A BIOMECHANICAL ANALYSIS OF THE PULL-OUT STRENGTH OF LATERAL MASS AND PEDICLE SCREWS IN LOWER CERVICAL SPINE

Sait NADERİ*, Mustafa FİDAN, Adnan ATICI****, Kemal YÜCESOY*,**

Handan ÇAKMAKÇI*, Tansu MERTOL*, M.Nuri ARDA***

ABSTRACT:

Posterior cervical instrumentation can be performed using lateral mass plating. Recently, pedicle screws have been used to avoid complications regarding pull-out. This study was planned to compare the pull-out strength of lateral mass screws and pedicle screws. Eight lateral mass screws and 11 pedicle screws were used. A mechanical device was used and a pull-out force applied at a loading rate of 6 mm/min. A mean of 88.25±12.52 and 348.64+38.58 Newton force were applied to lateral mass screws and pedicle screws, respectively. The results of this study supported the idea that pedicle screws provide a better screw pull-out resistance. It is concluded that pedicle screws have better pull-out resistance.

Key words: Biomechanics, cervical spine, lateral mass screw, pedicle screw

INTRODUCTION

A variety of procedures including, wiring and plating techniques can be performed to restore stability with lower cervical spine instability. Although lateral mass plating has been a choice of surgery in most cases with posterior cervical instability in the last decade (2), this type of screw fixation may be associated with some biomechanical disadvantages including short moment arm, and relative weakness of the lateral masses, particularly in C7 level. This leads to screw loosening, cut out and pull-out problems (2,3). Therefore, some authors prefered to use the pedicle as the bone-implant interface (1,4,6). This study was planned to compare the pull-out strength of lateral mass and pedicle screws in the lower cervical spine.

MATERIAL and METHODS

Four human lower cervical spines obtained from fresh cadavers were used in this study. The muscles of 20 vertebrae were dissected, so that only bony structures and ligaments left intact. All the specimens were analysed with computed tomography to detect the bone density of corpus pedicles and the lateral masses. According to measurements performed by computed tomography (Figure 1) eleven out of 20 vertebrae were found to be adequate for this study (bone density >100 mg/cc).

Screw insertion process was performed by the same surgeon to reduce the effect of variation in

* Dokuz Eylül University, School of Medicine, Departments of Neurosurgery,
** Biophysics and *** Radiology
**** Dokuz Eylül University, Occupational Technical College - İZMİR

techniques. The lateral mass screw was inserted according to Magerl (7) in a bicortical fashion, whereas the pedicle screw was inserted according to Abumi (1).

The pedicle screws were inserted in to the right side, whereas the lateral mass screws were inserted in to the left side of the specimens. A destruction of lateral mass occurred in three out of eleven vertebrae at the time of harvest. Therefore, 11 transpedicular and eight lateral mass screws were inserted.

A custom-made device was used to fixate an individual vertebra during the testing and a custom-made clamp connecting to screw head was used to pull the screw out. The second end of the grasping clamp was connected to Tensile Testing Machine (Lloyd I, England) (Figure 1).

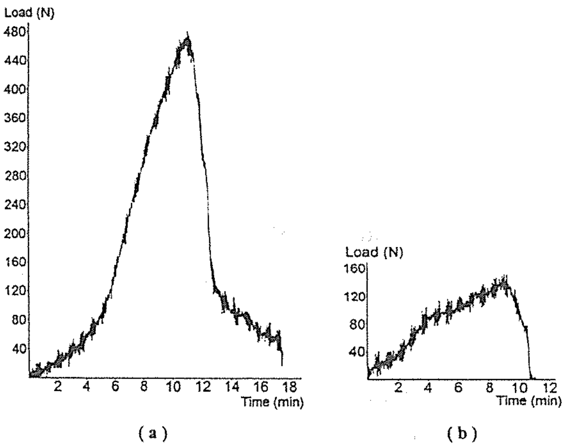

Figure 1. The load-time diagram of one case after pedicle screw (a) and lateral mass screw (b) insertion. In this particular case, pedicle screw showed a significantly hetter (460 N) pull-out strength when compared with lateral mass screw which shows a 150 N pull-out strength.

In order to connect the pull-out grasping clamp to the screw head and pull it out, the last thread of the screws was not inserted. A 3.5 mm screw was used for both the lateral mass and the pedicle. The lateral mass screws were 14 mm in length, whereas the pedicle screws were 24 mm in length. The grasping clamp was connected to the Tensile Testing Machine and screws were pulled out 6 mm per minute. The pull-out force was applied in an iso-axial manner with no torque. In all specimens, lateral mass screws were tested first. The results of the tests were recorded using a PL3XY/t Recotder (Lloyd instrument-England) in a special paper. The results were compared using student's t test.

RESULTS

The pedicle screws were pulled out by a mean 348.64±38.58 Newton (range 190-560 N), whereas lateral mass screws were pulled out by a mean 88.25+12.52 Newton (range 35.40-127.95) (Table 1).

Table 1. The applied load to the pedicle and lateral mass

Pedicle	Lateral Mass
305	68
380	60
290	58
290	58
460	150
290	132
560	90
310	--
560	90
190	--
200	--

The comparison between the pull-out strengths of pedicle screws and lateral mass screws was found to be significant (P=0.008). Figure 2 shows a load-time diagram comparing pull-out strength of pedicle and lateral mass screws.

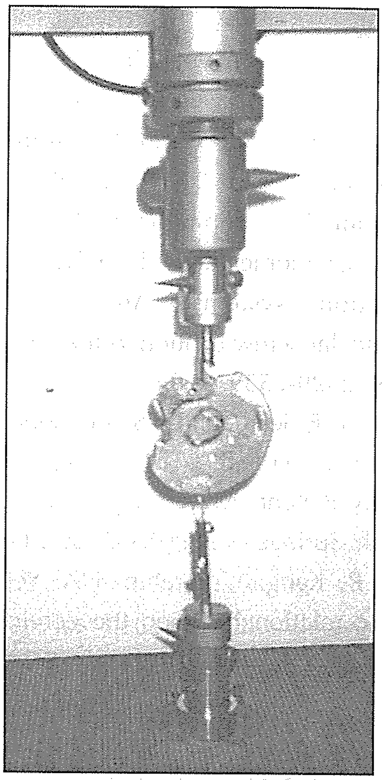

Figure 2. Tensile Testing Machine

DISCUSSION

The results of this study revealed that transpedicular screw fixation provides comparatively better pull-out strength. Thus, pedicle screws fixate cervical spine better than lateral mass ones. The results of this study, however, show a wide range of pull-out strength in both lateral mass and pedicle screw groups. This large range of pull-out strength may be explained by the variations in the thickness of different vertebrae in different individuals.

The effectiveness of pedicular fixation has been shown by two different studies (5,6). Kotani et al. (6), first compared the biomechanical properties of different anterior and posterior fixation devices in Bovine. Transpedicular fixation and combined anterior plating and posterior wiring were comparable in one level constructs. The biomechanical advantage of transpedicular screws was most apparent for the combination three-column, two-level instability pattern. The second study dealing with transpedicular fixation was performed in human by Jones et al(5). Jones et al. reported that pedicle screws demonstrated a significantly higher resistance to pull-out forces than did lateral mass screws. The results of our study is paralel to the results of other reported studies.

Despite the biomechanical advantages of transpedicular fixation, this type of fixation is more dangerous than lateral mass fixation. The cervical pedicle is surrounded by many neurovascular structures. Above and below are nerve roots, laterally and medially lie vertebral artery and spinal cord (4,8). The aforementioned anatomical relationships limit transpedicular fixation, and dictate a thorough knowledge regarding pedicle anatomy on the basis of preoperative CT scan. Even under ideal conditions, a cortical violation may occur. Preoperative work-up for transpedicular fixation should include pedicle diameter (both medial-lateral and superior-inferior), and optimal length of screw to be used. Altough we used 3.5 mm screw for pedicles with no complication, the diameter of pedicle may be smaller and requires the use of a thiner screw (2.7 mm). The relatively large length of the pedicle screws adds an additional pull-out strength in thinner screws (i.e., 2.7 vs 3.5).

The main drawback of this study was to compare a shorter and a larger (14 mm versus 24 mm) screws. This is so, because the lateral mass anatomy limits the use of a larger (e.g., 24 mm) screw.

In summary, it is concluded that the pedicle screws provide a better pull-out strength. Despite this biomechanical advantage, cervical pedicles are close to many neurovascular structures. This fact dictates a carefull three-dimentional analysis of pedicle anatomy before operation.

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Corresponding Address:
Sait Naderi, MD.
Dokuz Eylül University Hospital
Department of Neurosurgery
Izmir, Turkey
Fax:90-232-259 97 23
e-mail:snaderi@kordon.deu.edu.tr