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Morphometric measurement of Clivus using CBCT images as tool for age prediction and gender determination- A Retrospective observational study.

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Abstract:

Introduction: The aim of this study is to use cone beam computed tomography images to assess the Clivus length and width for age prediction and gender determination.

Methods: Full volume Cone Beam Computed Tomography (CBCT) scans of 100 subjects (50 Males and 50 Females) of the age ranging from 6–78-year-old males and females showing clivus completely, selected retrospectively. Each scan was made using Planmeca ProMax3DMid Proface CBCT unit and opened in the software viewer Romex is version 4.2.0 R 10/13/15. Data was extracted from the old records of the department randomly and was analysed by two observers.

Results: The clivus length and width were determined to be statistically significant in both the gender, indicating that there was a statistically significant difference between the mean values in gender (p value < 0.05). The clivus length and clivus width was found to be statistically non-significant in between different age groups ($p>0.05$). The mean value of clivus length was higher in age group 18 to 35 years (45.03mm) and clivus

width is higher in age group above 65 years (32.28mm) than other age groups.

Conclusion: The CBCT measurement of the clivus dimensions can be used to determine gender of individuals. So, it can be concluded that clivus dimensions can be used for gender determination. However, it shows no significance in age prediction.

Keywords: Age prediction, CBCT, Clivus, Gender Determination.

Introduction

The clivus is the portion of the skull base situated between the foramen magnum and the dorsum sellae (Chaurasia et al., 2017). The spheno-occipital synchondrosis forms the clivus, which is a bony structure generated by the fusion of the basioccipital and basi-spheniod bones. The mesoderm and ectoderm features are responsible for the downward sloping structure from the dorsum sellae to the foramen magnum (Rai et al., 2018). It results from the fusion of the synchondrosis between the basioccipital and exoccipital bones, which grows and ossify between 3-25 years of age to form the basisphenoid and the basio-ociput (Bayrak et al., 2019). One of the most plainly discernible reasons of variation in biological populations is age prediction and sexual dimorphism (Massarat et al., 2014). Because the bones of the skeleton decay slowly after death, they have been used to anticipate an individual's age and sexual dimorphism. Forensic anthropologists receive a half skeleton. As a result, determining sex and age requires looking into various sections of the bones (Chaurasia et al., 2017; Massarat et al., 2014). The clivus is a denser part of the bony skull that can be recovered whole from a damaged or burned skull (Chaurasia et al., 2017; Massarat et al., 2014). As a result, it can be employed as an anthropometric measurement for gender determination and age prediction in some medico-legal contexts (Chaurasia et al., 2017). CBCT (cone beam computed tomography) is a relatively new technology that is frequently employed in the Dento-maxillofacial region for a range of purposes, as well as in pre- and post-mortem procedures (Rai et al., 2018).Advantages of CBCT being dose reduction, multiplanar sections, image accuracy, rapid scan time and low cost as compared to CT scans (Kamburoglu et al., 2015).The objectives followed were to measure the clivus length in both gender and different age groups, to measure the clivus width in both gender and different age groups, to compare the above parameters in both gender and different age groups and to assess the applicability of CBCT as a tool to evaluate these clivus dimension in age prediction and gender determination. Until now, there has been virtually only some researchers has analysed the morphometric measurement of clivus using CBCT images as tool for age prediction and gender discrimination. Therefore, the aim was to quantitatively analyse the data with the help of cone beam computed tomography to determine forensic and medicolegal significance by measuring the clivus width and length in axial and sagittal section respectively for age prediction and gender determination.

Materials and Methods

It was retrospective observational study, conducted in the Department of oral medicine and radiology in the duration of 2 months. Study group included full volume CBCT scans of 100 subjects (50 Males and 50 Females) of the age ranging from 6–78-year-old males and females showing clivus completely, selected retrospectively. Each scan was made using Planmeca ProMax3DMid Proface CBCT unit according to the department's standard imaging protocol. During the imaging procedure, the patients were positioned in the upright position, with the Frankfort horizontal (FH)

plane parallel to the floor. Maintenance of maximum intercuspation, avoid swallowing and other movements during the scanning period are the instructions given to patients before scans were carried out. The exposure settings were 90 kV, 11.2 mA, 20 x 17 cm field of view, 200 μm voxel size, 18 to 40 seconds scanning time and 5 to 55 seconds reconstruction time. For further analysis, the images were saved as digital imaging and communications in medicine (DICOM) files, and these data sets were opened in the software viewer Romex is version 4.2.0 R 10/13/15 for clivus measurements in sagittal and axial section. Images were retrieved from the old records which was already present in the software evaluated by two observers randomly. Sample size was 50 males and 50 females which was calculated correctly, by clinically acceptable error between the two groups, by using convenience sampling technique. A prior informed consent was obtained for assessing CBCT scans for research work. Approval was taken from SAC & IEC before commencement of study.

Inclusion criteria for this study was CBCT scan of patients age ranging from 6-78 years showing clivus completely, selected retrospectively. CBCT scan showing no history of trauma and pathology diagnosed as normal and high-quality reconstructed images without any imaging artifacts. We had excluded scans with history of trauma, obvious pathology and facial asymmetry, scans with imaging artifact and low-quality images.

Subsequently, the observers performed measurement of clivus length as the longest distance superior-inferiorly from the upper point of dorsum sellae to the lowest point on anterior margin of foramen magnum (Figure 1) and measurement of clivus width as the longest distance from left to right side near the anterior peripheral margin of foramen magnum inferiorly (Figure 2).

Statistical analysis

Data obtained was compiled on a MS Office Excel Sheet (v 2019, Microsoft RedmondCampus,Redmond, Washington, United States). Data was subjected to statistical analysis usingstatistical package for social sciences (SPSS v 26.0, IBM). Descriptive statistics like frequencies and percentage for categorical data, Mean & SD for numerical data has been depicted. Inter group comparison (2 groups) was done using t test. Inter group comparison (>2 groups) was done using one way ANOVA followed by pair wise comparison using post hoc test. Bivariate correlation between 2 numerical variables was checked using Pearson correlation coefficient. Multivariate & regression analysis was carried out to establish relationship between numerical variables.

Results

The distribution was done in different age groups as shown in Table 1 and Graph 1 and genders as shown in Table 2 and Graph 2.According to the distribution of different age group, maximum individuals present in the 18-35 years age group (n=58) and minimum individual present in above 65 years age group (n=5) as depicted in Table 1 and Graph 1. There were 50 males and 50 females distributed according to gender as shown in Table 2 and Graph 2. The one-way ANOVA is applied todetermine association of clivus length and clivus width in age groups of individuals. The clivus length was found not statistically significant ($p>0.05$) in all age groups but the mean value of clivus length was higher in age group of 18 to 35 years (45.03mm) than other age groups as the other age groups almost had similar clivus length as shown in Table 3 and Graph 3. After comparing clivus width between age groups there was no statistically significant variation observed. The mean value of clivus width was higher in age group above 65

years (32.28mm) than other age groups as shown in Table 4 and Graph 4. Comparison of clivus length shown in Table 5 and Graph 5 and clivus width as shown in Table 6 and Graph 6 in between genders is done by using by t test. It was found that mean of clivus length and clivus width is higher in male as compared to females as shown in Table 5,6 and Graph 5,6.

Discussion

The clivus is a bony part of the cranium placed in the middle of the base of the skull. It at midpoint. It measures about 4 to 5.5 cm long and about 3 cm wide (Rai et al., 2018). Until puberty, the clivus remains a heterogeneous structure split by the spheno-occipital synchondrosis. As the principal region for the longitudinal growth of the skull base, this structure has remained a staple as a growth zone (Rai et al., 2018).One of the most challenging problems in forensic medicine is estimating the skeleton and separating human remnants. Now a days CBCT is also widely used for pre and post-mortem forensic practices (Bayrak et al., 2019). With the expanded use of CBCT, morphometric measurement of clivus dimension could be used in forensic medicine for age prediction and gender determination.

In our study the clivus length and clivus width was found to be statistically significant in both the gender (p value < 0.05). The clivus length which is measured in sagittal section and clivus width measured in axial section is higher in males as compared to females which shows strong positive correlation between clivus width, clivus length and gender with the help of CBCT. The clivus length and clivus width was found to be statistically non-significant in between different age groups (p>0.05). Using CBCT as tool formeasurement of clivus in sagittal and axial section gives accurate and excellent results.

In the study conducted by (Chaurasia et al., 2017)concluded that the mean of clivus length was statistically significant (p<0.05) and higher in males compared to females however the clivus width was statistically not significant (p>0.05) in both males and females. It also, can used to predict the age of individuals (Chaurasia et al., 2017**).** (Krogman et al., 1982) in their study found no significant difference between male and female (p-value>0.05) with clivus width. However, the clivus length was statistically significant (p<0.001) in both male and female population. According to Krogman et al the clivus width and clivus length was directly associated with age (Krogman et al., 1982). However, in our study clivus width and clivus length both found statistically significant in both males and femalesbut not significant in prediction of age in individuals. (Bayrak et al., 2019) in their study explainedthe width and length of clivus were higher in males as compared to females. Statistically significant differences were found between genders for all variables (p<0.05). There was a significant relationship and positive correlation between length of clivus and age groups (p=0.009, r=0.351) (Bayrak et al.,2019).Similarly, in our study clivus length in sagittal section and clivus width in axial section were higher in males as compared to females. However, we found statistically significant correlation between clivus length and width with only genders and not with age. In our study we used CBCT for measuring clivus dimensions however, Jehan M et al used CT measurements for gender determination. (Jehan et al 2016) concluded thatstatistically the mean clival length of male was found significantly larger than female and suggested that CT measurement of clivus length may be used for gender determination in medico-legal cases &

may be helpful in radiological diagnosis of some clivus pathology.[4]

We suggest the future study needs to be validated by larger sample size to find correlation between clivus width, clivus length and age by using mathematical derived equations with the help of CBCT measurements. In the future of forensic sciences, clivus can be use for sexual dimorphism and age prediction with good knowledge of cranial base, since it is least commonly used. CBCT is proposed as a new imaging modality for assessing biological characteristics such as age and sex, assessing trauma, and to predict personal identification.

Conclusions

The CBCT measurement of the clivus dimensions can be used to determine gender of individuals. So, it can be concluded that clivus dimensions can be used to differentiate male from female. However, it shows no significance in age prediction. When other factors or measures in medico-legal instances proved inconclusive, it can also be employed as an extra or sole parameter. It may also aid radiologists in the radiological identification of certain clivus pathologies and serve as a guidance for surgeons performing clivus and related region operations. CBCT as a imaging tool is very useful as it gives accurate measurements.

List of abbreviations

CBCT- Cone beam computed tomography

CT- Computed Tomography

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Tables Legends

Table 1**:** Distribution of groups as per Age.

Below 18	8
18 to 35 years	58
36 to 50 years	22
51 to 65 years	7
Above 65 years	5
Total	100

Graph 1: Distribution of groups as perAge.

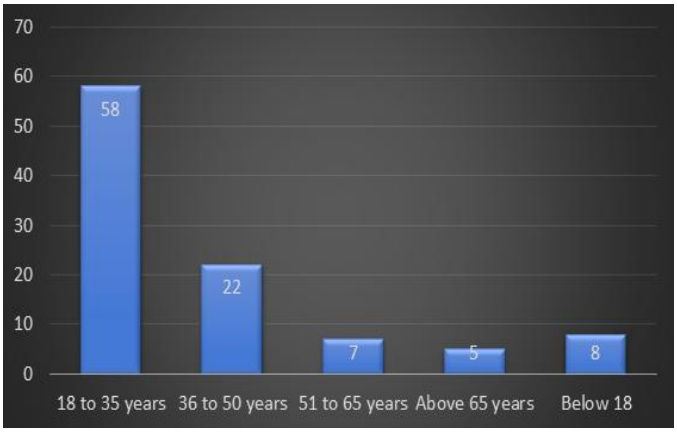

Table 2: Distribution of groups as per Gender.

Female	50
Male	50
Total	100

Graph 2: Distribution of groups as per Genders

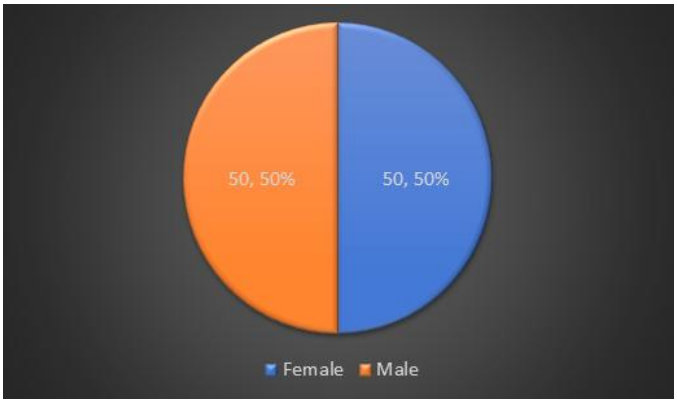

Table 3: Comparison of Clivus length between age groups.

Below 18	41.87 mm
18 to 35 years	45.03 mm
36 to 50 years	43.68 mm
51 to 65 years	43.91 mm
Above 65 years	43.87 mm

Graph 3: Comparison of Clivus length between age groups

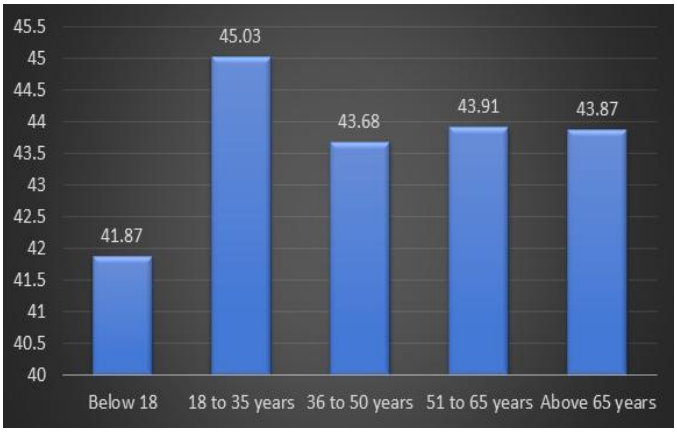

Table 4: Comparison of Clivus width between age groups.

Below 18	30.60 mm
18 to 35 years	30.48 mm
36 to 50 years	30.56 mm
51 to 65 years	29.96 mm
Above 65 years	32.28 mm

Graph 4: Comparison of Clivus width between age groups

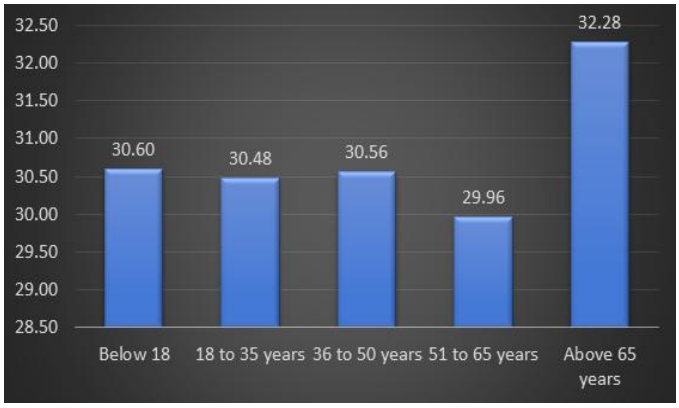

Table 5: Comparison of Clivus length between Genders.

M	46.245 mm
F	42.445 mm

Graph 5: Comparison of Clivus length between Genders

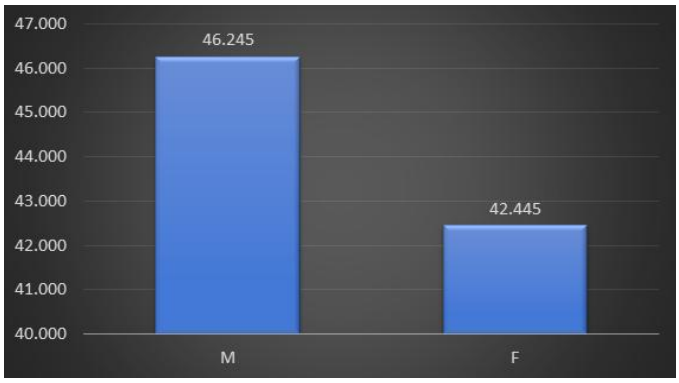

Table 6: Comparison of Clivus width between Genders.

M	31.336 mm
F	29.787 mm

Graph 6: Comparison of Clivus width between Genders

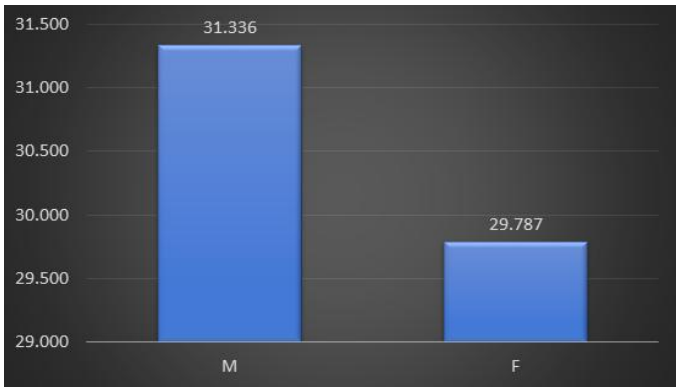

Table 7: Comparison of Clivus Width, Clivus Length values between Male and Female.

	Gender	N	Mean	Std. Deviation	Std. Error Mean	T value	p value of t test
Clivus Width	M	50	31.3362	2.92372	.41348	2.568	.012*
	F	50	29.7874	3.10408	.43898		
Clivus Length	M	50	46.2452	3.24405	.45878	5.890	.000**
	F	50	42.4448	3.20819	.45371		

There was a statistically highly significant difference seen for the values between the groups ($p<0.01$) for Clivus Length with higher values in Male as compared to Female.

Table 8: Comparison of Clivus Width, Clivus Length values between age groups.

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum	F value	p value of one-way ANOVA
						Lower Bound	Upper Bound				
Clivus Width	Below 18	8	30.5963	4.79545	1.69545	26.5872	34.6053	25.21	38.08		
	18 to 35	58	30.4833	2.70244	0.35485	29.7727	31.1938	22.46	38.41		

	years										
	36 to 50 years	22	30.5555	3.40161	0.72523	29.0473	32.0636	25.6	37.62	0.449	.773#
	51 to 65 years	7	29.9643	2.8862	1.09088	27.295	32.6336	25.65	33.22		
	Above 65 years	5	32.282	3.97092	1.77585	27.3514	37.2126	28	38.4		
	Total	100	30.5618	3.0993	0.30993	29.9468	31.1768	22.46	38.41		
Clivus Length	Below 18	8	41.87	2.848	1.007	39.49	44.25	36	45		
	18 to 35 years	58	45.03	3.663	0.481	44.07	45.99	36	52	1.624	.175#
	36 to 50 years	22	43.68	4.278	0.912	41.78	45.58	34	51		
	51 to 65 years	7	43.91	3.744	1.415	40.45	47.38	40	49		
	Above 65 years	5	43.87	0.842	0.376	42.83	44.92	43	45		
	Total	100	44.35	3.735	0.374	43.6	45.09	34	52		

There was a statistically non-significant difference seen for the values between the groups ($p>0.05$) for Clivus Width, Clivus Length

Figure 1: Clivus Length in Sagittal View.

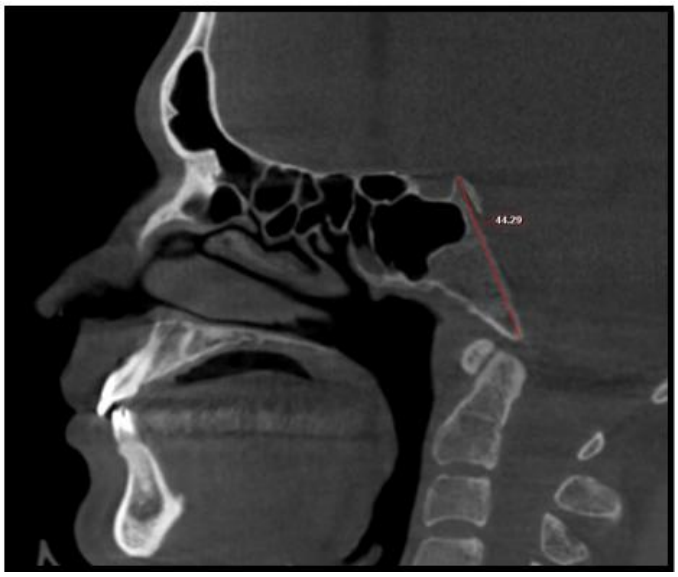

Figure 2: Clivus Width in Axial View.