Radio-morphometric evaluation of Clivus in Indian ethinicity-A cone beam computed tomography study

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Abstract

Objective: The aim of present study is to determine the age and sex related changes in clivus length and clivus width. The present study also evaluates the age prediction on the basis of clivus width and clivus length.

Material and Methods: The CBCT images of 200 subjects obtained from Carestream 9000cc (USA) CBCT machine at 90 Kvp, 4 mA for 11.3 seconds at FOV(17"x13.5")voxel size of 300 in the age group of 6yrs to 78 yrs (130 male, 70 female) were chosen. The clivus length and clivus width were measured using Trophy Dicom Ink software programme on sagittal images (DICOM images).

Results: 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. The Pearson correlation coefficient shows that the clivus length and clivus width was directly associated with age. The clivus length was found to be statistically significant in all age groups i.e. statistically significant difference was observed between age groups (p value <0.05). The clivus width was also found to be statistically significant in all age groups i.e. statistically significant difference was observed between age groups (p value < 0.05). The mathematical equations derived from linear regression analysis can be used for prediction of age in males and females if the clivus length and clivus width is known.

Conclusion: The CBCT measurement of the clivus dimensions can be used to predict the age of individuals. The clivus dimensions are directly related to age and gender. So it can be concluded that clivus dimensions can be used to differentiate male from female and age determination. However it can also be used as an additional or only parameter when other parameters or measures were inconclusive in medico-legal cases.

Keywords: Clivus, Foramen Magnum, Cone Beam Computed Tomography

Introduction

Anatomists, Forensic experts and Anthropologist has facing critical problem in identifying the exanimated persons from the hard tissue that is bone.(1) Among the causes of variation in biological populations, sexual dimorphism is one of the most discernible.(2,3) Skeletal remains have been used as a tool for sexual dimorphing the individual as bones of the body are last to disintegrate after death next to enamel.(1) Forensic anthropologists receive an incomplete skeleton. That's why it is important for alternate areas of the skeleton to be researched for sex determination.(4) Traditionally skull is most studied bone in physical anthropology.(5) Clivus being a denser part of bony skull can be recovered intact from a damaged or incinerated skull. Therefore it can alternatively used as an anthropometric measurement for gender determination to some extent medico legally.(4) The clivus is the part of the skull base situated between the foramen magnum and the dorsum sellae. It results from the fusion of the synchondrosis between the basioccipital and exoccipital bones, with growth and ossify from the 3 to the 25 year of age to form the basisphenoid and the basiocciput. The anterior margin of the clivus abuts the sphenoidal sinus, whereas the posterior surface is the anterior limit of the prepontine and premedullary cisterns. The inferior margin represents the posterior nasopharyngeal surface. The clivus is bounded laterally by the petrooccipital fissure, which begins near the cavernous sinus and extends inferiorly to the jugular foramen.(6)

Normal CT appearance: Clivus is best seen in the axial and sagittal view. Compact cortical bone forms the anterior and posterior boundaries, whereas the central portion consists of cancellous bone including narrow elements. Along with the fatty metamorphosis, the clivus is filled up with fatty narrow in adults.(7) Because of its peculiar location in posterior cranial fossa and its relation with brainstem, clinically it is an imperative surgical site for its pathology. Invasion of clivus is rarely involved in conditions like Giant cell tumours,(8) Meningiomas,(9) pituitary adenoma,(10) monostotic fibrous dysplasia(11) etc. Traditional studies by non-metrical methods were not reliable. So morphometry and statistical methods were introduced.[1]In this study we quantitatively analyse the data with the help of cone beam computed tomography to determine the forensic and medicolegal significance more than the clinical significance by measuring the clivus width and length in axial and sagittal section respectively.

Materials and Methods

This study was an observational study in which

Head and PNS CBCT images of 200 subjects (130 males and 70 females) in the age group of 6 yrs to 78 years were chosen. This age group was chosen because the final length and width are achieved before this age of an individual. The CBCT images of subjects having no history of trauma, pathology diagnosed as normal have been included in study. Any CBCT with obvious pathology, trauma and facial asymmetry were excluded from this study. All the patients were examined on CS9300 carestream CBCT machine. The sagittal images were obtained at 90 Kvp, 4 mA for 11.3 seconds at FOV(17"x13.5") voxel size of 300. The measurement of clivus dimensions were done directly on DICOM images using Trophy Dicom Ink software programme. The greatest measurement were taken after going through different slices in sagittal sections of CBCT images. The measurements are done as follows-

1. The clivus width was measured on axial reconstructed image and was defined as the longest distance from left to right side near the anterior peripheral margin of foramen magnum inferiorly.(**Fig. 1**)
2. The clivus length was measured on sagittal reconstructed image and was defined as the longest distance superio-inferiorly from the upper point of dorsum sellae to the lowest point on anterior margin of foramen magnum.(**Fig. 2**)

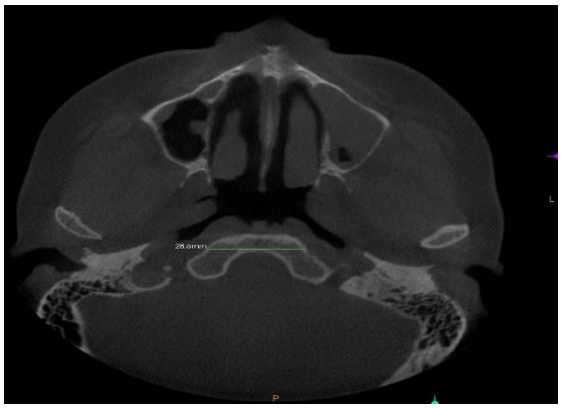


Fig. 1: Axial CBCT image showing the clivus width. It was measured on and was defined as the longest distance from left to right side near the anterior peripheral margin of foramen magnum inferiorly

Fig. 2: Sagittal CBCT image showing the clivus length. It was measured on and was defined as the longest distance superio-inferiorly from the upper point of dorsum sellae to the lowest point on anterior margin of foramen magnum

Results

Statistical Analysis: The categorical variables is presented in number and percentage (%) and continuous variables is presented as mean and SD. Quantitative variables is compared using Unpaired t-test between two groups and ANOVA test between three groups. Pearson correlation coefficient is used to determine the relationship between two scale parameters while correlation was defined as a measure of the strength of a linear relationship between two variables. A p value of <0.05 is considered statistically significant. The data will be entered in MS EXCEL spreadsheet and analysis will be done using Statistical Package for Social Sciences (SPSS) version 21.0.

The study samples consists of 200 subjects aged between 6 and 78 years with a mean age of 34.42±17.25 years. Majority of the study subjects were between 18 to 35 years of age (44.5%) followed by subjects below 18 years (17.0%), subjects 36 to 50 years (16.5%), 51 to 65 years (16.5%) and subjects above 65 years (5.5%)(**Table 1**). The sex ratio in our study population showed that males subjects (65%) outnumber the female subjects (35.0%) (**Table 2**).

Table

Age intervals	Frequency	Percent
Below 18 years	34	17.0
18 to 35 years	89	44.5
36 to 50 years	33	16.5
51 to 65 years	33	16.5
Above 65 years	11	5.5
Total	200	100.0

Table 2

Gender	Frequency	Percent
Male	130	65.0
Female	70	35.0
Total	200	100.0

Using unpaired t-test, the association of clivus length and clivus width was estimated in relation to gender, It was found that 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.(**Table 3**) The one way ANOVA is applied to determine association of clivus length and clivus width in age groups of subjects. The clivus length was found to be statistically significant in all age groups i.e. statistically significant difference was observed between age groups (p value < 0.05). The mean value of clivus length was higher in age group 51 to 65 years (46.5mm) than other age groups. The clivus width was also found to be statistically significant in all age groups i.e. statistically significant difference was observed between age groups (p value < 0.05). The mean value of clivus width was higher in age group 51 to 65 years (32.8mm) than other age groups (**Table 4**). The 2 tailed t-test is used to know the association between clivus length, clivus width and Age. It was found that the clivus length and clivus width was directly associated with age. The Pearson Correlation between age and clivus length, clivus width demonstrates a significant positive relation (i.e. r=0.164, p=0.021 and r=0.173, p=0.015 respectively).(**Table 5**).

Table 3

	Gender	N	Mean	Std. Deviation	P value
Clivus Length	Male	130	45.53	3.78134	<0.001*
	Female	70	43.10	3.83670	
Clivus Width	Male	130	30.62	3.53115	0.571
	Female	70	30.32	3.33882	

* Unpaired t test for significance

Table 4

					95% Confidence Interval for Mean		
		N	Mean	Std. Deviation	Lower Bound	Upper Bound	P value
Clivus Length	Below 18 years	34	42.5324	3.59340	41.2786	43.7862	0.001*
	18 to 35 years	89	44.8000	4.18287	43.9189	45.6811	
	36 to 50 years	33	44.9212	3.37433	43.7247	46.1177	
	51 to 65 years	33	46.4970	3.48555	45.2610	47.7329	
	Above 65 years	11	44.1182	3.69698	41.6345	46.6018	
	Total	200	44.6770	3.96469	44.1242	45.2298	
Clivus Width	Below 18 years	34	29.0294	2.95507	27.9983	30.0605	0.002*
	18 to 35 years	89	30.8337	3.65295	30.0642	31.6032	
	36 to 50 years	33	29.5364	3.56816	28.2711	30.8016	
	51 to 65 years	33	32.0788	2.86888	31.0615	33.0960	
	Above 65 years	11	30.7727	2.26278	29.2526	32.2929	
	Total	200	30.5150	3.45942	30.0326	30.9974	

One way ANOVA for test of significance. *Significant

Table 5

		Age	Clivus Length	Clivus Width
Age	Pearson Correlation	1	.164*	.173*
	Sig. (2-tailed)		.021	.015
	N	200	200	200
*Correlation is significant at the 0.05 level (2-tailed)				

Table 6

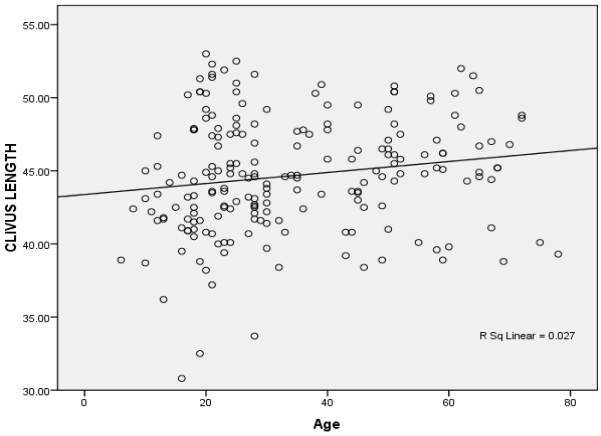
		Age	Clivus Length	Clivus Width
Age	Pearson Correlation	1	.003	.185*
	Sig. (2-tailed)		.975	.035
	N	130	130	130
*. Correlation is significant at the 0.05 level (2-tailed).				
**. Correlation is significant at the 0.01 level (2-tailed).				

Table 7

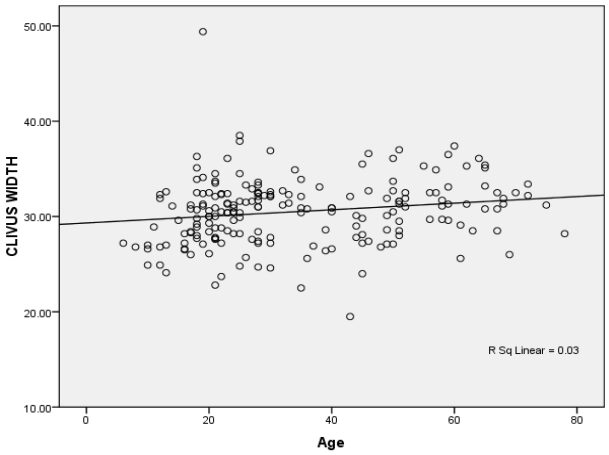
		Age	Clivus Length	Clivus Width
Age	Pearson Correlation	1	.446**	.129
	Sig. (2-tailed)		.001	.286
	N	70	70	70
**Correlation is significant at the 0.01 level (2-tailed)				

On the basis of strong positive correlation between clivus width, clivus length and age it was concluded that age plays an important role in determination of clivus length and Clivus width. Linear regression analysis has done for clivus length in relation to age and mathematical equation derived is- Y=2.614+0.712*X(**Graph 1**). Therefore it was concluded that if the clivus length of an individual is known, the age can be predicted with help of mathematical equation derived from linear regression analysis. The Linear regression analysis has been done for clivus width in relation to age and mathematical equation derived is- Y=8.160+0.860*X(**Graph 2**). Hence it was concluded that if the clivus width of an individual is known, the age can be predicted with help of mathematical equation derived from linear regression analysis.

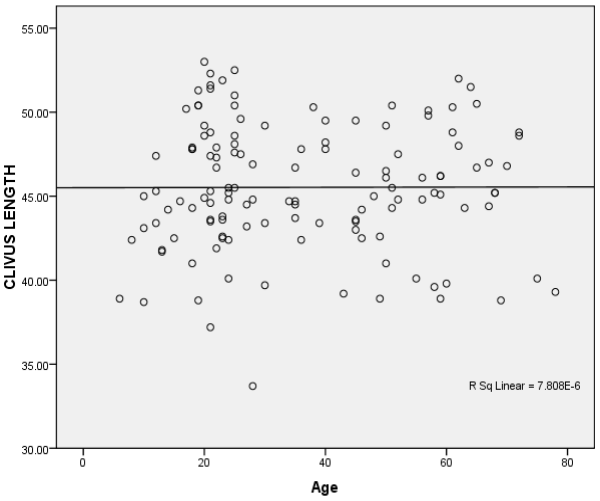
Graph 1



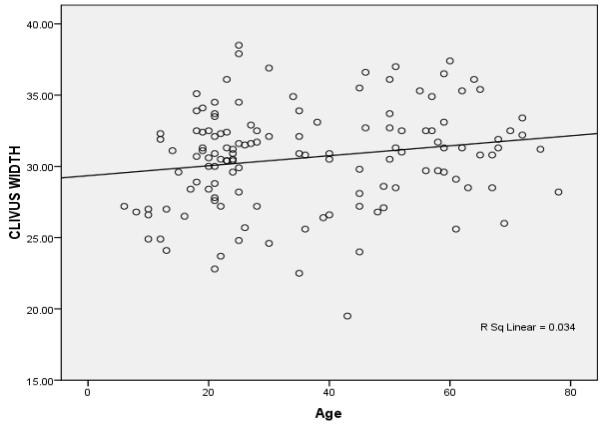
Graph 2



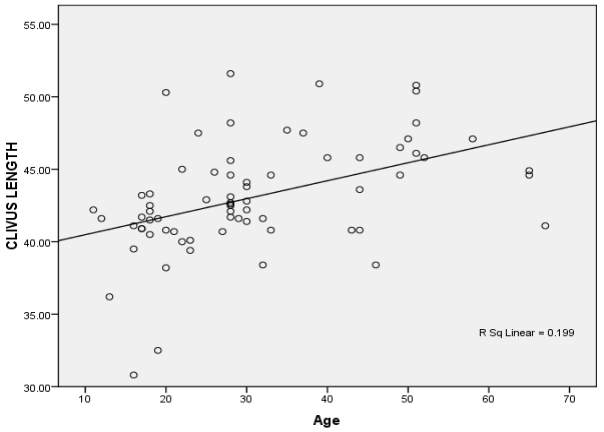
Graph 3



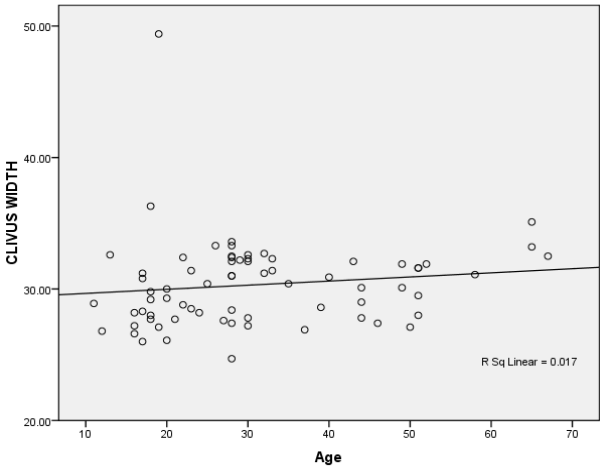
Graph 4



Graph 5



Graph 6



The cilvus length, clivus width is correlated with age in male subjects. By using pearson correlation and 2 tailed t-test it was found that there was no obvious significant correlation between age of male subjects with clivus Length. However clivus width were directly associated with age of males and demonstrate a significant positive relation (r=0.185, p=0.035)(**Table 6**).The mathematical equations derived by linear regression analysis for clivus length in male is Y=35.603+0.014*X(**Graph 3**). Therefore it was concluded that if the clivus length of a male subject is known, the age can be predicted with help of mathematical equation derived from linear regression analysis. The mathematical equations derived by linear regression analysis for clivus width in male is Y=6.358+0.976*X(**Graph 4**). Hence it was concluded that if the clivus width of a male is known, the age can be predicted with help of mathematical equation derived from linear regression analysis. The cilvus length, clivus width is correlated with age in female subjects. There was no obvious significant correlation between age of female subjects with clivus width. However clivus length were directly associated with age of females and demonstrate a significant positive relation (r=0.446, p=0.001)(**Table 7**). The mathematical equations derived by linear regression analysis for clivus length is Y=(-38.056)+1.603*X(**Graph 5**). Therefore it was concluded that if the clivus length of a female subject is known, the age can be predicted with help of mathematical equation derived from linear regression analysis. The mathematical equations derived by linear regression analysis for clivus width is-Y=14.842+0.534*X(**Graph 6**). Hence it was concluded that if the Clivus width of a female is known, the age can be predicted with help of mathematical equation derived from linear regression analysis.

Discussion

Rosas et a[(12)] suggested that traditional methods have difficulty in isolating size and differentiating the shape variables which depend directly on size (allometry), from those (if any) which depend on sex. He did study on osteology to separate within the morphological complex of an organism (or any of its anatomical parts) features of shape associated with size from those exclusively linked to sex.

There are many literatures about morphometric studies of sexual dimorphism in different primate species (O'Higgins and Dryden,[(13)] Richtsmeier et al[(14)]) but detailed studies on human crania are scarce and are based on relatively small sample sizes (Wood and Lynch[(15)]).

Jehan M et al[(16)] stated that final length of the clivus was reached by 11 years of life in both men and women, and then remained constant throughout life. It seems that the postnatal age up to 11 years of life is the crucial time of the development of the clivus, when the final adult width of the clivus is first reached. The mean Clivus length and width of male was larger than females and this difference was statistically significant (p<0.0001).

Krogman et al[17] stated that the shape of the cranial base as seen in the sellar angle was influenced by clefting whereas the size i.e., the clivus length and the anterior cranial base length were affected by sex therefore, we tried to make out dimensional analysis of the size of clivus and its sexual dimorphism in MP region.

Apart from these, other studies emphasize on clivus length that were correlated clinically with the soft tissue pathology of the related area. For example, Clivus length in Chiari malformation Type-I (CM-I) was measured and correlated with different parameters by Dufton et al.[18] Clivus length was shorter (P= 0.0009) in CM-I patients (4.02cm ± 0.45) than comparison patients (4.23cm ± 0.42). A negative correlation was found between tonsillar herniation and clivus length (r = -0.30, P<0.001) greater degree of cerebellar tonsillar herniation is associated with a shorter clivus length. Similar results by Heiss et al,[19] CM-I is characterized by hindbrain deformity and clivus and basiocciput lengths were significantly shorter than the values obtained in the control group. As clivus legth is influenced in CM1 group of patients and similar groups so we excluded from our study. Whereas in our study we done our study on CBCT in contrast to other studies that were done on CT scan and it is the only study which emphasize on gender determination and age determination.

In our study the clivus length was found to be statistically significant in all age groups i.e. statistically significant difference was observed between age groups (p value < 0.05). The mean value of clivus length was higher in age group 51 to 65 years (46.5mm) than other age groups. The clivus width was also found to be statistically significant in all age groups i.e. statistically significant difference was observed between age groups (p value < 0.05). The mean value of clivus width was higher in age group 51 to 65 years (32.8mm) than other age groups. It is found that there is strong positive correlation between clivus width, clivus length and age, it was concluded that age plays an important role in determination of clivus length and clivus width. And by the help of mathematical equations derived by linear regression analysis for clivus width and clivus length we can predict the age of the subject if the clivus width and clivus length is known. This is very revolutionary step in the field of forensic medical sciences.

Conclusion

The CBCT measurement of the clivus dimensions can be used to predict the age of individuals. The clivus dimensions are directly related to age and gender. So it can be concluded that clivus dimensions can be used to differentiate male from female and age determination. However it can also be used as an additional or only parameter when other parameters or measures were inconclusive in medico-legal cases. It may also be helpful to the radiologist in radiological diagnosis of some clivus pathology and may act as a guide to the surgeons for the surgery of clivus and related region.

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