BIOMECHANICAL EVALUATION OF TRANSPEDICULAR SPINAL IMPLANTS IN BURST FRACTURES

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Transpedicular implants are effectively used in the treatment of spinal burst fractures. The biomechanical proficiency of the Alıcı spinal instrument and the TSRH spinal instrument under axial loads were assessed in a comparative study. In vivo calf spines were used in these experiments. The burst fracture was simulated by a rubber spacer with a known density. The Alıcı spinal instrument is significantly stiffer than the TSRH instrument. On the other and, the TSRH system has almost no effect in stabilizing the fractured vertebral level when compared to the control group. These measures are true for the possible average axial load (450 N) that is suspected to affect a fractured spine of a standing human. Further studies are essential to evaluate the optimum strength of the above mentioned spinal implants under torsion and flexion-compression loads. To use rubber spacers to simulate burst fractures seems promising.

Key Words: *Spine, Biomechanics, Burst Fracture, Transpedicular Spinal Implant.*

INDRODUCTION

Thoracolumbar burst fractures and their internal fixation by transpedicular spinal implants are topics of interest as various modalities are under investigation. The objectives of surgical treatment are: 1. stabilization of the involved spine; 2. adequate reduction of the fractured vertebral body; 3. protection of the neural elements; and 4. providing earlier mobilization and care of the patients (1, 2, 3, 4). Posterior transpedicular systems are developed primarily to reduce the retropulsed fragment by distraction and ligamentotaxis. They also control the posttraumatic and postreduction kyphosis and limit the fusion to one level above and below the fracture (5, 6, 7). These instruments are effectively used after decompressive posterior laminectomy (8). The most commonly used posterior transpedicular spinal implants, at least in this country, are: 1. Alıcı Spinal Instrument, 2. Cotrel-Dubousset (CD) Transpedicular Instrument, 3. Texas Scottish Rite Hospital (TSRH) Universal Spinal Instrument and the 4. Isola Spinal Instrument. Two of these systems, the Alıcı spinal instrument and the TSRH universal spinal instrument, were biomechanically evaluated in a comparative study. The burst fracture was simulated by rubber spacers of three different densities.

MATERIALS AND METHODS

Preparation of the Calf Spines: The calf spines of the throacolumbar region were obtained from a local slaughter. Each specimen consisted of three vertebral segments. The anterior and posterior longitudinal ligaments, disc spaces, pedicles, and posterior elements of the spines were anatomically intact. Six specimens were used throughout the experiments. The specimens were kept in -20°C till the day of the experiment and they were thawed to room temperature three hours prior to the tests. The posterior part of the superior facets and the spinous processes of the vertebra were removed to enable the spinal implants to fit on to the posterior aspect of the spine. The average size of the most upper and lower faces of vertebral bodies and the length of the specimen were measured prior the biomechanical test in order to calculate the cross sectional area. The posterior aperture of each pedicle was prepared by pre-drilling with a 3.5 mm drill and pre-tapping with a 5.5 mm AO type tap. The vertebral body of the central spine and its adjacent disc spaces were removed by an electrical saw and the rubber spacer was placed in between the proximal and distal vertebral bodies with a precise fit to their endplates. The anterior and posterior longitudinal ligaments were transectioned at this time (Figure 1). Bone density and radiographic evaluation of the spines were not performed.

Rubber Spacers: The burst fracture was simulated by rubber spacers of three different densities. This seems to be a new approach, although rubber spacers have been used to simulate intervertebral discs (9). Soft, medium and hard rubber spacers are prepared and mechanically tested prior to the experiment. The shore of the soft rubber was 25, the medium 30, and the hard one was 40. Following mechanical tests with the rubbers, 30 shore rubber had the best resemblance to the properties of a burst fracture.

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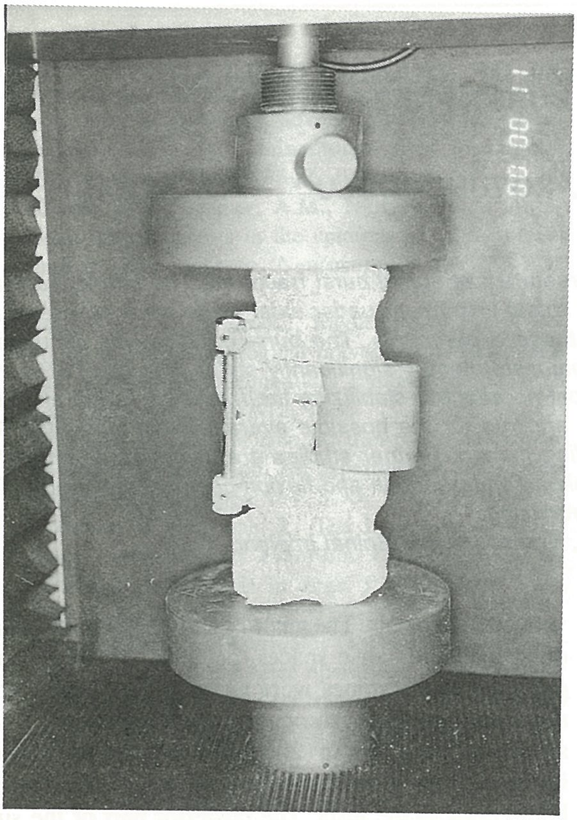

Figure 1: Experimental setup and the Alıcı spinal instrument while testing the sphecimen with the rubber spacer in place

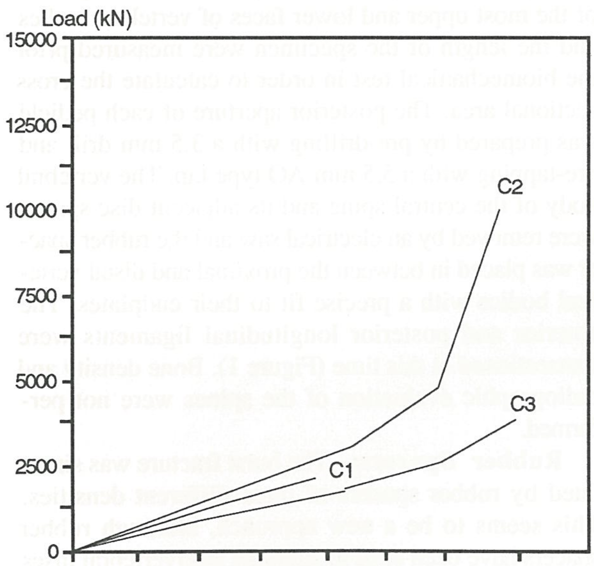

Figure 2: Load-deformation curves for three different shore rubber spacers

Spinal Instruments: The Alıcı and TSRH spinal instruments were utilized during the experiments. The pedicle size of each instrument was 6.5 mm and the screw length 40.0 mm. The rod length was 100.0 mm and the screws were placed to the distal and proximal endings of the rods to optimize the experiment. The torque produced during the screw placement and screw-rod fixation was not measured. The screws were applied to the pedicles with an approximately 5° to 10° inclination. The moduli of elasticity of the materials of the Alıcı and TSRH rods were determined prior the experiments.

Biomechanical Tests: The biomechanical tests were performed using the Lloyd M 30 K material testing device (UK) at the Biomechanical Laboratory of the Department of Engineering Sciences, Middle East Technical University. The test speed was 10 mm per minute and each specimen was tested up to 450 N in room temperature. 450 N is higher than the 350 N recommended by Edward's (10) and corresponds approximately to a sitting human 511). Load-deformation curves for destabilized and instrumented specimens are obtained. Two experiments were performed for each type of instrument. The control was with the rubber spacer but no instrument.

RESULTS

The load deformation curves for the three different shore rubber spacers is presented in figure 2. These results suggest that the 30 shore rubber is appropriate to be used in the simulation of a burst fracture. The experimental results are presented in figure 3. Recall that are performed only two experiments for each one of the two instrument types considered. In addition, we have a control experiment in which only the rubber spacer is used but not any instrument. Figure 3 presents the average of the two tests for each group. In this figure, "deformation" is the shortening between the two heads of the material testing device. Accordingly, the deformation includes the combined effects of the rubber spacer, the instrument and the soft and hard tissues of the spine.

DISCUSSION

Even though the number of tests were not sufficient to allow us to perform statistical analysis, the considerably higher contribution to the stiffness of the spinal construct provided by Alıcı instrument compared to TSRH instrument is evident. The load carrying capacity of Alıcı system seems to be higher, but the energy that this system can absorb is smaller.

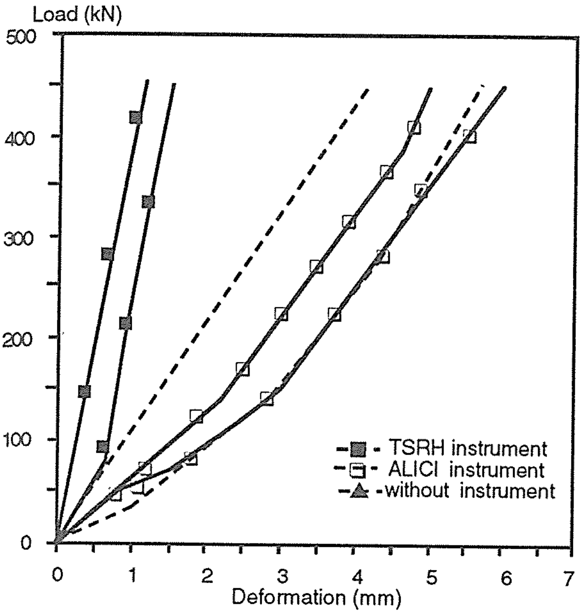

Figure 3: Comparison of the load-deforma-tion curves of the Alıcı and TSRH spinal instruments to the control specimens.

This implies that the impact loads in Alıcı system should be avoided. After 200 N load deformation curves exhibit a linear form; i.e., with the aid of implants the construct reach a constant stiffness which is higher than vertebra's original stiffness and this is approximately same for the TSRH instrument.

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