Occipital Bone Thickness Mapping for Safe Occipitocervical Fusion: An Observational Study

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INTRODUCTION

Occipitocervical fusion was first described in 1927 by the German neurologist Otfried Förster.¹ Since then, there are numerous arguments regarding safe and effective method of fusions. Cervical fixation using medial or lateral occipital screw placement along with rod or plate placement is one of the standard techniques described.¹⁻⁴ It is very important to define safe points for screw fixation to avoid inadvertent intradural penetration during surgery. In this study, in vitro mapping of computed tomography (CT) bone is done to determine the thickness of the occipital bone in 50 normal individuals which guides and gives confidence in placing the occipital screws.

MATERIALS AND METHODS

It is an observational study, where 25 adult males and 25 adult females are selected who have undergone CT scans for various reasons. The surface was divided into 1-cm segments extending laterally for 5 cm and 1-cm segments extending inferiorly for 4 cm from external occipital protuberance (EOP). Therefore, 11 × 5 sites were created in each patient [Illustration 1]. The position of the EOP was designated as level 0, and the position 1 cm below that was designated as level 1. Similarly, the median sagittal plane crossing the EOP was considered as a reference.
and divided into 1-cm segments on the right side (R1–R5) and left side (L1–L5). Two neurosurgeons independently noted the readings. The thickness of the occipital bone was measured in units of 0.1 mm orthogonal to the tangent at each measurement site.

**RESULTS**

Our study had 25 males and 25 females between the age group of 20–60 years. 14% were in the age group of 20–30 years, 24% in 30–40 group, 36% in 40–50 age group, and 26% in 50–60 age group, respectively [Table 1, Graph 1].

The average thickness of occipital bone in males at various points is tabulated [Table 2] and shown on the following graph [Graph 2].

The average thickness of occipital bone in females at various points is tabulated [Table 3] and shown on the following graph [Graph 3].

**DISCUSSION**

The indication in common is instability at the craniocervical junction, which may result in neural symptoms, which are the final indication for operation. The aim of all operative techniques is to reduce this instability. Although a close correlation between CT measurements assumed to be present, a significant amount of variability was also anticipated. Safe and effective insertion of occipital bone screws requires morphological analysis of the occipital bone, which is poorly documented in literature. Stable fixation of the occipital bone to the cervical vertebrae requires screws 8 mm or more in length, according to Heywood et al.[8,10] In response, a few authors have measured occipital bone thickness using CT in healthy subjects or morphological analysis in cadavers. Few detailed reports cover this[9,11-14] although no reports have been published in southern India to date.

In the present study, we documented occipital bone morphology in 50 healthy subjects using arbitrary CT slices to accurately measure the structure’s thickness. Our results revealed a wider range of regions with thicknesses >8 mm compared with the previous reports [Figure 1].

Ebraheim et al.[9] reported that 8-mm screws should be inserted up to 2 cm lateral from the midline at the level...
of the EOP, 1 cm from the median crest at a level 1 cm inferior to the protuberance, and 0.5 cm from the crest at a level 2 cm inferior to the protuberance.

Hertel and Hirschfelder and Naderi et al.\[^{11,12}\] reported that the area >8 mm thick was up to 1 cm lateral to the EOP at the level of the superior nuchal line and 2 cm inferior to the EOP [Figure 2].

Morita et al., the safe area was 2 cm lateral to the EOP at the level of the superior nuchal line and 3 cm inferior to the EOP [Figure 1].

In our study, there is variation in safe area when compared between males and females. In males, safe area extends 2 cm on either side at the level of EOP, 1 cm on either side at level 1, and till level 3 in median plane, whereas in females, this area extends up to level 2 [Figures 3 and 4].

The above study suggests that there is more safe area in males when compared to females and moderately safe areas can also be seen. However, considerable variability can be seen between individuals and those with craniovertebral junction anomalies. Therefore, we recommend measuring the thickness in every patient preoperatively. Post hoc calculations revealed that this study was adequately powered (>80%) to detect a difference of area between the data of these authors and ours.

Based on these data, there are 10 safe points for males which include M0, M1, M2, M3, L1, L2, R1, R2 at level 0,
CONCLUSION

Occipitocervical fusion is one of the most common procedures performed for various pathologies at craniovertebral junction. It's very important to have knowledge about the safe points on occipital bone for effective and safe placement of the screws. However, this aspect is in most cases only dealt with marginally, if at all. The intention of this article is to close this gap and offer an outlook on the pre-operative evaluation of the patient.

The current study suggests that there is less safe area for females than males for screw placement. Since there is great variability between individuals in occipital bone thickness, pre-operative CT examinations are warranted to determine optimal screw placement before performing occipital-cervical fusions. In general, the safest points for screw insertion are in the midline and the first paramedian regions above the inferior nuchal line. Future studies should repeat these measurements in pediatric patients and older age group patients.

REFERENCES

Veerapandian, et al.: Occipital bone thickness mapping for safe occipitocervical fusion
