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Anatomical study to estimate cranial capacity in dry human skull bones

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Abstract
Background: Cranial volume as an aspect of dimension equally expresses several degrees of growth and development and permits critical evaluation of unusually large, small or misshapen crania. Present study was aimed to anatomically estimate cranial capacity in dry human skull bones.
Material and Methods: Present study was single-center, descriptive, observational study, conducted among known gender skulls, from the adult skulls (< 20 years) & intact without any damage. The cranial volume was measured by the Lee-Pearson formula.
Results: In present study, 100 dry adult skulls were studied, 61 were of male while 39 of female. In male dry adult skulls, cranial length was 172.7±7.7 mm, cranial breadth was 133.5±7.1 mm, cranial height was 125.3±6.9 mm, cranial capacity was 1297.67±163.4 cc & cephalic index was 78.56±4.22%. In female dry adult skulls, cranial length was 168.4±9.3 mm, cranial breadth was 130.1±8.3 mm, cranial height was 123.5±8.7 mm, cranial capacity was 1241.63±133.3 cc & cephalic index was 76.05±2.34%. Majority skulls were Dolichocephalic (38), followed by Mesocephalic (33), Hyperdpolicocephalic (13), brachycephalic (10) & Hyperbrachycephalic (6).
Conclusion: Significant difference was observed between male & female skulls, majority skulls were dolichocephalic. Study of cranial capacity is important for gender, racial differences in field of forensic science & anatomy.

Keywords: Cranial capacity, cranial index, dry skull, dolichocephalic

Introduction
Cranial volume as an aspect of dimension equally expresses several degrees of growth and development and permits critical evaluation of unusually large, small or misshapen crania [1]. Cranial index variations between and within population have been attributed to a complex interaction between genetic and environmental factors.
Cranial capacity is one of the most important features used in hominin taxonomic and morphological analyses. For complete or nearly complete modern human crania, the traditional methods of estimating cranial capacity include filling the vault with seeds, the water displacement method, and the use of regression formulae based on craniometrics.
As cranial volume serves as one of the important parameter in the study of the human evolution, racial differences, in clinical practice for the study of abnormalities of cranial size and in sex determination of skulls, these dimensions will provide a baseline standard value for parameters in Indian population and will be of utmost importance to neurosurgeons, forensic experts in medico-legal cases and to the anthropologists [2]. Present study was aimed to anatomically estimate cranial capacity in dry human skull bones.

Material and Methods
Present study was single-center, descriptive, observational study, conducted in department of anatomy, at Srinivas Institute of Medical Sciences, Mangalore, India. Study duration was of 30 months (January 2014 to June 2015). Study was approved by institutional ethical committee.
All the skulls used for this study were known gender skulls, from the adult skulls (< 20 years) & intact without any damage. We excluded skull with broken and damaged parts, Atrophied /decomposed/deformed crania. Skulls with any injury, pathology or congenital anomaly. Various skull dimensions were measured with external linear dimensions. The vernier calliper was used to measure the length, by same person to avoid any mistake and errors during the process. Furthermore, the measurement is taken three times and their mean are calculated. The skull was placed that either the Frankfurt plane (line passing through the infraorbital border

and the upper border of external acoustic meatus) or the Reid's base line (a line passing through the infraorbital border and the middle of the external acoustic meatus) was parallel to the platform on which the skull to be measured is placed.

The cranial volume was measured by the Lee- Pearson formula [3, 4]. The linear parameters used to calculate the cranial volume were.

1. Maximum anteroposterior length-Measured between glabella and the inion.
2. Maximum breadth (biparietal diameter) - Measured between two parietal eminences.
3. Cranial height (auricular head height) - Measured between the external acoustic meatus and the highest point of the vertex, i.e., the bregma.

The cranial capacity was calculated as

- Males: 359.34 + 0.000365 × Length × Breadth × Height (cc)
- Females: 296.40 + 0.000375 × Length× Breadth× Height (cc)

Data was collected and compiled using Microsoft Excel, analysed using SPSS 23.0 version. Statistical analysis was done using descriptive statistics.

Results

In present study, 100 dry adult skulls were studied, 61 were of male while 39 of female. In male dry adult skulls, cranial length was 172.7±7.7 mm, cranial breadth was 133.5±7.1 mm, cranial height was 125.3±6.9 mm, cranial capacity was 1297.67±163.4 cc & cephalic index was 78.56±4.22%. In female dry adult skulls, cranial length was 168.4±9.3 mm, cranial breadth was 130.1±8.3 mm, cranial height was 123.5±8.7 mm, cranial capacity was 1241.63±133.3 cc & cephalic index was 76.05±2.34%.

Table 1: Various cranial parameters

Parameters	Male skulls (N=61)		Female skulls (N=39)		Total mean
	Mean	SD	Mean	SD	
Cranial length (mm)	172.7	7.7	168.4	9.3	170.9
Cranial breadth (mm)	133.5	7.1	130.1	8.3	132.8
Cranial height (mm)	125.3	6.9	123.5	8.7	124.9
Cranial capacity (cc)	1297.67	163.4	1241.63	133.3	1219.15
Cranial Index (%)	78.56	4.22	76.05	2.34	76.30

In present study, majority skulls were Dolichocephalic (38), followed by Mesocephalic (33), Hyperdpolicocephalic (13), brachycephalic (10) & Hyperbrachycephalic (6).

Table 2: Classification based on Cranial Index

Skull type	Male skulls	Female skulls	Total
Hyperdpolicocephalic (≤ 69.9)	6	7	13
Dolichocephalic (70.0-74.9)	24	14	38
Mesocephalic (75.0-79.9)	19	14	33
Brachycephalic (80.0-84.9)	8	2	10
Hyperbrachycephalic (≥ 85.0)	4	2	6
	61	39	100

Discussion

The craniometry of the skull also determines the cephalic index, which helps to classify the skull into Dolichocephalic, Mesocephalic, and Brachycephalic. The skull configuration is a reliable indicator for estimating the stature of an individual and the cranial capacity that helps to access brain development [3]. Quantitative analysis of growth, shape and size of the human skull especially the foetal skull is of great importance and efforts have been made to associate these craniometrical variations to characterize different races geographically.

Cranial capacity is the volume of the interior of the cranium of vertebrates that possess a cranium and a brain. Cranial volume is used to approximate the size of the brain, which is also suggestive of the intelligence of the organism. Larger capacities are observed in larger organisms and in colder environments as a feature of adaptability, but not always of superior intelligence.

In study conducted by Desai SD *et al*., [5] among 125 human adult dry skulls, maximum cranial index was 82.53 mm and 71.20 mm was minimum. The mean cranial index was 82.53 mm and 71.20 mm was minimum. The cranial index was 77.69+2.39 mm, in males it was 79.98+2.16 mm and 75.35+2.56 mm in females.

Craniometry evaluated by computed tomography and other radio-imaging and radiographic techniques are now a useful and modern tool to anatomists, anthropologists and neuroscientists accepted as a standard protocol for clinical diagnosis and surgical procedures or medico-legal examinations.

A sound understanding of cranial capacity is relevant to the study and comparison of populations with racial, geographic, ethnic and dietary differences. This knowledge is also useful for correlating cranial capacity and other cranial measurements and in studies of primate phylogeny [3].

Conclusion

Significant difference was observed between male & female skulls, majority skulls were dolichocephalic. Study of cranial capacity is important for gender, racial differences in field of forensic science & anatomy.

Conflict of Interest: None to declare

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