



## Sexual Dimorphism of Clivus Dimension by Computed Tomography Scan

### KEYWORDS

Clivus Length; Clivus Width; CT Scan; Sexual Dimorphism.

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### ABSTRACT

*Introduction: The clivus is a bone region formed by the fusion of basi-sphenoid and basi-occiput situated between dorsum sellae and foramen magnum, evaluated very clearly in routine CT scan due to its central location. Being a denser part of bony skull it can be recovered intact from scene of crime and therefore need to be researched as an alternate area for sex estimation.*

*Material and Method: CT images of 276 subjects of MP region, in the age group of 13-70 years (140 male, 136 female) were chosen. The Clivus length and width were measured using electronic caliper on DICOM viewing software.*

*Result: The mean clivus length and width of male was  $4.598 \pm 0.3024$ cm and  $2.981 \pm 0.3826$ cm respectively which were significantly ( $p < 0.0001$ ) larger than those of female with  $4.391 \pm 0.2475$ cm and  $2.647 \pm 0.2388$ cm respectively. Using Analysis of variance 78.57% of male and 76.47% of female clivus length; and 74.29% of male and 79.41% of female clivus width were sexed correctly. The overall accuracy of correct diagnosis was 76.43% in male and 77.94% in females.*

*Conclusion: CT measurement of the clivus dimensions can be used to differentiate male from female skull to some extent as an additional or only parameter when other parameters or measures were inconclusive in medico-legal cases.*

### INTRODUCTION:

Among the causes of variation in biological populations, sexual dimorphism is one of the most conspicuous<sup>1,4</sup>. The size is a major factor influencing sex differences in the human craniofacial complex<sup>4,7</sup>. Gender determination is considered as an important problem in the identification of unknown skull<sup>8</sup>. In most of cases forensic anthropologists receive an incomplete skeleton. That's why it is important for alternate areas of the skeleton to be researched for sex determination. Clivus being a denser part of bony skull can be recovered intact from a damaged or incinerated skull. Therefore it can alternatively be used as an anthropometric measurement for gender determination to some extent medico-legally. However, the difficulty of isolating size and shape has always been an unsolved problem in morphological approaches to sexual dimorphism. Thus, it is a goal of this article to use radiological approach which give exact measured dimension of the area to be researched for.

The Clivus is formed by the fusion of basi-sphenoid and basi-occiput. It is a bone region between dorsum sellae and foramen magnum<sup>9</sup>. It can be evaluated very clearly in routine brain MRI and CT scan due to its central location<sup>10</sup> and that's why we tried to measure and calculate its dimension using CT scan. The brainstem is located in the posterior cranial fossa, its ventral surface lies on the clivus.

Because of its location in posterior cranial fossa and its relation with brainstem, clinically it is an important surgical site for its pathology. Invasion of clivus is rarely involved in conditions like Giant cell tumours<sup>11</sup>, Meningiomas<sup>12</sup>, pituitary adenoma<sup>13</sup>, monostotic fibrous dysplasia<sup>14</sup> etc.

In this study we tried to normalize our data for the MP region and to find out its medico-legal significance (more than its clinical aspects) for sex determination by measuring clivus length and width using computerized

tomography scan. In addition it would be helpful to the radiologist for diagnostic purpose and to the surgeon for surgical purpose in the surgeries done through transcondylar region and other approaches to clivus region.

### MATERIAL and METHOD:

#### Selection Criteria :

This study was an Observational study in which Head and PNS CT images of 276 subjects (140 male and 136 female) of Madhya Pradesh region, in the age group of 13-70 years were chosen. This age group was chosen because the final length and width are achieved before this age of an individual. The scans of cases who had complaints of headache or with suspicion of some pathology but without radiological findings were collected and with no history of trauma and in whom CT Scan was normal as diagnosed by the Radiologists.

#### Exclusion Criteria :

Any CT radiography with obvious pathology or trauma, facial asymmetry or who had previously undergone surgical procedures or with cleft palate or ectopic and supernumerary teeth, or with history of Chiari malformation Type I, monostotic fibrous dysplasia or any genetic disorder were excluded from the study.

#### The Materials :

All the patients were examined on Siemens Emotion 16 (16 slice) Multi Detector Spiral Computed Tomography Scanner. The measurement of Clivus dimension were done directly on computer on DICOM images using Electronic Caliper inbuilt in the DICOM viewer software.

#### Methodology for Measurement of Clivus Dimension:

The greatest measurement were taken after going through different slices in sagittal sections of CT images. Parameter measured was as follows:

1. 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.1)

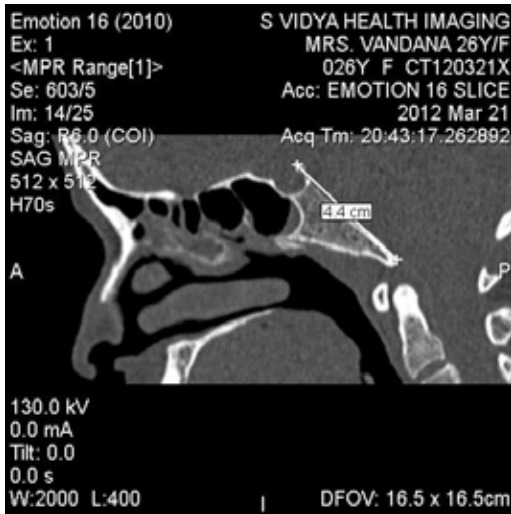


Fig.1 : Showing measurement of Clivus length in a Sagittal view of an adult CT.

2. 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.2)

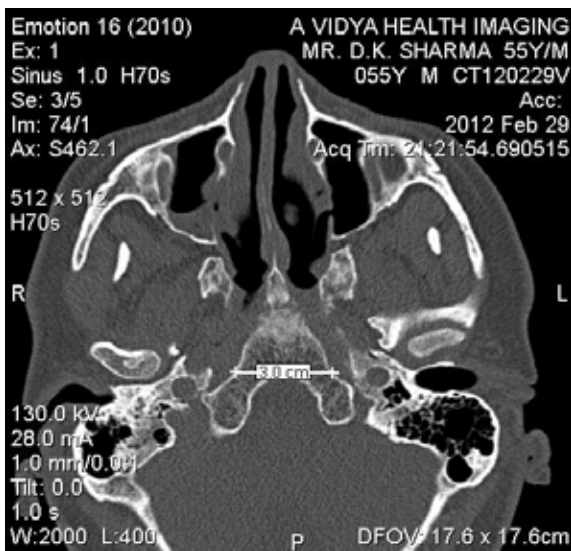


Fig.2 : Showing measurement of Clivus width in an Axial view of an adult CT.

**Statistical Evaluation:**

Unpaired Student t-test was carried out and the mean values, SD and p values for males and females were calculated separately and their average mean (M+F) were also calculated. Analysis of variance was also done. The statistical analysis was performed by using Graph Pad Prism and Word Excel Sheet windows 2007 compatible computer packaged softwares.

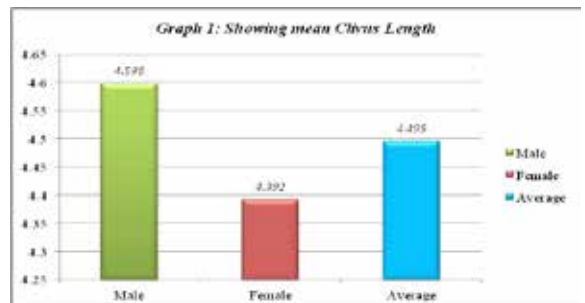
**RESULTS:**

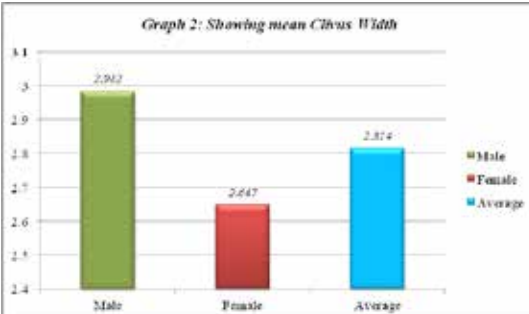
As observed in Table 1 & Graph 1 & 2, the mean clivus length  $\pm$  SD ( $4.598 \pm 0.3024$ )cm of male was larger than those of female ( $4.391 \pm 0.2475$ )cm; also the mean clivus width  $\pm$  SD ( $2.981 \pm 0.3826$ )cm in male was larger than female ( $2.647 \pm 0.2388$ )cm and these differences were statistically significant ( $p < 0.0001$ ) which suggests these to be the strong parameters for sexual dimorphism. We also did statistical analysis for product of Clivus Length and Width (LxW) with significant results equivalent to clivus length and width separately.

**Table 1: Showing statistics of Clivus Dimensions in male and female.**

Unpaired student t-test	Clivus length (L)		Clivus Width (W)		Clivus (LxW)	
	Male	Female	Male	Female	Male	Female
N	140	136	140	136	140	136
Mean	4.598 cm	4.391 cm	2.981 cm	2.647 cm	13.73 cm <sup>2</sup>	11.62 cm <sup>2</sup>
Std. Deviation (SD)	0.3024	0.2475	0.3826	0.2388	2.129	1.238
Std. Error (SEM)	0.02556	0.02122	0.03234	0.02048	0.1799	0.1061
Coefficient of variation	6.58%	5.64%	12.83%	9.02%	15.50%	10.65%
p value (Two-tailed)	P<0.0001 ***		P<0.0001 ***		P<0.0001 ***	
Difference between means	0.2067 $\pm$ 0.03331**		0.3344 $\pm$ 0.03852**		2.110 $\pm$ 0.2104**	
t, df	t=6.204 df=274		t=8.680 df=274		t=10.03 df=274	
95% confidence interval	0.1414 to 0.2720		0.2589 to 0.4099		1.697 to 2.522	
R squared	0.1232		0.2157		0.2684	
F test to compare variances						
F,DFn, Dfd	1.493, 139, 135		2.567, 139, 135		2.958, 139, 135	
p value	0.0099		P<0.0001		P<0.0001	
p value summary	**		***		***	
Are variances significantly different?	Yes		Yes		Yes	
Average (M+F) Mean $\pm$ SD	4.495 $\pm$ 0.275		2.814 $\pm$ 0.3107		12.675 $\pm$ 1.684	

N= no. of subjects; \*\*\* Significant at  $p < 0.0001$ ; \*\* Significant at  $p < 0.05$ ; df= degree of freedom.





By using analysis of variance as shown in Table 2; we find that 78.57% of male and 76.47% of female Clivus Length; and 74.29% of male and 79.41% of female Clivus Width were sexed correctly. This indicates that the clivus length is a better parameter in male and clivus width in female. The overall accuracy of correct diagnosis were greater than 75% with 76.43% in male and 77.94% in females. Analysis of LxW shown that 71.43% male and 82.35% females sexed correctly.

**Table 2: Showing results of Analysis Of Variance in male and female.**

Analysis Of Variance (Correct Diagnosis %)	Male	Female
Clivus Length	78.57%	76.47%
Clivus Width	74.29%	79.41%
Overall	76.43%	77.94%
Clivus (LxW)	71.43%	82.35%

## DISCUSSION:

Rosas et al<sup>4</sup> 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<sup>15</sup>, 1993; Richtsmeier et al<sup>16</sup>, 1993), but detailed studies on human crania are scarce and are based on relatively small sample sizes (Wood and Lynch<sup>3</sup>, 1996).

This study tries to use a new parameter and area of skull for sex determination using CT scan as a tool which gives exact length estimation. We have selected the dimensions of clivus which can be helpful to the forensic experts in sex determination of unknown skull. The 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, followed by the finalization of its growth in length as studied by Krmptić-Nemanić<sup>17</sup>, 2005. The mean Clivus length and width of male was larger than females and this difference was statistically significant ( $p < 0.0001$ ). In analysis of variance all parameters sexed both sexes with more than 75% accuracy with best results of 82.34% with clivus LxW for females. Krogman<sup>18</sup>, 1982 said 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.

In different other studies on clivus either rare clivus pathology or variant were noted or clivus length 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<sup>19</sup>, 2011. Clivus length was shorter ( $P = 0.0009$ ) in CM-I patients ( $4.02\text{cm} \pm 0.45$ ) than comparison patients ( $4.23\text{cm} \pm 0.42$ ). A negative correlation was found between tonsillar herniation and clivus length ( $r = -0.30, P < 0.001$ ). A greater degree of cerebellar tonsillar herniation is associated with a shorter clivus length. As clivus length was affected in CM-I patients we excluded this and the similar groups of patient from our study. Similar results by Heiss et al<sup>20</sup>, 2012 CM-I is characterized by hindbrain deformity and clivus and basiocciput lengths were significantly shorter than the values obtained in the control group.

## CONCLUSION:

It was concluded that CT measurement of the clivus dimensions can be used to differentiate male from female skull to some extent as an additional or only parameter when other parameters or measures were inconclusive in medico-legal cases with an overall accuracy of correct diagnosis 76.43% in male and 77.94% in females. 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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