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Comparison of the Use of Dowel-Supported and Cement-Supported Transpedicular Screws In Fresh Frozen Calf Vertebrae: An Experimental Study

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Abstract: The aim of this experimental was to compare the durability of the use of the study transpedicular screw supported by dowel or bone cement. In this experimental study which was performed on fresh frozen calf vertebrae, two groups were formed. 7 fresh frozen calf vertebrae were used in each group (n=7). A transpedicular screw supported by a dowel was placed to the left side of the vertebrae and a transpedicular screw supported by bone cement was placed to the right side. Then mechanical pulling force was applied to these groups. The force at which the pull out of the screw occurred and the expansion value up to the moment of pulling out were recorded. There was no fracture in any subject. There was no statistically significant difference between groups in terms of pulling out and expansion value (p = 0.58). There is no difference in durability between the uses of a transpedicular screw supported by a dowel or bone cement.

Keywords: Transpedicular screw, bone cement, dowel, vertebrae.

INTRODUCTİON

Internal fixation applications with the transpedicular screw have been used since 1958 [1]. Fixation with pedicle screw fixation provides a strong vertebral segmental fixation with high bone fusion and protection of adjacent normal segments. Pedicle screws application have some advantages. Some of these advantages are being effective in fixing the spine rigidly, usability in laminectomized vertebrae, keeping the instrumentation level short, being a suitable method for instrumentation of the sacrum and maintaining normal spinal curvature [2].

Although transpedicular screw application is an effective and safe method, however its usage may have some complications such as fracture, loosening, peeling and migration. Various studies have been performed in order to investigate the causes of these complications, to evaluate the stability of pedicle screws and to develop the existing systems [3].

The aim of our study was to compare the durability of the use of the study transpedicular screw supported by dowel or bone cement.

MATERIALS AND METHODS

This experimental research was carried out in the Division of Mechanical Sciences of Mechanical Engineering Department of Karadeniz Technical University. Ethics Committee of Karadeniz Technical University was approved (numbered 354, protocol numbered: numbered 2011/18, and dated 05.05.2011).

This study was composed of 2 groups; each of them included 7 fresh frozen calf vertebrae. In the first group, transpedicular screw supported by a dowel was placed onto the calf vertebrae. In the second group transpedicular screw supported by bone cement was placed onto the calf vertebrae.

7 fresh frozen calf vertebrae were bought from a local butcher. In this study, 14 titanium alloyed screws with eight grooves were used. They were 3.5 x 45 mm in dimensions. Depth of the grooves was 1 mm and groove intervals were 4 mm (Blackstone titanium 6-aluminium 4-vanadium model ASTM-136 Thoracic Screw). Plastic dowels which were 3,3x45 mm in dimensions were used in the study had seven grooves (Fisher Germany Art.- Nr 58106). Instron 3382 universal testing machine was used for mechanical pulling force.

In this study, we identified two experimental groups and 7 subjects in each group (n=7). In the first group, plastic dowels were placed to the left pedicles after drilling on the wax-fixed fresh frozen calf vertebra (Figure-1). After placing the dowel, a transpedicular screw was been placed into the dowel. In the second group, after drilling the right pedicle, bone cement was been placed and just after that a transpedicular screw was been placed. Bone cement was consisting of polymethylmetacrilate. After these steps a computed tomography image was taken for checking the appropriate positioning of the transpedicular screws (Figure-2). These vertebrae were then placed in the machine (Instron 3382) to apply mechanical pulling force.

Pulling force was applied in one direction and the force was applied by increasing it to 10 newton / second (Figure-3). Forces at where pulling out of the screws occurred were recorded.

Fig-1: Wax-fixed fresh frozen calf vertebrae, a dowel is seen on the left side

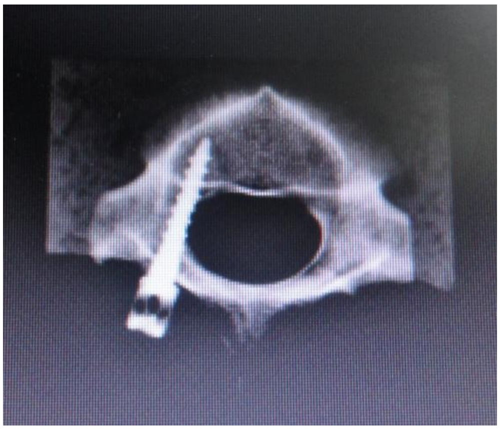

Fig-2: CT image after placing the transpedicular screw

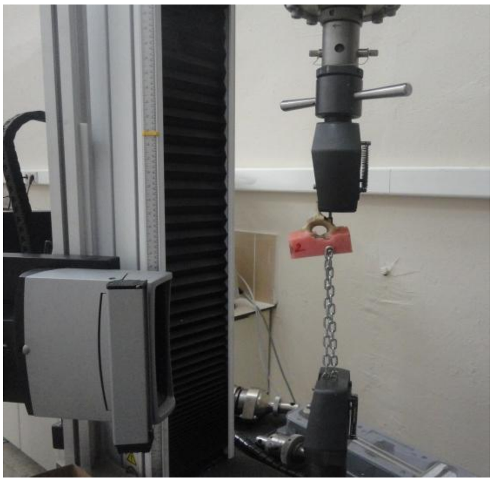

Fig-3: An image of the applying the pulling force of the machine

Statistical Analysis

Parametric test was used to determine mean differences. Results were compared statistically by using Independent Samples test. P values lower than 0.05 was accepted as statistically significant. Statistical analysis was carried out using statistical package SPSS (version 15.0).

RESULTS

The forces which were applied and expansion values are seen on table-1. The p value was detected as 0.58 between the groups in terms of applied force and expansion value. We didn't detect any fracture of the screw or pedicle during procedure.

Table-1: The applied forces where pulling out of the screw occurred and expansion values

Experiment group	Applied force (N)	Expansion
Group 1-1	904.75027	8.52682
Group 1-2	1983.00593	5.50649
Group 1-3	2062.83797	6.85325
Group1-4	1007.70732	9.33182
Group1-5	1601.25103	5.14650
Group1-6	114570186	4.85341
Group 1- 7	1506.98554	3.48011
Group 2-1	919.35294	11.20545
Group 2-2	138.86141	5.43014
Group 2-3	821.52598	3.27066
Group 2-4	1158.20551	5.16665
Group 2-5	369.36209	4.04841
Group 2-6	694.85134	3.67670
Group 2-7	1669.28992	5.86989

DISCUSSION

The results of this study showed that applying transpedicular screw supported by bone cement and dowel has no advantage to each other.

Transpedicular screw application is a widely used technique in spinal surgery [4]. This application stabilizes all the three columns of the spine. The screws allow for reduction maneuvers and allow lordosis to continue [5, 8]. Researchers can use various tests such as flexibility tests, load and fatigue tests that damage synthetic or cadaveric models, physics based models, or finite element models to get and advance their information about the spine biomechanics [6, 7]. The best spinal models are adolescent or young adults are vertebras taken from cadavers, however, their supply is difficult. It is also necessary to measure bone mineral density due to biological differences. Therefore, different spine models have been used (such as cattle, sheep, and rabbit spine or plastic models [8]. In animal spine models, mostly calf and sheep spine models are selected. In some studies the biomechanical properties of the calf spine have been shown to be similar to the human spine [9, 10]. Of these, the calf spine is the best alternative to the human spine in terms of shape and bone material [5, 8]. In addition, the calf vertebrae have similar mineral density similar to that of young people [11]. Another advantage of the use of the calf vertebrae is that its easy supply. Because of the aforementioned reasons, we used fresh frozen calf vertebrae.

Factors related to bone attachment properties of the transpedicular screws include the location of the application, preparation of the application area, the application force, the depth of the application, the diameter of the screw, the anatomical structure of the screw (screw thread penetration, screw thread prevalence, screw step, screw tip shape etc.), the loss of bone tissue, the structural features of the pedicle, and bone mineral density [12]. In some studies, transpedicular screw supported by the dowel was been compared with the transpedicular screw which was the same dimensions in osteoporotic spine and they find the superiority of the dowel-supported screw [13].

Application of the bone cement may have some complications. Zindrick *et al*., reported that the bone cement applied under pressure doubled the pulling out forces [14]. Şar *et al*., reported that the larger diameter screw application was superior to bone cement application in pull out cases [8]. In addition, it has been reported that bone cement may escape to the epidural space and lead to neural complications, also may cause embolism in large vessels and cause paraparesis, paraplegia or serious pulmonary problems [15, 16]. The use of dowel-supported transpedicular screw prevents the bone cement related complications.

One of the disadvantages of our study is that the dowels are made of plastic material and have no biocompatibility. Nowadays, dowels made with polyetherheretherketon (PEEK) have been patented. One of the important results of this study is that it allows the stabilization applications to be made with dowel considering the previous studies [13].

CONCLUSION

In this study, we compared the use of a transpedicular screw supported by a dowel and the use of a transpedicular screw supported with bone cement. As a result, no statistically significant difference was found between the transpedicular screw supported by cement and the transpedincular screw supported by the dowel.

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