PULL-OUT STRENGTH OF OCCIPITAL SCREWS

A biomechanical comparison of monocortical and bicortical screws placed in the different points of the occiput

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ABSTRACT

Several disorders lead to craniovertebral junction instability, and require an occipitocervical fixation. In cases in which screw is the choice of fixation, the types and places of the screws may affect the pull-out strength of the screw. The aim of this study is to compare pull-out strength of different screws inserted into the occipital bone in the midline and paramedian regions in a monocortical and bicortical fashion. This biomechanical investigation revealed the strongest pull-out strength in the midline following a bicortical screw insertion (521.14 ± 91.66 N), and the weakest pull-out strength in the lateral position following a monocortical screw insertion (271.85 ± 88.02). It is concluded that the bicortical midline occipital screw placement provide a biomechanical advantage.

Key words: Biomechanics, Craniovertebral junction, Occiput, Screw fixation

ÖZET

OKSİPİTAL VİDALARIN SIYIRMA DAYANIMI

Birçok hastalık, kranyovertebral bileşke instabilitesine yol açar ve oksipitoservikal fiksasyon yapılmasını gerektirir. Fiksasyon amacıyla vida kullanıldığı zaman, vidanın tipi ve yerleştirildiği yer, sonucu etkileyebilir. Bu çalışmanın amacı, oksipital kemikte, orta hat ve paramedian olarak yerleştirilen farklı vidaların sıyırma dayanımlarını karşılaştırmaktır. Bu çalışmada, en güçlü sıyırma dayanımının, orta hatta bikortikal olarak yerleştirilen vidalarda olduğu (521.14±91.66 N), en zayıf dayanımın ise monokortikal vidalarda olduğu (271.85±88.02) belirlenmiştir. Orta hatta bikortikal olarak yerleştirilen vidaların, biyomekanik olarak avantajlı olduğu sonucuna varılmıştır.

Anahtar sözcükler : Biyomekanik, Kranyovertebral bileşke, Oksiput, Vida fiksasyonu.

INTRODUCTION

Several diseases lead to craniovertebral junction instability requiring an occipitocervical fixation procedure using wires and screw (2,7,9,10). Recently, it has been shown that screw placement provided a better fusion rate than the wires (3). The use of the screw in the occipital bone dictates knowledge regarding occipital bone thickness to prevent the penetration of the inner table of the occipital bone, as well as an attention to the pull-out strength of the placed screws (1,2,9,11). Although there are some studies on the biomechanical effects of different cranivertebral junction fixation methods, there is only one study comparing the biomechanical effect of screw placement type and site of occipital screws (3,5). This study reports the biomechanical effects of

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different screws placed in the midline and paramedian areas of the occipital bone in a monocortical and bicortical fashion.

MATERIAL AND METHODS

Seven human occipital bones obtained from fresh cadavers were used for this study. All soft tissues including the superficial and the deep muscles in the region of the craniovertebral junction were dissected, so that only occipital bone left intact. The soft tissues of the other regions of the head were not dissected.

After preparetion of the occipital bone and determination of the bony landmarks, four points were chosen for screw insertion including two points in the midline (number 1: 2 cm. below the inion, and number 2: 4 cm. below the inion); and two points in the lateral (number 3: 2 cm. lateral to the midline and 3 cm. below the inion on the left side; and number 4: 2 cm. lateral to the midline and 4 cm. below the inion on the right side) (Figure 1).

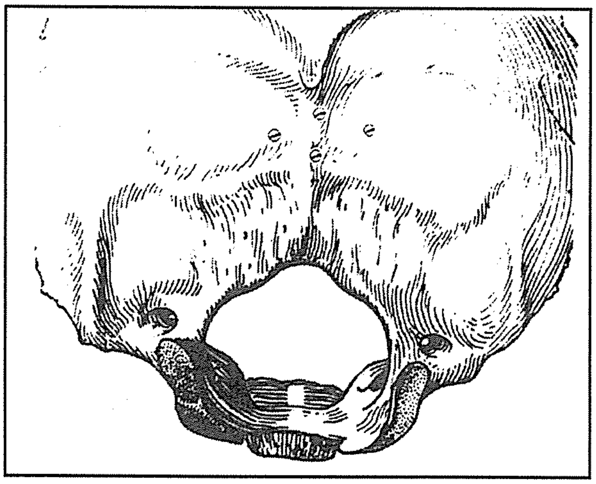

Figure 1. The sites of screw holes on the occipital bone. I: Midline bicortical; II: Midline monocortical; III: Lateral bicortical, and IV: Lateral monocortical.

Screws were placed after a bicortical drilling and tapping procedure. Two of the four screws were placed bicortically (points number 1 and 3) and the other two monocortically (points number 2 and 4). Screw insertion process was performed by the same surgeon to reduce the effect of variation in technique. A 3.5 mm. screw was used for both the midline and lateral screw placement. The lateral placed screws were 5-7 mm. in length, whereas the midline screws were 8-9 mm. in length. The length of the chosen screws depended on the thickness of each particular bone. The monocortically placed midline screws were inserted into the thicker points of the occipital bone, whereas the bicortical screws were placed 1 cm. inferior to the monocortical screw holes where the occipital bone was thiner and adequate for bicortical screw placement. Similarly, the monocortically placed lateral screws were placed in an appropriate point, so that the bone purchased whole the screw, whereas the bicortically placed lateral screws were inserted into the occipital bone in the thiner area.

A custom-made device was used to fixate the head during the testing. This fenestrated device covered the skull and allowed the connection between screw, connecting clamp and tensile testing machine through its fensters (Figure 2).

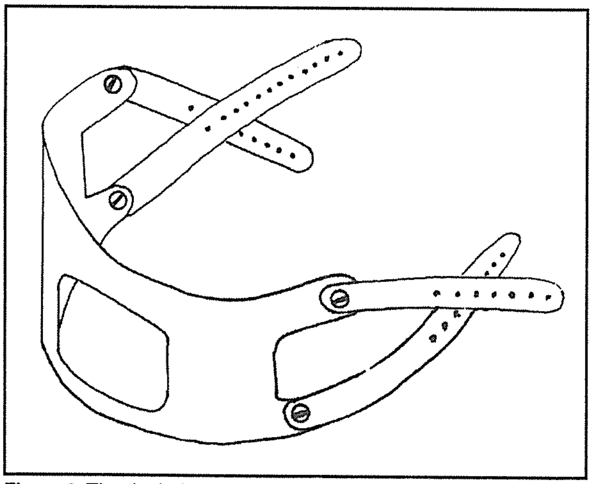

Figure 2. The depiction of the custom-made head fixation device.

On the other hand, a custom-made clamp which was connected to the head of screw was used to pull the screw out (Figure 3).

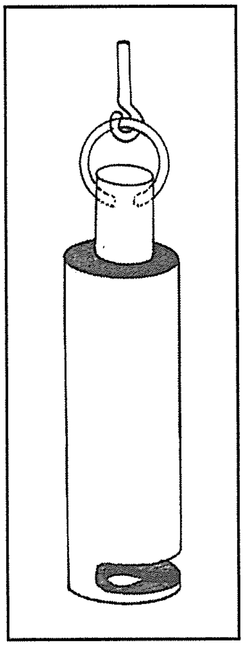

Figure 3. The connecting clamp

This clamp was 8 mm. in diameter and had a hole in the center of its tip proper for placement of 5 mm. screw. There was also a 4 mm. groove on the tip of the clamp allowing the placement of the screw head. In order to avoid the torque during the pull-out procedure, a joint was constructed between the connecting tip of the clamp and the connecting tip of the pull-out machine (Tensile testing Machine- Lloyd I, England). The angle of the connecting joint was oriented for each particular case to avoide the torque.

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. 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. The results of the tests were recorded using a PL3XY/t recorder (Lloyd instrument-England) on a special paper.

RESULTS

The mean pull-out strength was 521.14± 91.66, 407.71± 132.98, 411.14 ±65.88, and 271.85± 88.02 Newton for screw insertion number 1, 2, 3, and 4, respectively (Table 1).

Table 1. The mean pull-out strength of screws placed in different points of the occipital bone.

	I Midline-Bicortical	IV Lateral-Monocortical	III Lateral-Bicortical	IV Lateral-Monocortical
1.	670	250	458	349
2.	460	440	408	144
3.	462	644	460	270
4.	472	484	290	200
5.	604	373	420	340
6.	420	278	364	380
7.	560	385	478	220

521.14±91.66407.71±132.98

411.14±65.88271.85±88.02

One way Anova test revealed a significant difference between analysed groups. A detailed analysis using a Mann Whitney U test revealed that the significant decrease in the pull-out strength was primarily due to decreased pull-out strength in the group 4 (Table 2).

Table 2. Summary of the data comparing different screw points and sites.

I versus II	p=0.084 No difference
I versus III	p=0.025 Significant difference
I versus IV	p=0.001 Significant difference
II versus III	p=0.479 No difference
II versus IV	p=0.035 Significant difference
III versus IV	p=0.008 Significant difference

This study revealed no statistically significant difference between monocortical and bicortical screw placement in the midline. Figure 4 depicts a diagram comparing pull-out strength of different modifications.

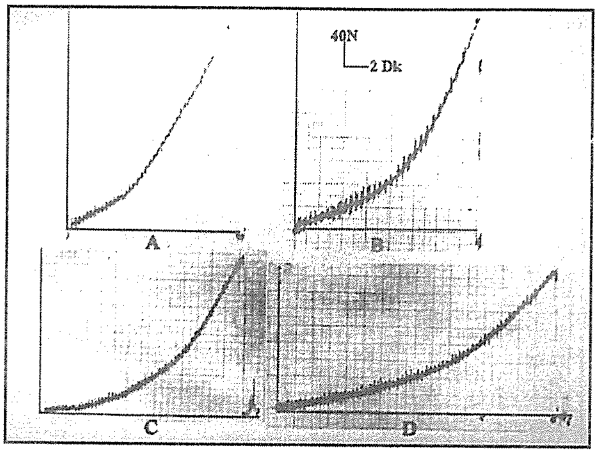

Figure 4. A diagram of different modifications showing different pull-out strength, A: Midline bicortical; B: Midline monocortical; C: Lateral bicortical, and D: Lateral monocortical.

In some specimens, before completing the pull-out procedure, a sudden decrease and then an increase in pull-out occured after loading. This suddenly decreased pull-out was due to destruction of the bony threads during turning-free pull-out procedure. This also led to an increased pull-out at the ultimate strength point, where the destructed bony threads compressed under the bone surface.

DISCUSSION

The use of screw at occipital bone-instrument interface has been encouraged in recent years. However, the construct may be failed. Screw pull-out is one of the most important causes of construct failure.This may be secondary to the placement of the screw in an inaccurate site, or the use of short screw. The results of this study confirm the effectiveness of bicortical screw placement on the midline when compared with paramedian screw placement. Additionally, this study revealed no significant difference between bicortical and monocortical median screw placement. Our results are comparable with the results of the Haher et al. (3). They compared a bicortical, monocortical screws and wires for occipital fixation. They reported 50% better pull-out strength using bicortical screw placement, when compared with monocortical screw placement. They stated, however, that monocortical screws pull-out strength at inion was comparable with that of the bicortical screws at other locations. Therefore, they recommended a monocortical screw placement on the midline at the level of the inion. Our results, however, showed an insignificant difference between mono- and bicortical screw placement in the midline inferior to the inion.

It is known that the thickness of the occipital bone around the inion is maximal (1,2,6,11), and the outer table forms 45% of the occipital bone (1,8).

The relation between bony markers and underlying venous sinuses was studied by Zipnick et al. (11), Modik et al. (4), and Ebraheim et al. (1). Although the bicortical screw fixation is more advantageous than monocortical fixation, the presence of the venous sinuses underneath the occipital midline limits the use of bicortical screw placement. The likelihood of the risk of venous sinus penetration by a bicortically inserted screw; and similar pull-out strength of the mono- and bicortical placed screws may limit the use of the monocortical screw placement.

One of the most important limitations of this study is the use of different size screws. Although the longer screws have a better pull-out strngth, the regional anatomy of the occipital bone prevented the use of the same length of screws. Therefore, we tested the various screws with different lengths.

In conclusion, our results support the use of the monocortical screw placement on the midline.

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