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Computed Tomographic Morphometric Study of the Occipital Bone Thickness in 100 Adult, Moroccan Patients

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Abstract

Background: Occipital cervical fixation (OCF) is an important and difficult technic and has certain risks due to its relation with adjacent special anatomic features. One of specific areas to perform screw fixation and to prevent technical failures is the thickness of the occipital bone which require detailed morphological anatomical knowledge. To our knowledge, no published study has provided thicknesses of occiput in African Continent.

Objective: The aim of this study was to evaluate occipital bony thickness in Moroccan population in order to determine the variability of the occipital bone thickness and to assess the feasibility and safety of hook and screw placement in these patients.

Patients and methods: We evaluated occipital bony thickness using computed tomography (CT) imaging in 100 patients (30 females and 70 males; age range, 18–70; mean, 36.2 ± 11.9 years). Axial CT cutting was made at 1.25 mm intervals.

CT measurements were performed on the bone windows at two levels starting at 1 cm under the external occipital protuberance (EOP) and 1 cm inferior to this level. Three measurements were performed both sides at 1 cm interval. We acquired 14 values.

Results: The mean thickness of occipital bones varied between 10.003 to 13.964 mm in the left and 10.747 to 13.715 mm in the right (± 2.8) and between 9.845 to 11.478 mm in the left and 9.903 to 11.371 in the right (± 2.5) at 1 cm and 2 cm above EOP respectively. The thickest point was in the midline with 17.366 mm and 12.579 mm at 1 cm and 2 cm above EOP respectively,

Intra-individual and inter-individual discrepancies are found between left and right sides ($p<0.05$) but not between age and sex at two levels in our adult patients.

Conclusion: Our radiological study findings suggest that there were significant differences between individuals and ethnics. The preoperative CT scans of occipital bony thickness as the pedicle size should be thoroughly analysed of patients undergoing occipital cervical fixation. These are essential for successful intraoperative fusion and to further decrease the risk of occipito-cervical fusion.

Keywords: Anatomy; Occiput; Computed tomography; Occipital thickness; Occipito-cervical fixation

Introduction

Several types of posterior approaches have been adopted for occipito-cervical fusion (OCF). Those technics has been used to treat many causes of instability of the occipito-cervical junction which may result from trauma, decompressive cranio-cervical junction surgery, infection, tumour, rheumatological disease, degeneration, and congenital malformation [1,2]. Many studies highlighted the high rates of instrumentation failure occurring in OCF [2,3]. Given these rates of failure, it is critical that sufficient attention is paid to minimize technical failures irrespective of the method chosen for OCF. Misplacement or choose of the wrong occipital region can potentially lead to complications which include venous sinus injury, dura penetration with cerebrospinal fluid leak, and death secondary to acute epidural hematoma [4].

So one of specific areas to perform screw fixation and to prevent technical failures is the thickness of the occipital bone which require detailed morphological anatomical knowledge this permit the selection of the most optimal hook or screw. Although a few previous anatomic or CT studies have looked at occipital bone thickness, there have been no studies in African populations at our knowledge.

The aim of this study was to perform a quantitative morphometric analysis using computed tomography (CT) to determine the variability of the occipital bone thickness to optimize hook and screw placement for OCF in patients from Moroccan patients.

Materials and Methods

We realised a morphometric study in One hundred adult patients from a multi-ethnic Moroccan population admitted to our institution between Marsh and October 2015, for the assessment of cranio-cervical spine. The patients included in this study aged 18 years and older, including 33 (33%) females and 67 (67%) males. Overage was 36.2 ± 11.9 years (range, 18–70 years) of all the patients. Mean age was 42 years (18 – 70 years) in females and 32 years (18 – 57 years) in males. CT cutting was made at 1.25 mm intervals in axial plan. Non-enhanced contiguous fine slice CT data were acquired for all patients. The CT measurements were taken with spiral CT on the bone windows, with a slice thickness of 1.5 mm. skull thickness was evaluated for the inner and outer tables from images of multiplanar reformations by Radian Dicom Viewer software. Plane measurement was the direction

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choosing for screwing direction, approximatively at 45° to McRae's line (Figure 1). Transversely, the occipital bone was divided into seven lines starting at the level of 1 cm below the EOP (One in the middle and 3 in each side). Horizontal lines then proceeded inferiorly in -1 cm segment below the first level. Three lateral measurements were made at 1 cm interval at either sides of the midline with intervals on the left being negative (−1, −2, and −3) and on the right being positive (+1, +2, and +3). A measurement grid was built containing 14 measurement points (7 slices each in two planes).

Exclusion criteria

The no Moroccan patients and who had occipito-cervical abnormalities were excluded from this study.

Statistical Analysis

Data were entered into SPSS (version 22; SPSS IBM, Inc., Chicago, IL). Continuous variables were analysed using t test and categorical variables were analysed using Chi-square test. Paired t test was used to compare the parameters in males and females and between the right and left. The level of significance was fixed at 0.05.

Results

The results of measurements of occipital bone thickness are shown in Tables 1 and 2. Occipital thickness in those levels ranged from 4.8 mm to 28.5 mm. They were ranged from 4.8 to 25.00 mm in males and from 5.7 mm to 28.5 mm in females (Figure 2). The maximum thickness of the occipital bone, was in the midline at 1 cm above EOP (17.36 mm ± 3.46 mm) followed by 2 cm below EOP (12.57 mm ± 2.43 mm). There were no statistically significant differences between genders for the values of bone thickness measured in two levels (P>0.05). However, there was a statistically significant difference between the overall thickness on the left side at 1 cm above EOP from the midline as the lateral distance compared to the right (P = 0.01), but there was no such difference at 2

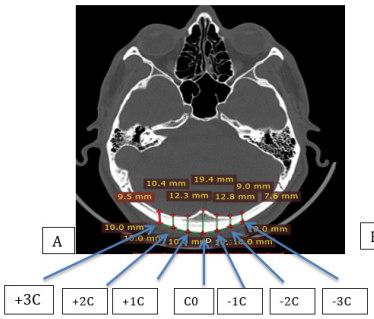

Figure 1: CT Image of horizontal (A) and sagittal (B) planar reconstruction showing the distances measured on CT bone window at m interval. C+: measurement on the right, C-: measurement on the left.

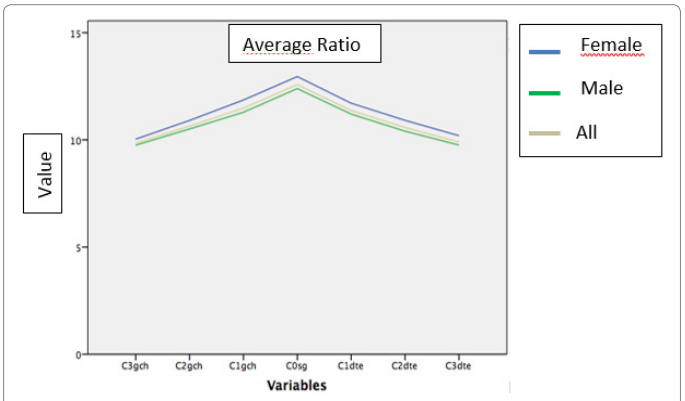

Figure 2: Curve representing the average thickness of occipital bone according to gender.

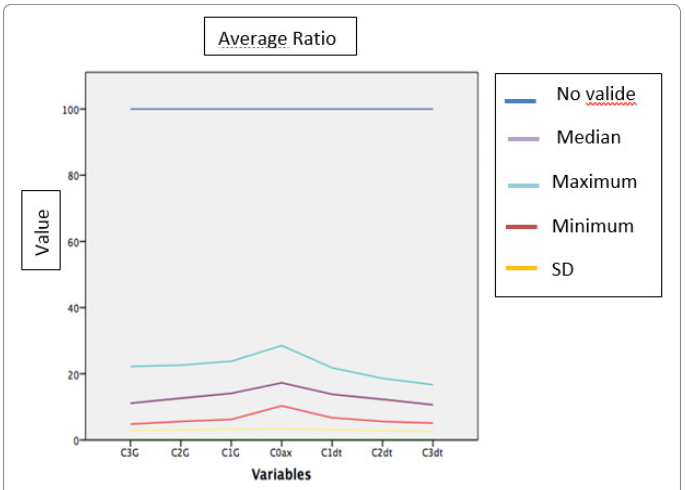

Figure 3: Curve representing the thickness distribution of occipital bone in axial plan.

Sex		-3 C	-2 C	-1 C	C0ax	+1 C	+2 C	+3 C
Female	Average	11.167	12.515	13.942	17.591	13.585	11.827	10.603
	SD	3.1835	3.2848	3.5652	3.7448	3.4567	3.0407	2.8487
	Median	11.100	12.600	14.100	17.100	13.600	12.300	10.500
	Minimum	5.7	7.6	8.3	11.9	7.5	6.3	5.2
	Maximum	22.2	22.6	23.8	28.5	21.8	18.6	16.6
Male	Average	10.922	12.381	13.975	17.255	13.779	12.140	10.818
	SD	2.6815	2.8906	3.1120	3.3481	2.9195	2.7087	2.4553
	Median	11.200	12.900	14.100	17.600	13.900	12.300	10.600
	Minimum	4.8	5.6	6.2	10.3	6.7	5.6	5.1
	Maximum	17.2	19.3	21.4	25.0	21.4	18.4	16.7
All patients	Average	11.003	12.425	13.964	17.366	13.715	12.037	10.747
	SD	2.8430	3.0104	3.2504	3.4686	3.0908	2.8110	2.5792
	Median	11.100	12.650	14.100	17.250	13.800	12.300	10.600
	Minimum	4.8	5.6	6.2	10.3	6.7	5.6	5.1
	Maximum	22.2	22.6	23.8	28.5	21.8	18.6	16.7

Table 1: Thickness of occipital bone 1 cm below EOP.

cm below EOP. Moving inferiorly down the midline from the EOP, the decreasing thickness of the occipital bone was significant (P<0.01) with an estimated decrease of 0.2 mm to 0.3 mm for every centimetre below the EOP. In addition, we have analyzed occipital thickness according to age patients and we found that they were not correlated to age in our adult patients and does not undergo a normal distribution going from one age group to another. The estimated distribution of occipital bone thickness in the different axes at 1 cm below EOP is illustrated in Figure 3.

Discussion

Occipito-cervical fusion (OCF) is required when the junction is rendered unstable by a variety of pathological conditions. Various techniques were described and used widely; involve the screw placement to the occipital diploic bone [5-8]. The unique anatomy and function of the region, the perceived high risk of vascular and neurological complications, and the anatomical variations make OCF a challenging procedure.

The aim of this study is to achieve a quantitative morphometric analysis using computed tomography (CT) to determine the variability of the thickness of the occipital bone and optimize size and adequate screw location for the OCF in Moroccan population. There are many studies that have attempted to share analyzes of the occipital mapping. However, if the measurements are performed directly from cadavers or radiographic images of subjects, most studies report a relatively small sample size or were performed in the Euro-American and Asian populations. In this study, we focus on measuring the thickness of the occipital bone in places compatible with screw location. The results of this study can therefore be taken as a reference to a safety OCF. The occipital is an irregular bone [9]. The external occipital protuberance (EOP) which composed of dense cortical bone is the thicker point [3,10,11]. The maximum value for thickness is 28.5 mm and 20.5 mm at 1 cm and 2 cm above EOP respectively. The thickness decreases laterally with men values of 14.10 mm, 12.65 mm and 11.10 mm at -1 cm, -2 cm and -3 cm respectively and 13.80 mm, 12.30 mm and 10.60 mm at +1 cm, +2 cm and +3 cm respectively. In this study of occipital bone thickness in a Moroccan population, we found that the thickest point was in the midline with a maximum thickness below the EOP of 17.36 mm (± 3.46 mm). This maximum was thicker in our population compared to those in others studies. This difference is also found in lateral points (Table 3). This midline and paramedian bone offers the best purchase for screws and is commonly used in most OCF instrumentation systems [5,8,12]. Moreover, the screws are also placed into the region of the fossa cerebellaris [13], where the bone offers a thickness of only about 3 mm. Significant morbidity has been reported with inappropriate screw placement in the occipital region and includes construct weakness, venous sinus penetration leading to extradural hematomas, injury to the underlying neural structures, and cerebrospinal fluid leak [4,14]. To ovoid those complications, it seems important to choose the points for intervention on the bone with regard to bone thickness to guarantee minimum risk of complications arising from perforation of the bone and maximum stability of the instrumentation. There are different proposals for screw length and no screw length commonly agreed on by the different authors [15]. For safety and to avoid failure, we suggest that entrance point is 1 cm to 2 cm from the midline above EOP with

Sex		-3 C'	-2 C'	-1 C'	C'0 ax	+1 C'	+2 C'	+3 C'
Female	Average	10.033	10.909	11.861	12.955	11.712	10.912	10.197
	SD	2.4410	2.5013	2.5143	2.5801	2.4902	2.5688	2.6921
	Median	9.600	10.800	12.400	13.600	11.600	10.600	9.800
	Minimum	5.8	6.1	7.1	7.6	6.4	5.9	5.5
	Maximum	15.1	16.0	16.9	18.5	16.7	16.5	16.6
Male	Average	9.752	10.510	11.290	12.394	11.203	10.407	9.758
	SD	2.3247	2.4115	2.4658	2.3522	2.3945	2.3677	2.4327
	Median	9.600	10.300	11.000	12.400	10.800	10.100	9.400
	Minimum	6.0	6.4	7.0	7.4	6.8	6.3	5.9
	Maximum	19.9	20.6	21.5	20.5	20.3	19.9	19.2
All patients	Average	9.845	10.642	11.478	12.579	11.371	10.574	9.903
	SD	2.3554	2.4361	2.4839	2.4311	2.4258	2.4346	2.5161
	Median	9.600	10.400	11.200	12.600	11.150	10.300	9.800
	Minimum	5.8	6.1	7.0	7.4	6.4	5.9	5.5
	Maximum	19.9	20.6	21.5	20.5	20.3	19.9	19.2

Table 2: Thickness of occipital bone 2 cm (C') below EOP.

Levels		-3 C	-2 C	-1 C	C0ax	+1 C	+2 C	+3 C
Hertel (USA) 1999		6.67	6.43	8.07	11.87	8.48	6.65	6.82
Ebraheim (USA) 1996	Male	5.5 ± 1.9	5.7 ± 1.9	7.2 ± 2.7	11.1 ± 2.5	6.7 ± 2.2	5.9 ± 1.8	5.7 ± 1.7
	Female	4.3 ± 1.3	4.3 ± 1.3	5.1 ± 1.6	9.5 ± 2.2	5 ± 1.6	4.4 ± 1.2	4.8 ± 1.6
Naderi (Turkey) 2001		6.8 ± 2.4	7.2 ± 2.5	8.7 ± 3.3	12.7 ± 4.1	8.9 ± 2	7.7 ± 2.2	6.5 ± 1.7
King NK (Singapore) 2014	All	6.5 ± 1.6	8.4 ± 2.3	11.2 ± 2.5	16.2 ± 3.0	9.9 ± 2.7	7.0 ± 2.0	5.6 ± 1.2
	Male	6.2 ± 1.8	7.7 ± 2.5	11.4 ± 2.8	16.6 ± 3.2	10.5 ± 2.9	7.0 ± 2.3	5.6 ± 1.4
	Female	6.7 ± 1.6	9.1 ± 2.0	11.0 ± 2.3	15.9 ± 2.9	9.5 ± 2.5	7.0 ± 1.8	5.7 ± 1.1
Tomonori (Japan) 2015	All	7.3 ± 2.2	7.3 ± 2.8	9.9 ± 3.7	14.7 ± 3.3	10.6 ± 3.9	7.8 ± 2.9	7.3 ± 2.5
	Male	7.5 ± 2.2	7.4 ± 2.8	10.4 ± 3.9	15.4 ± 3.4	11.3 ± 4.1	8.1 ± 3	7.8 ± 2.9
	Female	5.2 ± 2	7.1 ± 2.7	9.4 ± 3.4	13.8 ± 3	9.9 ± 3.5	7.6 ± 2.8	6.8 ± 2
Morocco	All	11.0 ± 2.8	12.4 ± 3.0	14.0 ± 3.2	17.4 ± 3.5	13.7 ± 3.1	12.0 ± 2.8	10.7 ± 2.6
	Male	10.9 ± 2.7	12.4 ± 2.9	14.0 ± 3.1	17.2 ± 3.3	13.8 ± 2.9	12.1 ± 2.7	10.8 ± 2.4
	Female	11.2 ± 3.2	12.5 ± 3.3	13.9 ± 3.6	17.6 ± 3.7	13.6 ± 3.4	11.8 ± 3.0	10.6 ± 2.8

Table 3: Occipital thickness 1 cm above EOP in different countries.

mean value 8 mm to 10 mm of screw length. Contrary to the findings of Ebraheim, et al. [16], no statistically significant gender difference could be found in our patients as reported by many authors [14,15,17].

The values of bone thickness of the left and the corresponding right sides were compared. There was statistically significant difference in favour of the left ($P<0.05$). Therefore, it is important to keep the gender and race of patients in mind when evaluating and planning for occipital screw fixation.

Conclusion

As occipital screws are becoming more popular, requiring that may be placed either medially or laterally in the occipital bone, the need for computed tomography (CT)-confirmed data regarding the thickness of the occiput in its various areas has become more critical. This first study of occipital bone thickness in the Moroccan population reveals that occipital bone thickness is greater in this population compared to the European, Western or Asian population. These results should help to improve the safety of OCF and contribute toward reducing technical failures by assisting the surgeon in the optimal selection of screws for this procedure.

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