Versatility of TSRH spinal instrumentation system

Experience in 67 patients with trauma and spinal deformities

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We evaluated the effectiveness of the TSRH (Texas Scottish Rite Hospital) spinal instrumentation system in treating patients with spinal deformities and trauma to the spine. 38 patients (29 women) with spinal deformities and 29 (13 women) with trauma to the spine underwent fusion using the TSRH implant system. In patients with idiopathic scoliosis, the amount of curve correction achieved varied depending on the curve pattern, where patients with single thoracic (type III) or single extended thoracic (type IV) curves showed an improvement of 54% and 63%, respectively, compared to patients with King type II curves in which correction averaged only 45%. We found the TSRH spinal system to be effective for correcting the scoliotic curve. The fact that no neurologic complications were observed and that patients demonstrated a rapid ability to stand and walk as compared to the lengthy immobilization required with more traditional methods, suggests that the TSRH system is superior for scoliotic curve correction.

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A universal spinal implant system must be able to safely and effectively treat instabilities arising from all possible causes throughout the spinal axis. Thus, it must be both versatile and flexible. The introduction of the TSRH universal spinal instrumentation system offered an alternative for correction of spinal deformities amongst a broad spectrum of implant systems. The system was developed in an attempt to improve existing devices, providing a safe and versatile method for correction and stabilization of the spine followed by spinal fusion. It was designed to provide a better fit of the rods with new hooks, to eliminate the pedicle hook shift and with the cross-link transverse connectors, to achieve a rigid and safe fixation without postoperative immobilization.

The TSRH system allows for easier revision surgery. Versatility of the TSRH system comes from its ability to build hybrid constructs, such as lumbar screws and thoracic or laminar hooks all attached to the same rod, while the flexibility of the system comes from the multiple positions in which the screws and hooks can be attached to the rods, the unique anatomical hook design and the special characteristics of the variable angle screws.

Proof of the universality of the TSRH implant system, however, depends on studies which can show its application to manage various spinal disorders, including scoliosis, trauma and degenerative deformities. We evaluated the effectiveness of the TSRH spinal instrumentation system in treating two different patient populations, those with spinal deformities and patients with spinal injuries.

Patients and methods

The TSRH system: The system consists of rods, hooks, screws and cross-links plates, in addition to the surgical instrumentation needed for implantation (Ashman et al. 1991 and 1993). The system has various hook shapes, several sizes of central posts and pedicle hooks are anatomically designed to encompass the pedicle without penetrating its cortex. Three standard laminars are used; a buttressed laminar which is used most often and 2 circular laminar hooks. A special transverse process hook has been found useful for the superior end of the construct on the convexity of a curve.

Screws with 2 head styles (fixed and variable angle) come in 3 diameters with varying lengths. Variable angle screws offer a rigid screw fixation at different degrees of angulation and displacement from the rod. The rods also come in 3 sizes and have hexagonal ends which facilitate rotation. Several sizes of cross-links plates prevent rod migration and increase the overall construct rigidity. Eyebolt assem-

blies ensure proper fit for the locking mechanism on each rod size. Moreover, an open or split eyebolt may be enclosed around a rod, in places where a regular eyebolt was needed, but had not been preplaced. In addition, top tightening eyebolts can make the hook easier to tighten in certain circumstances. Trial hooks which are identical to the implants are used for preparing the hook site. The fact that once the trial hook is inserted, it is not necessary to insert the implant hook until final instrumentation has been found particularly convenient.

Patients: During the last two years 38 patients with spinal deformities and 29 patients with spinal trauma underwent spinal fusion using the TSRH instrumentation system at the Department of Orthopaedic Surgery, University of Ioannina. Of the 38 patients with spinal deformities, 29 were women. 1 patient had neglected infantile scoliosis, 1 had juvenile scoliosis, 23 had adolescent scoliosis, 12 had adult scoliosis and 1 patient had adult kyphosis. The average age of children, at surgery, was 15 (11–19) years, the adults averaged 33 (20–68) years in age. There were 7 patients with King (1983) I curves, 11 patients with King II curves, 9 patients with King III curves, 8 patients with King IV curves and 2 patients with King V curves. The Risser sign was recorded for each young patient before surgery; 2 patients had Risser I, 3 had Risser III, 13 had Risser IV and 7 patients had Risser V.

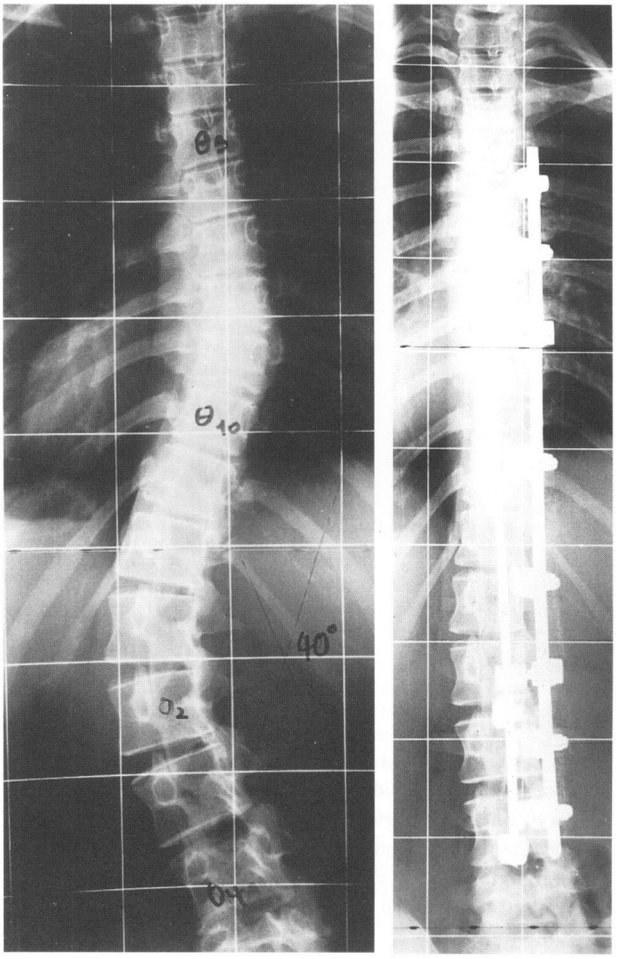


Figure 1. King IV left thoracolumbar idiopathic scoliosis measuring 40° in a 15-year-old girl. Excellent correction at 1 year using the TSRH spinal system.

Standing frontal and lateral plane radiographs were obtained preoperatively and the first week postoperatively. Side-bending and supine with manual traction frontal plane radiographs were examined preoperatively (Lonstein 1987, Soucacos et al. 1996). All measurements were made using the Cobb method. For spinal cord monitoring both somatosensory evoked potentials and wake-up test were used intraoperatively. In addition the controlled hypotension technique was used. The charts of these patients were reviewed for complications, estimated blood loss, operative time, postoperative immobilization and hospital stay.

The average age was 41 (16–70) years in the 29 patients (12 women) with a traumatic unstable spine. 13 patients had complete paraplegia, 4 had incomplete paraplegia and 12 patients were neurologically intact. Radiographs and computerised tomography were obtained in all patients. Surgery was performed between 24 hours and 9 months after injury. Of the 19 patients with thoracic fractures, 16 underwent posterior decompression and fusion using TSRH instrumentation, while 3 patients underwent a combination of anterior and posterior procedures. All 19 patients with thoracic fractures underwent placement of sublaminar, pedicle and transverse process hooks. Of the 10 patients with lumbar fractures, 7 underwent a combination of anterior and posterior procedures and also had placement of transpedicular variable angle screws, while the remaining 3 patients underwent posterior procedures only. 4 patients with fractures in the thoracolumbar region underwent placement of combination of hooks and screws. Placement of the rods was determined according to the mechanical analysis of each fracture, in a distraction, neutral or compression mode.

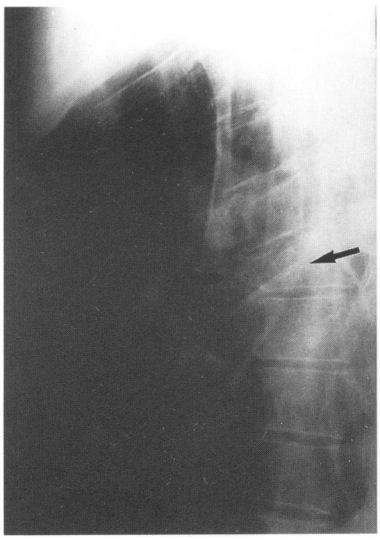
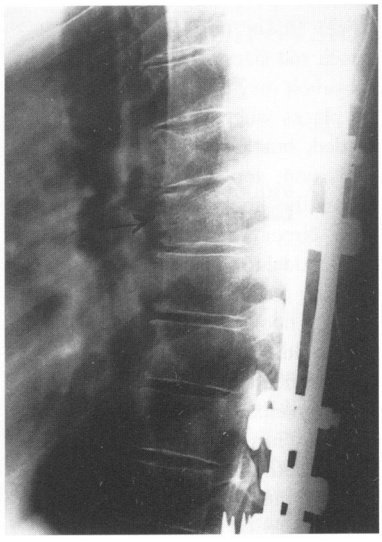


Figure 2. Preoperative view of a T5–T6 fracture/dislocation in 46-year-old man with complete paraplegia.



Immediate postoperative view with reduction of the dislocation and excellent anatomical correction of the wedge deformity of the T6 vertebra with the TSRH spinal implant.

Results

Curve correction varied depending on the curve pattern for patients with idiopathic scoliosis. 1 patient with a type King III curve which was extremely rigid due to ankylosing spondylitis and one patient with a large, rigid type IV curve related to neglected infantile scoliosis which had fused in situ were excluded from the final analysis. Patients with single thoracic or single extended thoracic curves (types III and IV) improved 54% and 63%, respectively compared with those with type II curves in whom the thoracic correction averaged only 45%.

Patients with single thoracic or thoracolumbar curve patterns types III and IV achieved the greatest degree of correction (Table 1). All but one of the patients with type II deformities underwent instrumentation of both curves; the one patient had selected instrumentation of the thoracic curve. The overall correction for King type II curves was 45%. Postoperative correction in the small number of posteriorly instrumented type I and V curves was 24% and 55%, respectively.

Intraoperative or postoperative transfusions averaged 3.7 (2–6) units. All patients received cephalosporine prophylaxis one day preoperatively, during surgery and for 72 hours postoperatively. The average operation time was 5 (4.5–6) hours, excluding anaesthesia preparation.

Ambulation usually started on the third postoperative day without spine immobilization, and the average length of hospitalization was 7 days. There were no intraoperative complications and no wound infections. Late complications included 2 cases of hook dislodgment in the group of scoliosis patients and 1 trauma case with inappropriate hook placement.

Table 1. Average frontal plane correction for the different King curve types

Curve type King	Preop. angle (°)	Postop. angle (°)	Correction (%)
I	58	44	24
II	67	36	45
III	55	25	54
IV	46	17	63
V	38	17	55

Discussion

The amount of curve correction we achieved using the TSRH system in patients with scoliosis was associated with the curve type, where single thoracic curves (types II and IV) showed greater correction compared to double curves (type II). This is probably due to the greater preoperative elasticity of single curves (Soucacos et al 1996). Similar results have been reported in previous studies (Richards et al 1994, Lenke et al 1992). We observed improvement of sagittal balance and no decompensation in type II

curves after surgery. The poor results associated with King type I curves may be attributed, in part, to the small number of patients and to the fact that 3 of the patients were adults with degenerative and translational deformities. In the later, we preferred hooks instead of screws, in order to avoid neurological complications in these, otherwise, neurologically intact patients.

The few complications could be attributed to the learning curve where dislodgment of the distal sublaminar upgoing hooks occurred in our second TSRH case. A similar complication occurred in an adult scoliosis with osteoporosis where fractures in the lamina resulted in hook dislodgment. Hooks were easily removed, releasing the eyebolt and nut mechanism without any loss of correction. The third revision included extension of the construction using the cross-links axial plates to securely link the rods end-to-end.

A universal spinal instrumentation requires implants capable to stabilize and manipulate the entire spinal column. These systems were developed to improve the management of scoliosis through application of multiple corrective forces. Our experience indicates that TSRH is a truly universal system which is able to safely and effectively treat instabilities arising from various possible causes throughout the spinal axis. Hooks, screws and cross-links plates used the same three-point clamping mechanism of the eyebolt-nut system and provided substantial resistance to axial, torsional, shear and bending forces. The design of the hooks allowed the rods to be inserted from above in proximity to either side of the hook. We found the system easy to apply for deformity correction and segmental fixation, and avoided the disadvantages of hook fixation, including the potential for neurologic injury secondary to sublaminar hook placement, thoracolumbar stabilization secondary to facet orientation, and cervicothoracic junction secondary to small pedicles and transverse processes (Stillerman et al. 1994). Pedicle screw fixation offered strength to the pedicle, no metalwork needed to be placed in the spinal canal, no need for fixation of posterior elements, anterior and posterior columns purchase, application of corrective forces, and potential for short segment fixation.

Since the TSRH instrumentation provided several levels of rod stiffness, a patient with a moderately flexible severe deformity, could be effectively treated with the use of the stiffer rods on the concavity of the curve. We found that this allowed maximal rotational correction to be reached, without loss of the contoured rod kyphosis. In addition, we found that the eyebolt mechanism made the system easy for revision, including extension of the existing instrumentation and replacement of failed implants; since by loosening the locking nut, the system could be removed immediately or new instrumentation could be added without disturbance. Overall, because the hooks, screws and cross-links used the same locking mechanism to attach to the rod and eyebolt system, the TSRH system proved to be exceptionally versatile. We found this to be its greatest advantage over other spinal implant systems.

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