EARLY RESULTS OF TEXAS SCOTTISH RITE HOSPITAL (TSRH) SYSTEM IN THE TREATMENT OF IDIOPATHIC SCOLIOSIS

KIŞ M., M.D. **BENLİ T., M.D.** **ÇITAK M., M.D.**
AKALIN S., M.D.

Texas Scottish Rite Hospital (TSRH) Instrumentation, one of the recently developed systems, builds a rigid frame with multiple hooks and crosslink plates and is effective in correcting the deformity in three planes in the treatment of scoliotic deformities.

From September 1991 to April 1992, 21 TSRH instrumentations were performed for the treatment of idiopathic scoliosis at the 1st Orthopaedics and Traumatology Clinic of Ankara Social Security Hospital. When all curve types were included, the mean preoperative Cobb angle of the major curve that was 55,9° ± 17,7° was corrected by 57,9 ± 18,3 %. The highest correction rate was obtanied in King Type III curves with a single thoracal flexible curve (mean 73.2 %). In 71.4 % of the patients physiologic thoracal kyphosis and in 47.6 % physiologic lumbar lordosis was reconsituted. In all of the patients, an improvement in pulmonary functions was observed at 6 months follow-up. Complication rate in the early postoperative period was 9.5 %.

In light of these findings it is suggested that TSRH system is one of the first choices in the treatment of idiopathic scoliosis surgery, as it has advantages such as providing correction in three planes and the possibility of building a rigid frame with crosslink plates.

Key Words: *Idiopathic scoliosis, TSRH, Spinal instrumentation.*

INTRODUCTION:

Idiopathic scoliosis is a rotational deformity of the spinal column with lateral bending in the frontal plane and deterioration of the physiological contours in the sagittal plane. Therefore the goal of the treatment in idiopathic scoliosis is correction of the curve in all three planes. In addition, halting the progression of the curve and prevention of pain and pulmonary dysfunction are the other important targets. Lastly, correction of the patient's body balance is another important aspect (1-5).

In the last 35 years, a rapid development in the surgical treatment of idiopathic scoliosis has occured. Harrington rod system was developed in the 1960's and has been used widely up to date. Even with the additional compression rod, complications such as 25 % pseudoatrthrosis, 15 % metal failure still occur and are major disadvantages of this system (6-9).

In 1973 Luque developed Segmental Sublaminar Wiring System in which, wires are passed under the laminae and attached to double "L-rods" providing fixation in all levels. There are many reports suggesting this system has high correction rates with rigid fixation properties. However, Winter and Anderson and other authors reported significant correction loss in their series if postoperative external immobilization wasn't used after Luque-SSI. Also the system has a high neurologic complication risk (1-5, 10-15).

In recent years, the development of the three plane deformity concept in scoliosis surgery has led to the popularization of the Cotrel-Dubousset System throughout the world. This system builds a rigid frame with multiple hooks placed on the strategic vertebrae, double rods and DTT system. In the frontal plane, especially in flexible thoracal lordoscoliosis, this system has high correction rates in all curve patterns. Also this system's high success in reconstituting physiological sagittal contours and correction of rotational deformity by the derotation manoeuvre with minimal loss of correction at follow-up has been reported (1-5, 16-25).

In 1985 Johnston and Ashman began seeking a mechanical solution to the problem of rod migration in SSI. They determined that with weightbearing loss of fixation and correction was inevitable, especially in the osteopenic patients and when posterior elements weren't securely fixed with wires. They developed the Texas Scotish Rite Hospital crosslink plates which increased the resistance to upwards-downwards sliding forces. Ashman et al. reported that with the use of TSRH plates as crosslinks, correction loss was low and rigidity was high (27-33).

Surgeons of the Texas Scottish Rite Hospital developed a new spinal system which is basically a

From the 1st Orthopaedics and Traumatology Clinic, Ankara Social Security Hospital, Ankara, Turkey

modification of Cotrel-Dubousset instrumentation. The most important difference of TSRH system from the other systems is elimination of elements such as the connector and blockers as hooks are connected to the rods with a three point locking system ("nut" and "eyebolt") (27, 30).

There are reports suggesting that this system builds a rigid frame which is resistant to axial the torsional and shearing forces. Another important advantage of the system is its ease of application and revision possiblity. (27-36)

Studies with TSRH are not numerous in the orthopaedic literature at present. In this study, early surgical results of TSRH system in the treatment of idiopathic scoliosis at the 1st Orthopaedics and Traumatology Clinic of Ankara Social Security Hospital is presented and the results are discussed in light of the literature.

PATIENTS AND METHOD:

The first TSRH in our clinic was realized by Dr.Kış, one of the authors of this study, in August 1991. From August 1991 to April 1992, 21 Texas Scottish Rite Hospital (TSRH) instrumentations were performed in the surgical treatment of idiopathic scoliosis at the 1st Orthopaedics and Traumatology Clinic of Ankara Social Security Hospital. Mean follow-up period was 6.3 months (2-9 months). Fifteen (71.4 %) of the patients were female and 6 (28.6 %) were male.

All of the patients were older than 5 years. Two (9.5 %) patients had juvenile idiopathic scoliosis. One of them was 7 and the other was 8 years old. The remaining 19 (90.5 %) patients were between 10-20 years and had adolescent idiopathic scoliosis.

Preoperatively, patients were evaluated in detail by clinical, radiological and laboratory examinations. Antero-posterior, lateral and bending radiograms of the patients in erect position were taken, Cobb angles, sagittal contour angles, and their correction percentages were measured. Also pulmonary function tests were performed and rotation angles of the apical vertebra of the major curve were measured by the method of Aaro and Dohlborn.

Curves were grouped according to the King classification. Appropriate TSRH planning was done according to the suggestions made by Herring and Johnston. (27, 28) In some rigid Type I and Type II curves (5 patients) anterior release and fusion were performed as a first stage procedure followed by posterior instrumentation. In all but 2 juvenile cases in which a subcutaneous instrumentation had been performed, all patients underwent a posterior fusion with a mixture of autologous and allograft bone.

The patients were turned to their sides during the first day and were seated on the 2nd day. On the 3rd day, all of the patients were encouraged to walk. No postoperative cast or brace was utilized. All patients returned for a follow-up visit at the postoperative 1st, 3rd and 6th months. Clinical and radiological examinations were repeated and pulmonary function tests were done.

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

RESULTS:

After clinical and radiological examinations it was found that 2 (9.9 %) patients had Type I, 8 (38.1 %) patients had type II, 10 (47.6 %) had Type III and 1 (4.8 %) had Type IV curves.

In 2 patients with Type I curves the mean preoperative Cobb angle was 56,5 ± 12,0 in the lumbar and 47 ± 4,2 in the thoracal curve. In the bending radiograms, 51,8 ± 11,1 % and 19,7 ± 7,1 % correction was obtained in thoracal and lumbar curves respectively. In the sagittal plane one patient had a hyperkyphosis and one had hypokyphosis in the thoracal region (Table-1, 2).

In 6 patients with Type II curves with a lordotic pattern in the thoracal region (Type II lordotic) the mean preoperative Cobb angles of the thoracal rigid curve and lumbar flexible curve were determined as 64° ± 11,4° and 37,5° ± 8,8° respectively. In 2 patients with a kyphotic pattern in the thoracal region (Type II kyphotic) mean preoperative Cobb angle was 92° ± 16,9° in the thoracal and 62,5° ± 3,5° in the lumbar region. In bending radiograms 18,7 ± 13,1 % correction was obtained in the thoracal curve and 44,9 ± 20,1 % correction was obtained in the lumbar curve. These patients with a lordotic pattern had 8,2° ± 13,1° of thoracal kyphosis and 18,3° ± 6,9° of lumbar lordosis. In 2 hyperkyphotic patients the mean kyphosis angle was 80,5° ± 14,1° and mean lordosis angle was 70,5° ± 5,1°.

Of 10 patients with Type III curves, 2 had juvenile idiopatic scoliosis Preoperatively mean Cobb angle of the Type III curves were measured as 42,2° ± 3,9°. In bending radiograms an average of 46,5 ± 11,1 % of correction was noted. All of the patients in this group had hypokyphosis or lordosis in the thoracal curve.

The sagittal contour angle was averagely 7,9° ± 11,7° in the thoracal and 23,2° ± 6,7° in the lumbar curves.

The preoperative Cobb angle in one patient with a Type IV curve was 70° and a correction of 42,8 % was obtanied in bending radiograms. This patient had 25° of hypokyphosis in the thoracal and 30° hypolordosis in the lumbur curve. The thoracolumbar junction angle was 24°.

Postoperative correction degrees and percentages of the patients in the frontal and sagittal planes are seen in table I and Table II.

Postoperatively 61,4 ± 16,1 % 43,4 ± 8,3 % corrections were obtained in the thoracal flexible and the lumbar rigid curves respectively in the patients with a Type I curves. These rates were higher than the correction rates in bending radiograms. In this group averagely 16° ± 29,7° of correction was obtained in the thoracal kyphosis and in one patient physiological thoracal kyphosis was restored. Also, sagittal contours in the lumbar curves were corrected by 10° ± 14,1° and in one patient normal lumbar lordosis was restored. The other patient had a 10° of deviation from the normal lordosis limits. In both sagittal and frontal planes, there was no statistically significant difference in the thoracal and lumbar regions ($p > 0.05$).

In Type II lordotic curves mean postoperative Cobb angles were corrected by 48,1 ± 6,8 % in the thoracal and by 35,1 ± 13,1 % in the lumbar region. In Type II kyphotic curves mean postoperative Cobb angles were corrected by 31,3 ± 8,8 % in the thoracal and 53,3 ± 7,4 % in the lumbar region. These correction rates were much higher than the values obtained in the bending radiograms. In Type II kyphotic curves, mean thoracal kyphosis angle was lowered to 57,5° ± 11,1° and lumbar lordosis angle was brought to 50°. In Type II lordotic curves the mean thoracal kyphosis angle was increased to 28,3° ± 7,3° and lumbarlordosis angle was brought to 31,7° ± 7,5°. When all the patients with Type II curves were evaluated, the sagittal contour angles were brought within normal limits in 5 (62,5 %) and within 10° of normal in 2 difference in both frontal and sagittal planes in the thoracal and lumbar regions ($p < 0.05$). But, in Type II kyphotic curves, there was no statistically significant difference in either frontal or sagittal planes in the thoracal and lumbar regions ($P > 0.05$).

The mean Cobb angle of the Type III curves was corrected by 73,2 ± 12,4 %. The correction rates that were obtanied in this group were nearly twice the correction rates achieved in the bending radiograms ($p < 0.05$). The thoracal kyphosis and lumbar lordosis angles of the patients with Type III curves were averagely corrected by 30,6° ± 8,4° and 16,2° ± 5,2° and were brought to averagely to 38,6° ± 4,2° and 39,0° ± 7,3° respectively. Thus, in 9 patients (90 %) in this group the physiological thoracal kyphosis was restored. The remaining patient was brought within 10° of deviation from normal limits. There was a statistically significant difference between preoperative and postoperative sagittal contour angles in both thoracal and lumbar regions ($p < 0.05$).

In one patient with Type IV curve, 45,7 % correction was obtained in the frontal plane. The thoracal kyphosis ad lumbar lordosis angles were brought within normal limits.

When all curve types were included, mean Cobb angles of the major curves corrected by 57,9 ± 18,3. Physiological sagittal contours were formed in 16 (76,2 %) patients in the thoracal and 10 (47,6 %) patients in the lumbar curves. Postoperatively, the highest correction was obtained in patients with single thoracal flexible lordoscoliosis in which a derotation manoeuvre had been performed and this group was followed by Type I with and Type II curves ($p < 0.05$). The least amount of correction was obtained in the lumbar curve of the Type II curves. The overall correction rates obtained in thoracolumbar curves were better than the lumbar curves.

Early postoperative complications were seen in 2 patients (9,5 %). In 1 patient an incomplete neurological deficit was seen in the right lower extremity. This deficit improved and left only a slight strength loss in dorsiflexion in the 6th postoperative month. Now this patient is able to walk with normal shoes. In one patient with a Type II curve, both dital laminar hooks on the concave and convex sides dislocated and postoperative correction dropped from 40 % to 6,7 %. This patient was revised and 44 % correction was achieved. No further complications occurred and the correction was maintained. In the remaining patients, solid fusion was noted in the 6th postoperative month and no pseudoatrthrosis was seen.

DISCUSSION

In the last decade, the three plane deformity concept of idiopathic scoliosis has led to the evolution of spinal instrumentations that correct the deformity in all three planes. Multiple level fixation with wires or hooks at strategic vertebra,e double rods and transverse connecting devices have become the state-of-the-

		Preoperative A ± Sd	Postoperative A ± Sd	Correction Percantages	t p
Type I n = 2	T L	47° ± 4,2° 56,5° ± 12,0°	18,5° ± 9,2° 31,5° ± 2,1	61,4 ± 16,1 43,4 ± 8,3	8,14 > 0,05 3,57 > 0,05
Type II Lordotic n = 6	T L	68,6° ± 11,4° 37,5° ± 8,8	35,0° ± 9,4° 25,8° ± 9,7°	48,1 ± 6,8 35,1 ± 13,1	17,12 < 0,05 7,00 < 0,05
Type II Kyphotic n = 2	T L	92,0° ± 16,9° 62,5 ± 3,5	62,5° ± 3,5° 26,5° ± 0,7°	31,3 ± 8,8 53,3 ± 7,4	3,11 > 0,05 4,43 > 0,05
Tip III n = 10	T T	42,2 ± 3,9	11,7° ± 6,6°	73,2 ± 12,4	29,45 < 0,05
Tip IV n = 1	TL	70	38	45,7	- -
Total n = 21	M	55,9° ± 17,7°	26,3° ± 17,7°	57,9 ± 18,3	30, 42 < 0,05

Table 1: Pre and postoperative mean Cobb angles for different curve types. (T: Thoracal curve, L: Lumbar curve, TL: Thoracolumbar curve, M: Major curves, n: number of cases, A: Average, Sd: Standard Deviation)

		Preoperative A ± Sd	Postoperative A ± Sd	Correction Percantages	t p
Type I n = 2	T L	56° ± 43,8° 27,5° ± 10,6°	40° ± 14,1° 37,5° ± 3,5°	16° ± 29,7° 10° ± 14,1°	0,76 > 0,05 1,00 > 0,05
Type II Lordotic n = 6	T L	8,2° ± 13,1° 18,3° ± 6,9°	28,3° ± 7,3° 31,7° ± 7,5°	20,1 ± 7,3° 13,3° ± 5,8°	6,73 < 0,05 5,68 < 0,05
Type II Kyphotic n = 2	T L	80,5° ± 14,1° 70,5° ± 5,1°	57,5° ± 11,1° 50° ± 0,0°	23° ± 4,2 20,5° ± 6,4	7,67 > 0,05 4,55 > 0,05
Type III n = 10	T T	7,9° ± 11,7° 23,2° ± 6,7	38,6° ± 4,2° 30,0° ± 7,3°	30,6° ± 8,4° 16,2° ± 5,2°	11,54 < 0,05 9,92 < 0,05
Type IV n = 1	T L	25° 30°	35° 40°	10° 10°	- - - -

Table 2: Pre and postoperative sagittal contour angles of different curve types. (T: Thoracal, L: Lumbar, n: number of cases, A: Average, Sd: Standart Deviation)

SAGITTAL CONTOUR	Type I	Type II	Type III	Type IV	Total
Within normal limits	2 (% 100)	4 (% 50,0)	9 (% 90,0)	1 (% 100)	12 (% 76,2)
Deviation less than 10°	-	3 (% 37,5)	1 (% 10,0)	-	4 (% 19,0)
11° - 20° deviation	-	-	-	-	-
Deviation more than 21°	-	1 (% 12,5)	-	-	1 (% 4,8)
TOTAL	2 (% 100)	8 (% 100)	10 (% 100)	1 (% 100)	21 (% 100)

Table 3: Distribution of cases according to deviation from physiological thoracal sagittal contours after instrumention with TSRH

art technology in addressing this complex problem (1-9).

The Harrington rod system, one of the cornerstones in scoliosis surgery can effectively correct the scoliotic deformity only in the frontal plane. It has been shown that its effect on the sagittal contours and rotation are minimal. This system has 15 % rod failure and 25 % pseudoarthrosis rates and its resistance to axial loading, lateral bending and torsional forces is minimal. Also its morbidity is high as 6-9 months of postoperative casting is required. An additional compression rod has a negligable effect on the rigidity of the system (6-9, 16, 17).

Modifications of HRSF and Luque-SSI systems are more rigid systems. Especially with the Luque-SSI system, high correction rates in the frontal plane have been reported. However, this system has a high rate of correction loss if postoperative external immobilization is not used. It has been reported that especially is osteopenic patients correction loss is inevitable as wire fixation is not stable in the axial plane (10-15,26-33). Furthermore, neurological complications such as cord contusion, root injuries and dura ruptures are seen in high rates such as 10-20 %. Wilberg and Thompson reported neurologic deficit rates as high as 17,7 % with SSI. Bernard and Johnston reported 2 cases in which wires broke under bending or torsional forces during activity or trauma and casued neurologic complications by protruding into the spinal canal (1, 8, 17, 18, 42, 43).

Cotrel-Dubousset system has found a wide utilization in spinal surgery in the recent years and there are a number of reports suggesting its high correction potential in all planes when compared to other systems. With the derotation manoeuvre, correction of rotational deformity in the transverse plane which is a revolution in spinal surgery can be achieved (3-5, 16-25).

Bonnel, in 1986, has reported that CD has equal resistance to compression with Luque-SSI but superior resistance to anterior, posterior, lateral bending and rotational forces when compared with other systems. Roach and Ashman reported CDI as the most resistant system to axial loading and torsional forces (20, 21).

A rigid plate implant, which is connected to a spinal rod an eye-bolt and locking nut, now available as the Texas Scottish Rite Hospital (TSRH) Crosslink was developed to bring the concept of rigid cross-bracing to reality by Johnston and Ashman, after their studies on the rod migration problem in the Luque-SSI system. The axial stiffness of an SSI construct was significanty improved by the simple addition of cross, links (26, 27).

In 1987 Johnston et al. reported that although a significant amount of derotation could be achieved with the Cotrel-Dubousset Instrumentation, its resistance to torsional loads was not sufficient. Biomechanical testing showed that the CDI system's resistance to torsion could be increased significantly with TSRH cross-link plates (26, 27).

In 1989 surgeons of Texas Scottish Rite Hospital developed the TSRH system which is basically a modification of CDI. Major advantages of the system are attachment of all elements to the rod by a three point locking system, all of the hooks are open and can be attached easily to the rods, the rods have 3 different types with varying hardness and 3 different screw designs. It has been reported that three point locking system has more rigidity than the rigidity achieved by breaking both screws on a closed CD hook (26, 27, 33-36). As all of the hooks are attached to the rod by the same system, it eliminates elements such as the connector, blocker and collar (26, 27, 34).

There is a minimal tendency for friction or binding between a smooth rod and hook body during a rotational manuever. Friction between a rougher knurled rod and hook body could prevent statisfactory rod rotation, or more seriously, it coult displace a hook during the rotation manuever if the binding is too great. Pedicle hook displacement into the spinal canal during the rotational maneuver has been suspected in some cases of neurologic injury associated with Cotrel-Dubousset Instrumentation (26, 27). The smooth rod of the TSRH system eliminates this potential risk.

Rotational correction of a scoliosis requires that the rod be stiff enough that the spine conforms to the contouring of the rod and that the kyphosis that is contoured into the rod is maintained after the rotational maneuver. Many surgeons using Cotrel-Dubousset Instrumentation have reported that the rod flexibility often does not produce the desired amount of kyphosis, because the rods bend intraoperatively during the rotation maneuver in response to the stiffness of the deformity. Rod flexibility provides a safety factor during the rotation maneuver in case the kyphosis countoured into the rod is excessive or the spinal deformity is too stiff to allow full rotational correction. For this reason, the TSRH instrumentation provides three levels of rod stiffness (26, 27).

Hooks and hook guides are neurologically safer. With anatomical design of the pedicle hook, it holds the pedicle and doesn't penetrate the cortex. Three different types of laminar hooks are available. Damage to the medulla spinalis removal of the wires in revision of SSI-Luque is absent (26, 27).

One of the major advantages of TSRH is its ease of instrumentation and revision. In CD if the screws are broken, hooks can be removed only by cutting the rod. As placement of the nuts are lateral, cosmetic complaints due to the prominent hooks and rods under the skin aren't seen contrary to CDI (26, 27).

In this study 21 TSRH instrumentations used in the treatment of idiopathic scoliosis between August 1991 and April 1992 at the 1st Orthopaedics and Traumatology Clinic of Ankara Social Security Hospital were evaluated. When all the patients were included averagely, 57 ± 18,3 % correction in the major curves was observed. In 76,2 % of the patients physiological thoracal kyphosis was restored.

The highest correction rate was obtained in the King Type III patients. In this group, the thoracal sagittal contours came within normal limits in 90 % of the patients. This group was followed by rigid double curves and thoracolumber curves.

Many spinal surgeons recommend anterior discectomy and fusion as a first stage and posterior instrumentation and fusion later in rigid curves and report their successful results on this subject (44-46). Johnston and Herring report that Cotrel-Dubousset's recommendation of placing of two rods to the concave side and appliaciton of transverse traction is not satisfactory in rigid curves. They suggest that anterior release, fusion and TSRH instrumentation and then posterior fusion and instrumentation in the same stage, or halo-traction after anterior release for a period of time and, fusion and posterior TSRH instrumentation and derotation achieves better results (26, 27, 47). These authors, contrary to King's suggestion in Type II patients recommend including the secondary curve in the lumbar region in the instrumentation and fusion area to prevent decompensation (26, 47).

Lower correction rates in the lumbar curve than the thoracal curve obtained in this study is related to application of CD planning in these curves to TSRH instrumentations, before Dr. Benli's (one of the authors of this study) visit to Texas Scottish Rite Hospital. Correction rate was significantly increased in two step operations.

In this study 4,3 % reversible incomplete neurologic defficit and hook dislocation complications were seen. It is thought that both complications were related to surgical application errors rather than instrumentation design and technique.

Postoperative cast or brace wasn't used in any of the patients and as correction loss and pseudoatrhrosis wasn't seen, this system was concluded to be very rigid.

Few reports have been published up to date on the utilization of TSRH in idiopathic scoliosis as sufficient follow-up period is not available. Although our are early results are very encouraging and deserve to be mentioned, the final results after longer follow-up periods should be taken into account. In this preliminary report we have found the TSRH system to be a safe and effective procedure in the treatment of idiopathic scoliosis.

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