Print ISSN: 2321-6379
Online ISSN: 2321-595X

Original Article

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

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Abstract

Introduction: There are various diseases and anomalies in humans which require occipitocervical fusion using medial or lateral occipital screw placement along with rod or plate placement.[1] There are many ongoing arguments regarding the safe area for screw placement on the occiput during fusion techniques. Morphological analysis of occipital bone thickness provides confidence in placing screws. Here, we try mapping occipital bone using computed tomography (CT) which would benefit for safe fusion in population of southern Tamil Nadu.

Materials and Methods: We randomly selected the CT scans of 50 patients in the age group of 20–60 years, and occipital bone thickness mapping is done and tabulated and compared with the previous studies from different demographical areas.

Results: The maximum thickness of the occipital bone was at the level of the external occipital protuberance (EOP) at 16.2 mm. Areas with thicknesses >8 mm were more frequent at the EOP and up to 2 cm in all directions, as well as up to 1 cm in all directions at a height of 1 cm inferiorly, and up to 3 cm from the EOP inferiorly in males and it's up to 2 cm in females. The male group tended to have a thicker occipital bone than the female group, and the differences were significant around the EOP. Based on these data, there are 10 safe points for males which include: M0, M1, M2, M3, L1, L2, R1, R2 at level 0, L1, and R2 at level 1 and 9 safe points for female which include all the above except M3.

Conclusion: There is variability in the thickness of occipital bone in adult people from different demographic areas and there is also a significant difference between male and female patients. Hence, this study helps in pre-operative planning in occipitocervical fusion in people of this region.

Key words: Computed tomography, Occipital bone mapping, Occipitocervical fusion

INTRODUCTION

Occipitocervical fusion was first described in 1927 by the German neurologist Otfried Förster.[7] 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.[1-6] 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.

Access this article online

www.ijss-sn.com

Month of Submission : 01-2019
Month of Peer Review : 02-2019
Month of Acceptance : 02-2019
Month of Publishing : 03-2019

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

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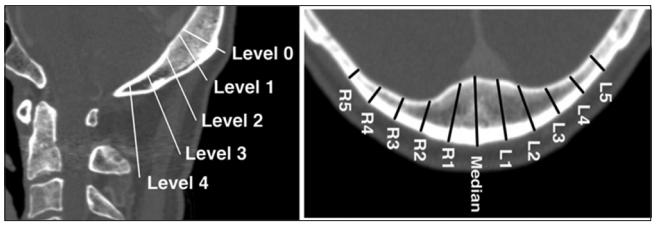
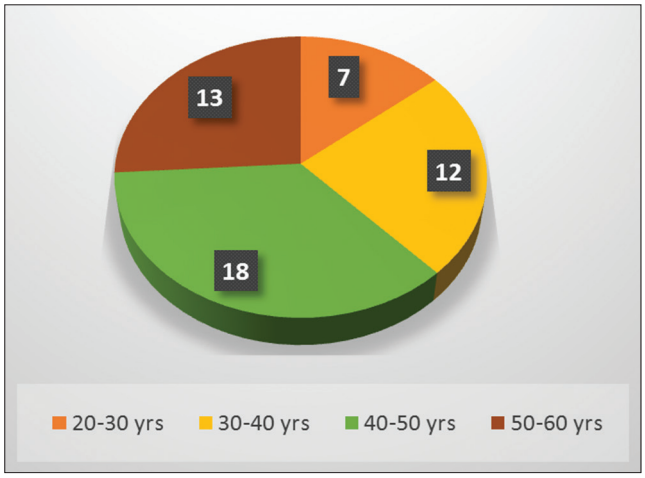


Illustration 1: Computed tomography measurements of the occipital bone. Sagittal plane showing slices of the external occipital protuberance (EOP). The points represent 1-cm segments using the EOP as a reference, for a distance up to 4 cm. From these points, cross-sections were created orthogonally to the external cortical bone. Axial plane showing points created at each level in 1-cm segments laterally in both directions using the EOP as a reference, for a distance up to 5 cm. The respective distances orthogonal to the cortical bone were measured



Graph 1: Age-wise distribution of the study groups

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].

Table 1: Age-wise distribution

Age group (years)	*n* (%)
20–30	7 (14)
30–40	12 (24)
40–50	18 (36)
50–60	13 (26)

Table 2: Averages of thicknesses at various points on occipital bone in males

Males	R5	R4	R3	R2	R1	M	L1	L2	L3	L4	L5
Level 0	6.9	6.9	7.7	9.1	11.5	16.2	10.9	9.2	7.8	7.9	7.1
Level 1	7.5	7.8	7.9	7.8	12.1	14.6	11.3	7.9	7.9	7.2	6.8
Level 2	7.2	7.3	7.5	7.9	7.9	12.9	7.6	7.6	7.7	7.6	6.6
Level 3	6.1	5.8	5.8	7.1	7.8	9.2	7.1	6.5	6.6	6.9	5.2
Level 4	5.6	6.1	5.8	7.1	6.9	7.2	6.6	5.4	4.9	5.2	5.4

Table 3: Averages of thicknesses at various points on occipital bone in females

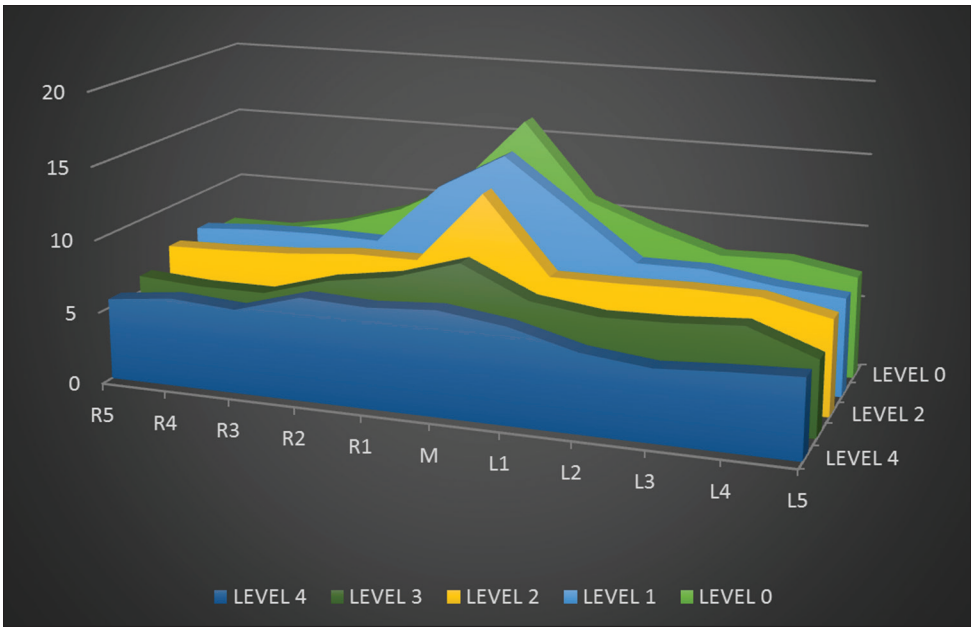
Females	R5	R4	R3	R2	R1	M	L1	L2	L3	L4	L5
Level 0	6.5	6.8	7.2	9.5	12.1	15.5	9.9	9.8	7.7	7.1	6.9
Level 1	6.9	7.4	7.7	8	11.1	13.6	10.6	7.7	7.5	7.5	6.3
Level 2	6.9	7.2	7.8	6.9	7.5	10.3	7.7	7.5	6.5	6.1	6.2
Level 3	5.9	6.8	6.9	7.1	7.2	7.8	7.5	6.9	6.2	5.9	5.7
Level 4	4.8	5.1	4.9	6.6	6.9	6.9	6.5	5.9	5.9	5.2	4.6

DISCUSSION

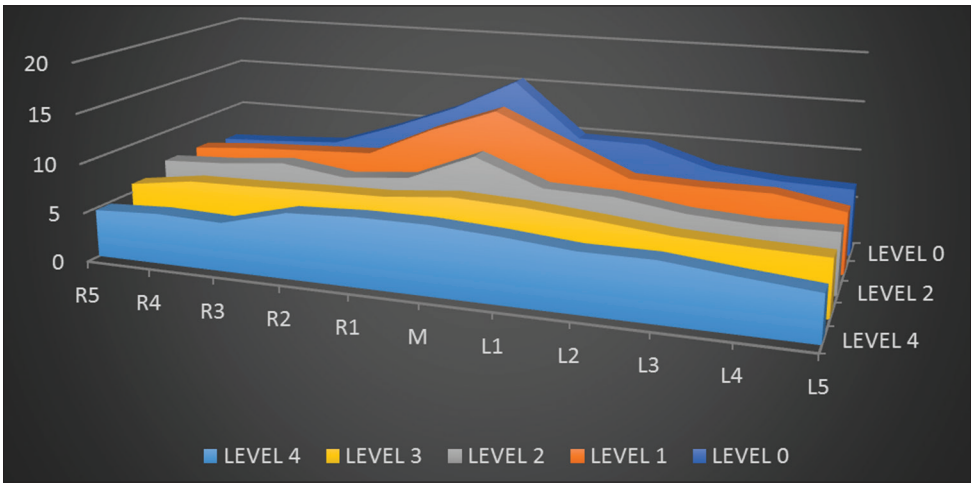
The indication in common is instability at the craniocervical junction, which may result in neural symptoms, which are the final indication for operation. The aim of all operative techniques is to reduce this instability. Although a close correlation between CT measurements assumed to be present, a significant 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



Graph 2: Occipital bone mapping in males



Graph 3: Occipital bone mapping in females

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, they are 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,

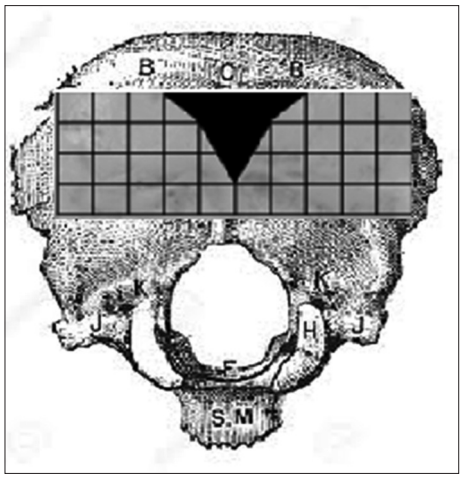


Figure 1: Morita *et al*.

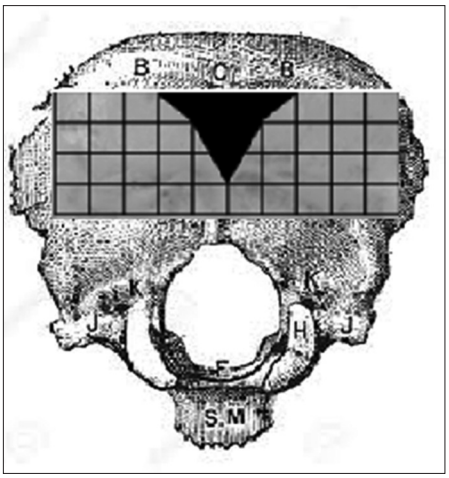


Figure 3: This study; males

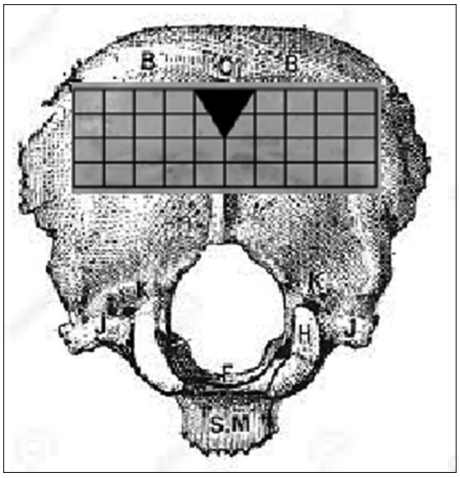


Figure 2: Hertel and Hirschfelder and Naderi *et al*.

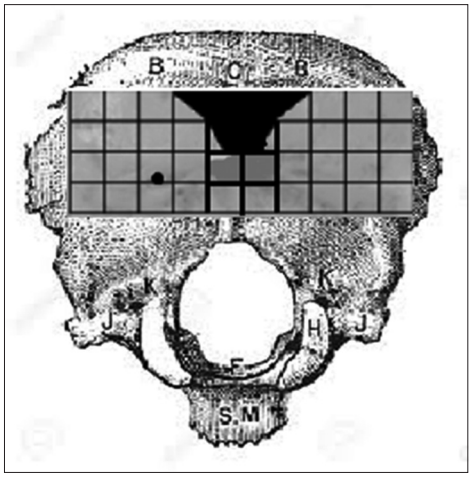


Figure 4: This study; females

L1, and R2 at level 1 and 9 safe points for female which include all the above except M3.

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.

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How to cite this article: Veerapandian R, Manimaran R, Prasad RJVV. Occipital Bone Thickness Mapping for Safe Occipitocervical Fusion: An Observational Study. Int J Sci Stud 2019;6(12):106-110.
Source of Support: Nil, **Conflict of Interest:** None declared.