3 cm deviation in 2 (3.2 %) patients. In the follow-up period no correction loss occurred in the patients in which body balance had been restored.

Preoperative and postoperative Cobb angles and their correction values and percentages according to different curve types are seen in Table II and Table III. The highest correction in the frontal plane was obtained averagely by 67.4 ± 14.3 % in the patients with Type III curves in which a derotation manoeuvre had been performed. This group was followed by the Type IV curves (53.8 ± 23.2). Type I and Type II curves were corrected more than the correction amounts in bending radiograms but the correction rates were lower than the Type III and Type IV curves. Especially in the lumbar region correction was less than the thoracal curve. Statistically significant differences between preoperative and postoperative Cobb angles in both thoracal and lumbar regions were observed ($p < 0.05$).

Potoperatively in Type I curves, averagely 12.8° ± 5.7° of correction of the sagittal contour angle in the lumbar region was obtained. The normal thoracal kyphosis was restored in all the patients but only 20 % of the patients were brought within normal lumbar lordosis limits. In Type II curves with a lordotic pattern in the thoracal region, kyphosis angles increased averagely 16.7° ± 2.8° and all of the patients were brought within 20° of the deviation limit for physiological kyphosis. In Type II curves with a kyphotic pattern in the thoracal region, thoracal kyphosis angles were lowered averagely -19.8° ± 6.9° and 80 % of the patients were brought within normal limits. In type III patients 26.1° ± 9.4° of correction was achieved and physiological sagittal conturs were provided in all. In Type IV patients although no significant difference was observed in thoracal and lumbar regions, the thoracolumbar junction angle was brought within normal limits in 66.6 % of the patients.

Preoperative values of RAsag, RAml and RAdev and their correction values and percentages according to different curve types are seen in Table IV. There were statistically significant differences between preoperative and postoperative rotation angles in all types of curves ($p < 0.05$). Computerized tomography revealed that,l when all curve types were included, 19.6 ± 15.4 % of correction had been obtained in RAsag, 20.2 ± 16, 6 % in RAml and 21.1 ± 18.2 % in RAdev. There were statsically significant differences in correction rates between types of the curves ($p < 0.05$). The highest correction was achieved in Type III curves. In this group averagely 24.8 ± 18.2 % correction was obtained in RAsağ, 25.8 ± 18.4 % in RAml and 26.5 ± 20.8 % in RAdev respectively. This group was followed by Type IV and Type II curves. Poor results were obtained in Type I curves with rigid lumbar curves.

With the derotation manoeuvre, the average correction percentages of the rotational deformity was 24.8 ± 16.9 % in the apical vertebra, 10.0 ± 2.2 % in the upper, 10.0 ± 2.3 % in the lower intermediate vertebrae, 0.6 ± 1.5 % and 0.7 ± 1.7 % kin the upper and lower neutral vertebrae respectively (Table V). In the type III curves, there were statistically significant differences between preoperative and postoperative RAsag values in the apical and intermediate vertebrae ($p < 0.05$), but there were no significant differences in upper and distal neutral vertebrae ($p < 0.05$). In light of these findings it was found that the derotation manoeuvre mostly affected the apical vertebra. This effect decreased towards the intermediate vertebrae and was almost zero at the neutral vertebrae.

When King Type III patients were evaluated for the derotation manoeuvre's effect on sagittal contour angles it was found that when the thoracal kyphosis angle was below 15 degrees an average correction of 11.8 ± 6.9 (30.5 ± 18.1%) and when it was above 15° an average correction of 3.4° ± 1.3° (13.3 ± 3.9) was achieved. The highest correction was obtained when the thoracal sagittal contour angle was below 15° ($p < 0.05$). When all curve types were incldedr a high correlation between correction rates of the rib-hump deformity and RAsag was found ($r = 0.739$, $p < 0.05$). This correlation was lower in rigid curves such as Type I and Type Iı and increased in Type III curves in which derotation manoeuvre had been performed.

During follow-up examinations 0.9° 1.1 and 0.4° of loss of was correction observed in the RAsag, RAml and RAdev anlges respectively. 7.2° (0° - 25°) of correction loss was seen in the Cobb angle. No secondary lumbar or cervical curve occurred in Type III curves and no increase in the secondary flexible curves in Type I and Type II curves was observed.

DISCUSSION :

Scoliosis at the present is regarded as deformity in all three planes. Besides the lateral curve in the frontal plane, there is a significant rotation especially in the apical vertebra and deterioration of physiological ky-

Table 3: Distribution of mean correction values of thoracal sagittal plane angles in various curve patterns. (T: Thoracal, L: Lomber, A: Average, Sd: Standard Deviation, n: Number of the patients).

Curve type		Preoperative A ± Sd	Postoperative A ± Sd	Amount of correction A ± Sd	t p
King Type I n = 5	T L	22,1° ± 7,4° 14,2° ± 4,3°	34,0° ± 4,2° 27,0° ± 7,4°	11,8° ± 5,4° 12,8° ± 5,7°	4,93 < 0,05 5,00 < 0,05
King Type II (Lordotic) n = 7	T L	(–4,7°) ± 7,7° 32,9° ± 8,9°	12,0° ± 7,5° 36,9° ± 7,4°	16,7° ± 2,8° 4,0° ± 3,2°	15,7 < 0,05 3,34 < 0,05
King Type II (Kyphotic) n = 5	T L	69,6° ± 13,5° 38,2° ± 11,1°	49,8° ± 11,8° 38,4° ± 4,7°	(–19,8° ± 6,9° 0,4° ± 4,5°	6,41 > 0,05 0,19 > 0,05
King Type III n = 39	T	9,7° ± 11,4° 36,1° ± 6,3	35,8° ± 4,7° 39,6° ± 4,8	26,1° ± 9,4° 3,6° ± 3,9	17,40 < 0,05 5,59 < 0,05
King Type IV n = 6	T L	35,0° ± 6,1° 29,7° ± 8,1°	38,5° ± 4,9° 34,5° ± 7,2°	3,5° ± 2,6° 4,8° ± 1,9°	3,31 > 0,05 6,10 < 0,05

Table 4: According to different type of the curvatures, preoperative and postoperative average angle of the rotation, amount of te degrees and percentages of the correction. (L:Apical vertebra in the lomber region, T:Apical vertebra in the thoracal region, AL:Apical vertebra thoracolumbar region, n: number of cases, A:Average, Sd:Standart Daveiation)

Type of the curve	Angles of rotation	Preoperative A ± Sd	Postoperative A ± Sd	Percentages of Correction A ± Sd	t p
King Type I n = 5 (L)	RAsag RAml RAdev	33,5° ± 13,8° 59,5° ± 23,4° 26,0° ± 9,7°	31,8° ± 14,2° 56,0° ± 23,6° 24,4° ± 9,4°	5,9° ± 5,8° 6,6° ± 3,3° 6,8° ± 1,7°	3,01 < 0,05 7,21 < 0,05 6,48 < 0,05
King Type II Lordotic n = 12 (T)	RAsag RAml RAdev	41,1° ± 9,1° 73,4° ± 18,8° 32,3° ± 9,8°	36,4° ± 8,4° 64,6° ± 8,7° 28,3° ± 7,9°	11,6° ± 4,3° 11,9° ± 4,9° 12,2° ± 6,3°	6,55< 0,05 5,99 < 0,05 4,79 < 0,05
King Type II Kyphotic n = 5 (T)	RAsag RAml RAdev	34,1° ± 10,3° 62,2° ± 17,5° 28,2° ± 7,6°	31,4° ± 10,8° 50,3° ± 19,8° 25,5° ± 7,8°	9,4° ± 6,7° 9,4° ± 5,7° 10,9° ± 6,8°	3,85 < 0,05 1,95 < 0,05 5,52 < 0,05
King Type III n = 39 (T)	RAsag RAml RAdev	34,3° ± 9,2° 61,5° ± 18,3° 27,2° ± 9,5°	25,3° ± 7,9° 44,7° ± 15,6° 19,4° ± 8,3°	24,8° ± 16,9° 25,8° ± 18,4° 26,5° ± 20,8°	8,04 < 0,05 7,45 < 0,05 6,66 < 0,05
King Type IV n = 6 (TL)	RAsag RAml RAdev	25,4° ± 11,2° 45,8° ± 18,3° 21,9° ± 9,9°	21,4° ± 19,0° 39,3° ± 15,9° 18,2° ± 7,9°	15,5° ± 4,4° 14,1° ± 5,4° 16,4° ± 4,9°	4,22 < 0,05 3,81 < 0;05 3,93 < 0,05
Total	RAsag RAml RAdev	34,1° ± 10,2° 61,2° ± 19,2° 27,3° ± 9,4°	27,2° ± 9,6° 47,8° ± 17,8° 21,2° ± 8,7°	19,6° ± 15,4° 20,2° ± 16,6° 21,1° ± 18,2°	8,72 < 0,05 8,32 < 0,05 7,56 < 0,05

phosis and lordosis posture in the sagittal plane. This three-plane-deformity concept has led to the necessity of providing correction in three planes during surgical treatment (Bridwell, 1992 (7); Leatherman and Dickson, 1988 (13); Moe and Byrd, 1987 (17); Stagnara, 1988 522); Tachdjian, 1990 (23)). It has been accepted that the traditional Harrington rod system corrects the lateral curvature only by its distraction effect but has no effect on the sagittal and transverse plane (Benson, 1977 55)). After adding a compressive rod to Harrington distraction system, the derotational effect achieved is also minimal (Aaro, 1982 (3)).

Sublaminar Segmental Wiring (SSW) corrects the lateral curve in high rates and is successful in consititing physiological thoracal kyphosis (Herring and Wenger, 1982 (10); Hullin et. al., 1991 (11); Luque, 1982 (14)). It has been shown that this strong corrective effect has a moderate effect on rotational deformity (Michel and Michel, 1988 (16)).

In 1991, Hullin, et al reported 61 patients with idiopathic scoliosis treated by the Luque technique. Although they obtained 59-63 % correction in the frontal plane, they were able to provide only 6°-10° of derotation in single thoracic curves. There was no significant effect on the rib hump deformity, and they obtained correction in all the three planes in lumbar curves (Hullin et. al., 1991 (11)).

In 1987 Nagata, et. al. reported that they obtained 25.5 % correction in RAml, in 31 idiopathic scoliotic patients treated by the Cotrel-Dubousset Instrumentation. They also suggested that depending upon the derotational effect, chest deformity was corrected and when compared with Harrington, Harrington+DTT and Luque systems, it was 3 times more effective in the correction of rotation (Nagata et. al., 1987 (13)). In the series of Michel and Michel, 20 cases each of four different instrumentation types was compared (Armstrong, CDI, Armstrong-Luque, Luque-Dove). It was found that 68 % correction could be obtained with the Armstrong and CDI and 50 % correction with Armstrong-Luque and Luque-Dove systems. They also suggested that their success in reconstituting physiological contours in the sagittal plane was similar but CDI was superior to other systems in the derotational effect by 20 % (Michel and Michel, 1988 (16)).

Akbarnia, et al reported 33 idiopathic scoliosis cases in which they used CDI, obtained 17 %, 22 % and 11 % corrections in RAml, RAsag and RAdev respectively. They proved that statistically, derotation achieved in the apical vertebra had a strong relationship with the correction of the rib hump deformity and based on these data they phostulated that this system had significant effect on the correction of chest deformity (Akbarnia et. al., 1988 (4)).

There are also reports about the high rotational corrective effect of the Anterior Ventral Derotational System. It is succesful in reconsituting the lumbar lordosis however it has difficulties of application to curves above T with the added risk of an anterior approach (Ogilvie, 1988 519); Zielke and Pellin, 1976 (27)).

Three plane analysis of the CDI system shows that it is highly successful in the thoracal region but its derotational effect in the lumbar region is low (Akbarnia et. al., 1988 (4); Bridwell et. al., 1988 56); Chopin and Morin, 1992 (8); Mason and Carango, 1991 (15)).

In this study, sagittal and transverse plane corrections achieved with the CDI were evaluated in patients with idiopathic scoliosis treated at the 1st Orthopaedics and Traumatology Clinic of Ankara Social Security Hospital. When all of the patients were included, it was determined that averagely 19.6 %, 20.2 % and 21.1 % correction was obtained in RAsag, RAml and RAdev respectively. The highest correction was obtained in thoracal single flexible curves (Type III) in which a derotation manouevre had been performed. In patients in which a derotation maneouevre had not been performed correction was relatively low. In rigid lumbar curves, Cotrel-Dubousset system had a minimal effect on deformity. It was concluded that in these curves, the first step should be anterior release, anterior instrumentation, derotation and fusion followed by posterior instrumentation to increase correction rates.

The maximum amount of correction in the rib hump deformiy was obtained in Type III curves by 76.0 % in which a derotation manoeuvre had been performed. A significant amount of correction was achieved in all other curve types. A positive correlation was found between the correction of rib hump deformity and correction of rotation. It was concluded thatl, with the derotation manoeuvre the CDI corrects the rib hump deformity, increases the radius of the chest and provides cosmetic improvement.

Peterson, et. al. reported a loss of correction of 1.4° in RAml in 34 patients which they had performed CDI (Paterson et. al., 1988 (20)). In our study, after an average of 26 months' follow-up period, 1.1°, 1.3° and 0.5° of correction loss was observed in RAsag, RAml and RAdev respectively.

In 1991 Gray, et. al. investigated the relation between the amount of correction in the frontal plane and

Table 5: According to different vertebrae levels, preoperative and postoperative RAsag degrees and amount of correction in the thoracal flexible curves (King Type III)(n: number of the patient)

Level of the vertebrae n = 39	Preoperative	Postoperative	Percentages of Correction	t p
Apical	34,3 ° ± 9,2	25,3° ± 7,9	24,8 ± 16,9	8,04 < 0,05
Upper Intermediet	20,0° ± 8,2°	18,8° ± 7,4°	10,0 ± 2,2	13,7 < 0,05
Dital Intermediet	19,9° ± 8,2°	18,3° ± 7,1°	10,2 ± 2,3	4,39 < 0,05
Upper Neutral	2,6° ± 1,7°	2,6° ± 1,7°	0,6 ± 1,5	2,51 < 0,05
Distal Neutral	2,6° ± 1,7°	2,5° ± 1,6°	0,7 ± 1,7	2,42 < 0,05

Table 6: According to sagittal contour angles, preoperative and postoperative RAsag degrees, amount of the correction and percentages of the correction in flexible thoracal curves which performed deviation manouvre (n = number of the patients)

Aangle of the thoracal kyphosis	Preoperative	Postoperative	Percentages of Correction	t p
Below 15° (n = 26)	38,8° ± 6,8°	27,0° ± 8,3°	30,5° ± 18,1°	8,60 < 0,05
15° - 30° (n = 13)	25,4° ± 6,6°	21,9° ± 5,9°	13,3° ± 3,9°	9,41 < 0,05
Total (n = 39)	34,3° ± 9,2°	25,3° ± 7,9°	24,8° ± 16,9°	8,04 < 0,05

the derotation amounts in 10 patients treated by CDI. Although they achieved a significant amount of frontal plane correction in rigid curves, the amount of derotation and correction of rib hump deformity was low (Gray et. al., 1991 (9)). Similar results were obtained in our study, the amount of correction of the rotation deformity was lower in rigid curves than flexible curves.

In 1989 Bridwell, et. al. analyzed preoperative and postoperative sagittal plane values of 160 idiopathic scoliotic patients treated with CDI. They reported that the CDI system had a poor derotation effect on the lumbar spine. In the thoracal spine this effect was significant in cases with a thoracal kyphosis angle less than 15° but was minimal if the angle was greater than 15° and almost none if there was a kyphoscoliosis (Bridwell et. al., 1988 (6)). In our study, it was observed that when the sagittal contour angle was between 15-30° the correction in rotation deformity was 13.3 %, but when the sagittal contour angle was less than 15° correction of rotation was 30.5 %. It was concluded that as lordosis in the thoracal region increased, the derotational effect became markedly improved.

Transfelt, et. al. suggested that by the derotation manoeuvre, rotational deformity in the thoracal region shifts to normal levels proximal and distal of the deformity causing progression potential in the secondary curve (Transfeldt et. al., 1989 (24); Transfeldt et. al., 1989 525)). Wood, et al reported CT studies of 10 patients treated by CDI in 1991. They found 26 % correction in Type III curves but only 1,3 % correction in Type I curves. They also stated that the derotation achieved in the apical vertebra in relation to the pelvis was not very much as a segmental secondary derotation occurred in the lumbosacral and cervicothoracic junctions (Wood et. al., 1991 (26)). Mason and Carango also showed that spinal decompensation occurred in a higher rate in patients instrumented with CD than with HRSF or its variants (Mason and Carongo, 1991 (15).

However, in this study it was found that the derotational effect was maximum at the apical vertebra, decreased towards the intermediate vertebrae and was almost zero at the end vertebrae. Thus the derotational force was not carried segmentally to the normal proximal or distal parts of the vertebral column. In 62.9 % of the patients the weight line was carried to its physiological position and no loss of correction or decompensation was observed during the follow-up period. In addition, no formation of secondary curves (in Type III curves) and no increase in secondary curves (in Type II curves) occurred.

In conclusion, it is suffested that the CDI system, in addition to high correction rates in the frontal and sagittal planes, also provides significant correction in the transverse plane especially in flexible thoracal lordoscoliosis. It should be noted that the effect of derotation on rigid lumbar curves in minimal. The system is very rigid and correction loss is minimal. The derotation manoeuvre affects mainly the scoliotic curve and does not cause decompensation of body balance and a significant correction of the chest deformity can be obtained.

REFERENCES

1. Aaro S, Dahlborn M: Estimation of vertebral and the spinal and rib cage deformity in scoliosis by computer tomography. Spine (1981) 6:460-467.
2. Aaro, S, Dahborn M: The longitudinal axis rotation of the apical vertebra, the vertebral, spinal and rib cage deformity in idiopathic scoliosis, studies by computer tomography. Spine (1981) 6:567-572.
3. Aaro S: The effect of Harrington Instrumentation on the longitudinal axis rotation of the apical vertebrae and on the spinal and rib cage deformity in idiopathic scoliosis studied by computer tomography. Spine (1982) 7:456-462.
4. Akbarnia BA, Scheid KD, Merenda JT, Graviss E: The three dimensional correction of CD Instrumentation in idiopathic scoliosis. In: 5 th International Congress on CDI, (1988) Sauramps Medical, Montpellier, pp:39-43.
5. Benson DR: The effect of Harrington rod distraction on vertebral rotation and thoracic compresion. Clin Orthop Rel Res (1977) 125: 40-44.
6. Bridwell KH, BLetz R, Capelli AM, et al: Sagittal plane analysis in idiopathic scoliosis patients treated with Cotrel-Dubousset Instrumentation. (1988) In: 6th International Congress on Cotrel-Dubousset Instrumentation, Sauramps Medical, Montpellier, pp:65-71.
7. Bridwell KH: Idiopathic Scoliosis. In: The Textbook of Spinal Surgery. (1992). Ed: Bridwel KH, DeWald RL. Ed.1, Vol.1, JB Lippincott Company, Philadelphia, pp:97-162.
8. Chopin D, Morin C: Cotrel-Dubousset Instrumentation for odolescent and pediatric scoliosis. In: The Textbook of Spinal Surgery. (1992). ED: Bridwell KH, DeWald RL. Ed.1, Vol1, JB Lippincott Company, Philadelphia, pp: 183-217.
9. Gray JM, Smith BW, Ashley RK, et al: Derotational analysis of Cotrel-Dubousset Instrumentation in idiopathic scoliosis. Spine (1991) 16 (Suppl):303-391.
10. Herring JA, Wenger DR: Segmental spinal instrumentation. Spine (1982) 7:285.
11. Hullin MG, Mc Master MS, Drofer ERC, Duff ES: The effect of Luque Segmental Sublaminar Instrumentation on the rib hump in idiopathic scoliosis. Spine (1991) 15 (4):402-406.
12. King HA: Selection of fusion levels for posterior instrumentation and fusion in idiopathic scoliosis. Orthop Clin North Am. (1988) 19(2):247-55.
13. Leatherman KD, Dickson RA: The management of spinal deformities. (1988) 1st Ed, Wright Company, London, pp:1-104,433-460.
14. Luque ER: Segmental spinal instrumentation for correction of scoliosis. Clin Orthop Rel Res (1982) 163:192.
15. Mason DE, Corango P: Spinal decompensation in Cotrel-Dubousset Instrumentation. Spine (1991) 16(8):394-403.
16. Michel F, Michel CR: Comparison of different posterior instrumentations of the scoliotic spine. A study in the three planes of the space. In: 5th International Congress on Cotrel-Dubousset Instrumentation, (1988) Sauramps Medical, Montpellier, pp:27-31.
17. Moe JH, Byrd JA: Idiopathic Scoliosis. In: Moe's Textbook of Scoliosis and Other Spinal Deformities. (1987) Ed: Bradford DS et al. 2nd Ed, WB Saunders Company, Philadelphia, pp:191-232.
18. Nagata H, Onomura T, Watanabe H et al: Study on derotational effect of CD Instrumentation. In: 4th Proceeding of International Congress on Cotrel-Dubousset Instrumentation, (1987) Sauramps Medical, Montpellier, pp:75-86.
19. Ogilvie JW: Anterior spine fusion with Zielke Instrumentation for idiopathic scoliosis in adolescent. Orthop Clin North Am, (1988) 19(2):313-328.
20. Paterson DC, Çundy PJ, Hillier T et al: Vertebral rotation with Cotrel-Dubousset Spinal Instrumentation. In: 5th International Congress on Cotrel-Dubousset Instrumentation, (1988) Sauramps Medical, Montpellier, pp:33-37.
21. Pérez-Grueso S, Arienza D, Ballio F et al: The effect of Cotrel-Dubousset Instrumentation on the vertebral rotation and the spinal sagittal alignment. In:5th International Congress on Cotrel-Dubousset Instrumentation, (1988) Sauramps Medical, Montpellier, pp:27-31.
22. Stagnara P: Spinal Deformity. 51988) Eng Ed, Butterworth & Co Ltd, Somerset, pp:1-86, 185-287, 299-325.
23. Tachdjian MO: Pediatric Orthopaedic. (1990) 2nd Ed, pp:2265-2379, WB Saunders Company, Philadelphia, pp:2265-2379.
24. Transfeldt E, Thompson J, Bradford D: Three dimentional changes in the spine following Cotrel-Dubousset Instrumentation for adolescent idiopathic scoliosis. In: 6th International Congress on Cotrel-Dubousset Instrumentation, (1989) Sauramps Medical, Montpellier, pp:73-80.
25. Transfeld E, Thompson J, Bradford D: The three dimensional deformity in adolescent idiopathic scoliosis with special reference to rotation and coupling. In: 6th International Congress on Cotrel-Dubousset Instrumentation, (1989) Sauramps Medical, Montpellier, pp:81-88.
26. Wood KB, Transfeldt EE, Ogilvie SW, et al: Rotational changes of the vertebral-pelvis axis following Cotrel-Dubousset Instrumentation. Spine (1991) 16(8-50 pp1):404-408.
27. Zielke K, Pellin B: Neve instrümente und implantate zur erganzung des Harrington system. Z Orthop Chir (1976) 114:534.