THE BIOMECHANICAL ENDURANCE OF ANTERIOR AND POSTERIOR ALICI SPINAL SYSTEMS AGAINST COMPRESSION FORCES IN BURST FRACTURES

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ABSTRACT :

We carried out this experimental study in order to compare and test the biomechanical strengths of Anteriar Spinal System and Posterior Alıcı Spinal System which we have been using in the treatment of burst fractures in our clinic since 1991. Biomechanical test were performed on 14 fresh thoracal 11 to lumbar 3 spines from calves and in the 13 of them burst fractures were formed. Six of them were stabilized by Anterior Alıcı Spinal System and 6 of them with Posterior Alıcı Spinal System. The thoracal 11 and lumbar 3 vertebrae and their inter vertebral discs of 14 vertebral columns were removed. Axial compression force which was 20 mm/minute ramp loading was applied to the experimental models in the Haunsfield universal materials testing device. The endurance of the intact vertebra to the axial compression force was 11000 Newton, the fractured vertebra's 7200 Newton, Anterior Alıcı Spinal System's 11500 Newton, Posterior Alıcı Spinal System's 15200 Newton while the fractured vertebra was deformed at 2800 Newton, this value in the intact and instrumented vertebrae were approximately 11000 Newton. Because the Anterior and Posterior Alıcı Spinal Systems have biomechanically nearly the same strength, in the treatment of burst fractures, especially those who need decompression, anterior approach with Anterior Alıcı Spinal System using decompression, correction and stabilization will be more beneficial to the patients who have burst fractures with significant retropulsion of bony fragments into the spinal canal.

INTRODUCTION :

Burst fractures of the thoracic and lumbar spine are unstable fractures caused by axial compressive load (8). The fact that a fragment of vertebral body is displaced backward into the neural canal increases the risk of damage to the cauda equina and conus medullaris (8, 9, 12). Many authors believed that such unstable fractures should be treated by surgical methods (2, 4, 7, 9, 11, 14, 15, 17, 18, 19). Various posterior surgical approaches and devices such as Harrington (11), luque (18), Dick (10), Cotrel-Dubousset (7), Alıcı (2) etc. were developed and started to be used widely in these fractures. However upon some reports indicating late onset of neurologic deficit after old burst injuries, some authors in order to obtain beneficial results started to perform anterior surgical approach along with anterior fixation for some burst fractures of the spine (5, 6, 9, 12, 14, 15, 19).

Today a generally accepted standard treatment protocol for burst fractures including surgical methods is not available. Spinal surgeons apply either anterior or posterior surgical approaches routinely according to their experiences. Various authors treat burst fractures with anterior approach using correction, decompression and stabilization (12, 14, 15) or with posterior approach (2, 9, 10, 11). Besides they treat these fractures with a combination of the two approaches, decompression from the anterior and correction and stabilization through instrumentation from posterior (23). Anterior Alıcı Spinal System (ASS) or posterior ASS are used widely in all of these 3 applications (2). We have been using anterior and posterior ASS in our clinic since 1991. In Turkish literature, there are two publication concerning the biomechanical compression of fixateur intern with Harrington instrumentation (3) and biomechanical analysis of pull-out strengths of augmentation of transpedicular screws with sublaminar wiring (1). However, there is none regarding biomechanical testing of anterior or posterior ASS.

For this reason we carried out this study in order to compare anterior and posterior ASS's. Because of this we tested the biomechanical endurance of vertebral columns having burst fractures in their lumbar 1 vertebras which were stabilized with posterior or anterior ASS against axial compressive forces in vitro conditions.

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MATERIALS AND METHODS :

Biomechanical tests were performed on 14 fresh thoracal 11 to lumbar 3 spines from calves. The spines, which were obtained from a local abattoir, were similar in size an age (approximately 2 years old). The spine of specimens were dissected off the surrounding soft tissue and muscle, with care being taken to preserve bone and spinal ligaments. Corpus of first Lumbar vertebra of 13 specimens were osteotomized from the middle transversely. By applying a second osteotomy beginning from the middle of the osteotomy line ranging to the inferoposterior the anterior and middle column were damaged and as a result an experimental burst fracture was done. Their stabilization was achieved by applying anterior ASS on 6 of them (Fig. 1) and posterior ASS on 6 of them (Fig. 2). THen, thoracal 11 and lumbar 3 vertebrae and their discs of all of the specimens were removed. Axial compression force which was 20 mm/minute ramp loading was applied to the experimental models in the Haunsfield universal materials testing device (Fig 3 - 4). Failure load and stiffness of the specimens were measured.

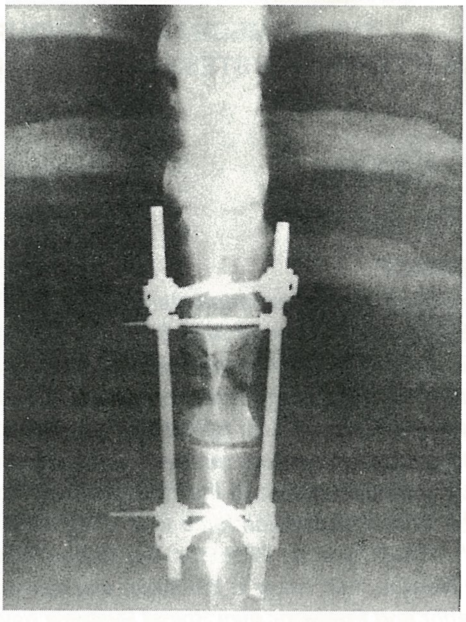

Figure 2 : Radiograph showing burst fracture of the lumbar first vertebra stabilized with anterior ASS.

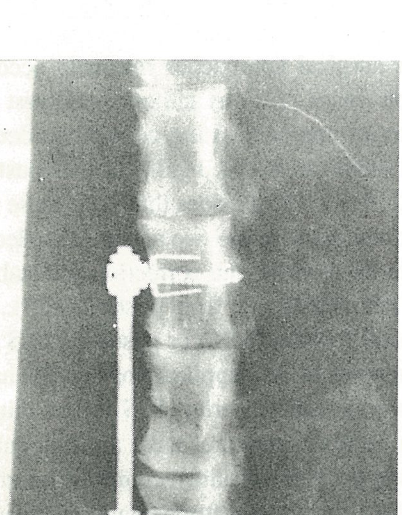

Figure 1 : Radiograph showing burst fracture of the lumbar first vertebra stabilized with posterior ASS.

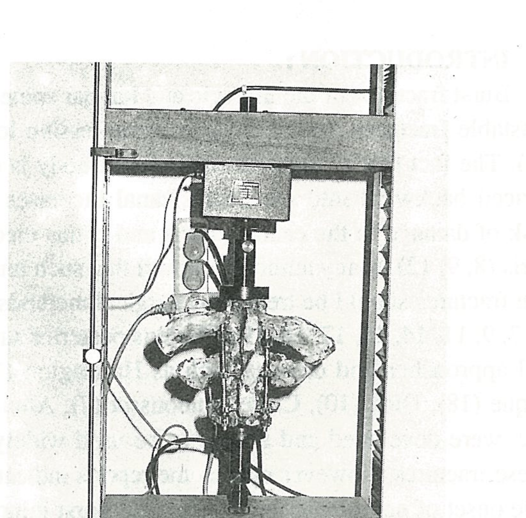

Figure 3 : Photograph showing experimental model of burst fracture of lumbar first vertebra stabilized with posterior ASS in the Hounsfield universal compression device.

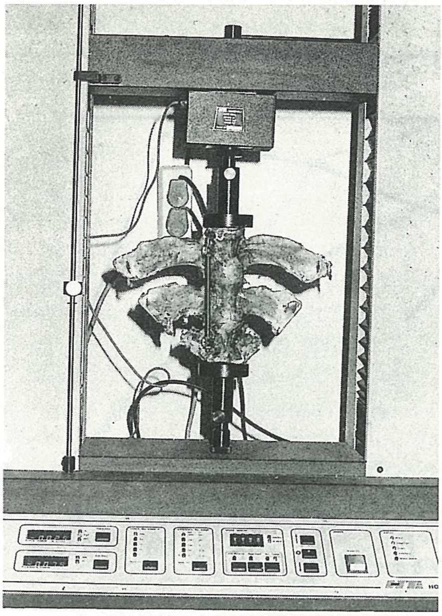

Figure 4 : Photograph showing experimental model of burst fracture of lumbar first vertebra stabilized with anterior ASS in the Hounsfield universal compression device.

RESULTS :

1. The failure load of intact vertebra against axial compressive load was 11000 Newton; whereas, the failure load of fractured vertebra was 7100 Newton. Following the 12 mm shorthening the endurance of fractured vertebra failed. While the intact vertebra keeped up its endurance until a 14 mm shortening. In the Figure 5 the axial compressive forces applied on intact and fractured vertebrae and the height losses formed by these can be seen with graph.

2. The failure load of vertebral segment which was stabilized by posterior ASS against axial compressive load was average 15200 Newton. This value was average 11500 Newton in the system which had anterior ASS stabilization application. The graphs in figures 6/A, B, C, D, E the endurance that the experimental models showed against 20 mm/minute compressive force in the comparative experiments carried out using anterior ASS and posterior ASS and together with the amount of compressive forces at this time the height losses that these forcs caused can be seen. Both the posterior and the anterior ASS showed endurance until 12 mm against the axial compressive load. Over these values, although posterior ASS was observed to be carrying the load, a very quick height loss (failure of the stiffness) in the vertebra was formed.

3. In the lower values of axial compressive forces there was not a major difference among endurance values in all specimens. This condition corresponds to a 4 mm shortening that is formed by 2800 Newton. A fast height loss is formed above these values in the fractured vertebra. In the intact and in the instrumentated vertebra this value was approximately 11000 Newton. In the instrumented systems the load over 2800 Newton carries implants.

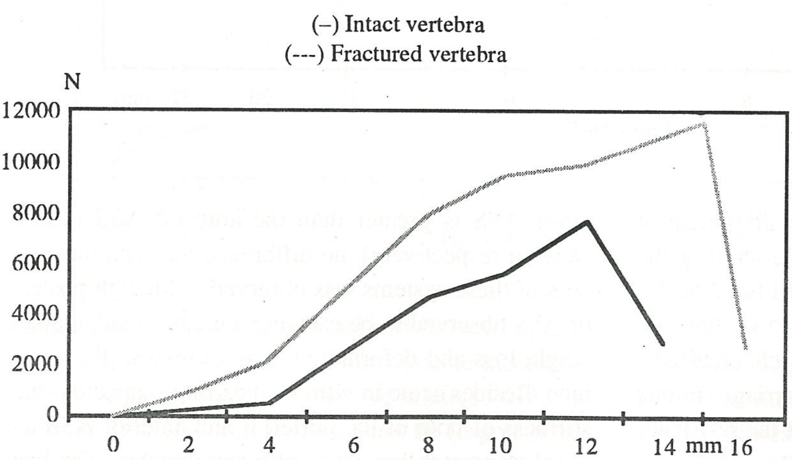

Figure 5: The axial compressive forces applied on intact and fractured vertebrae and the height losses formed by these (load - deformation curve) can be seen with the graphic.

DISCUSSION :

Today the superiority of surgical treatment of unstable vertebral fractures over postural reduction (whether may have neurological deficit or not) is generally accepted (2, 4, 6, 8, 10, 11, 16). The purposes of the surgical treatment of unstable vertebral fractures are to restore the normal anatomic alignment of the vertebral column, to decompress the spinal canal, to protect the neurologic structures and to obtain early mobilization of the patient. In order to achieve these goals, various anterior and posterior spinal systems are used. A good spinal system should not be insufficient biome-

Figure 6: The load-deformation curves of the experimental model against 20 mm/min compressive force in the comparative experiments carried out using anterior ASS and posterior ASS can be seen in figures A, B, C, D.

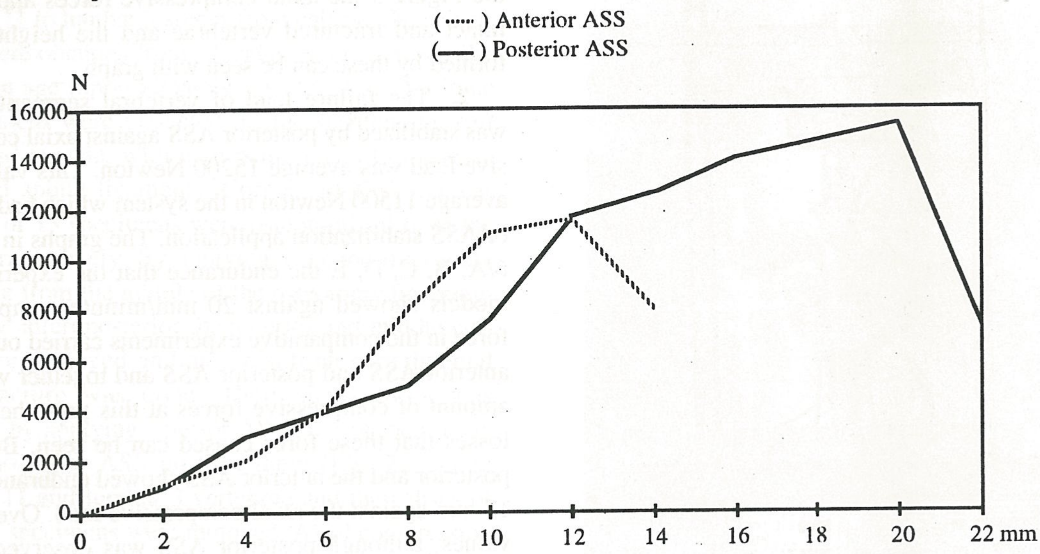

Figure 6-A

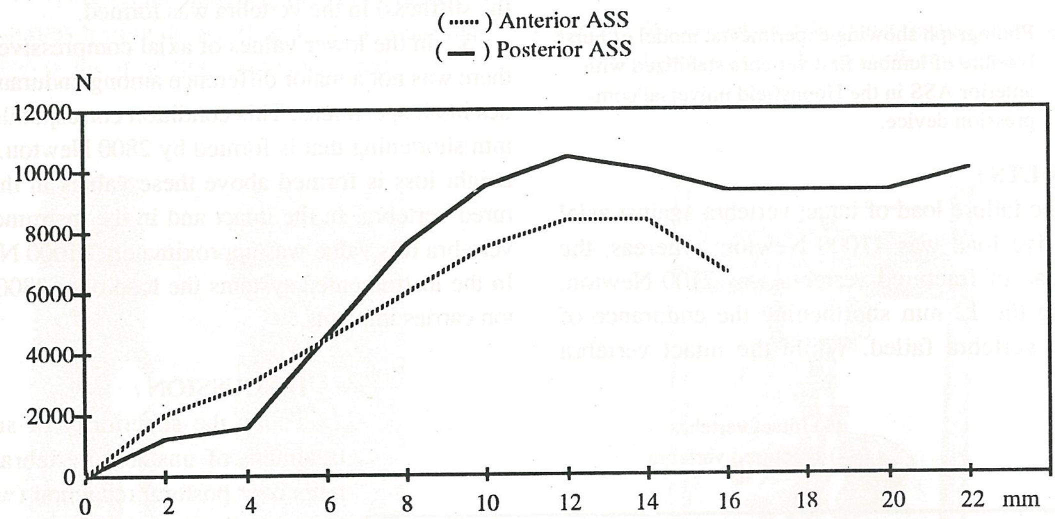

Figure 6-B

chanically while restoring the anatomic alignment of the injured vertebral column and while sharing the loads acting on the vertebra until a solid biologic fusion takes place (2, 7, 10, 14, 15, 16, 21). For this reason it should have two biomechanical characteristic properties. These are the limit of load carriage (failure load) and stiffness which is a measure of the resistance of the construct to deformation when the consruct is subjected to a load (13, 16, 20, 21, 22). According to our results, although the load carriage capacity of posterior ASS is greater than the anterior ASS (15200 Newton respectively), no difference between the stiffness of these systems was observed. Although posterior ASS observed to be carrying a greater load, a quick height loss and deformation was formed in the vertebrae. Besides acute in vitro load carriage capacities and stiffness of both of the posterior and anterior ASS are equal or greater than those of intact vertebra. The load that falls on the lumbar vertebrae in erect position approximately 4 times of the body weight; for a 80 kg

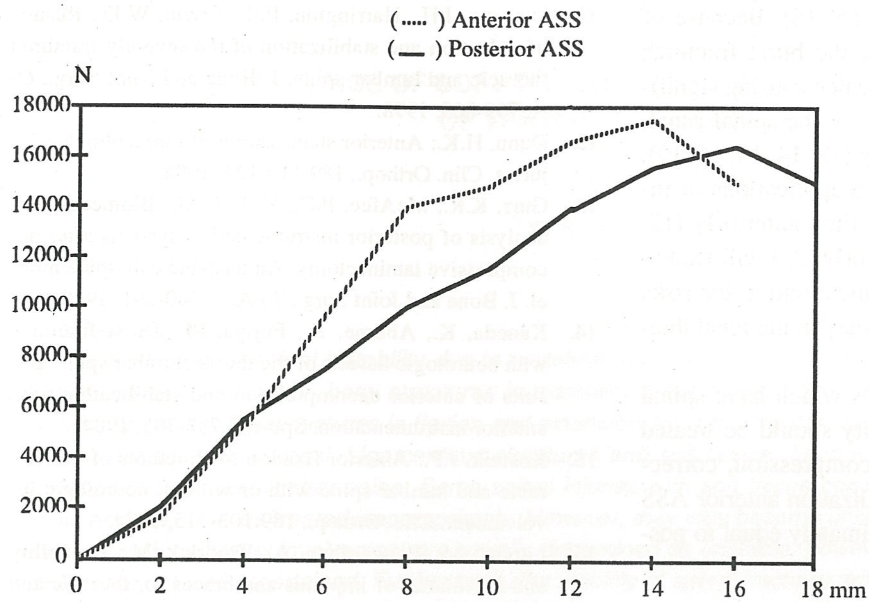

Figure 6-C

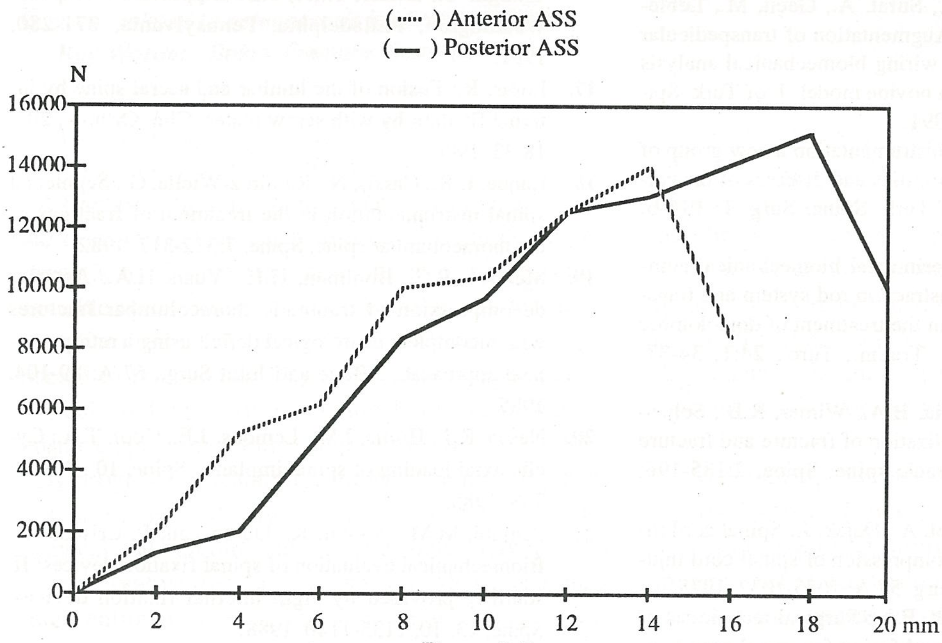

Figure 6-C

person, this load is approximately 3140 Newton (16). This value, from the point of view of acute loading, is very much lower than the values we achieved from our experiments. However, it should not be forgotten that for months on in vivo 3000 Newton force will effect cyclically the spinal implants. For this reason, the presence of pathologies which will delay the union of the fracture of the vertebra or the solid biological fusion of the injuried spinal segment, will lead to late device failures even in the strongest implant (10, 16, 17, 24).

Various posterior spinal systems are applied in the treatment of burs fractures for decompression, correction and stabilization from posterior surgery (9, 10, 11, 18). The superiority of transpedicular systems (like Cotrel-Dubousset), according to rod-hook systems, sublaminar wiring or the modifications were hown (13, 22). It was show that the posterior ASS equal or better than Cotrel-Dubousset system clinically (2). Spinal cord decompression in posterior surgery is achieved by the indirect reduction of the fracture through ligamentotaksis (2, 10, 11, 16). With this technique the removal of bone fragments from the neural canal is possible if the bone fragments would remain attached to the annulus fibrosis, posterior or anterior longitudinal ligament (14, 15, 16, 22). Various reports have now indicated that this is not always valid for burst fractures (5, 14, 15). Besides during the fracture the penetration of neighboring discs into the corpus of the vertebra will cause the delay of the union of the fracture and in this way it will lead to late device failure of the spinal system (6, 12, 15, 16). Because of these reasons, the spinal cord in the burst fractures which have neurologic deficit or which causing significant occlusion (greater than 50%) of the spinal canal, should be decompressed anteriorly (12, 14, 15, 16, 19). In these cases for stabilization the applications of instrumentation either in the same time anteriorly (12, 14, 15) or in a second one posteriorly (23) will lead to a second surgical injury in the patient and to the risks that it will bring with it and to a delay in the rehabilitation of the patient (14, 15).

As a result, the burst fractures which have spinal cord decompression as the priority should be treated with anterior approach using decompression, correction and stabilization. In the stabilization anterior ASS which is biomechanically approximately equal to posterior ASS can be used.

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