Section: Anatomy

Original Research Article

MORPHOMETRIC CRANIOMETRY IN SOUTH INDIAN ADULTS USING SKULLS

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Received : 06/01/2024
Received in revised form : 19/03/2024
Accepted : 01/04/2024

Keywords:
Anthropometric measurements, Cranial index, Orbital index, Auriculo-vertical index, CT, MRI.

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DOI: 10.47009/jamp.2024.6.2.148

Source of Support: Nil,
Conflict of Interest: None declared

Int J Acad Med Pharm
2024; 6 (2); 706-711

Abstract
Anthropometric measurements of skeletal bones are crucial for identifying sex and assessing growth in various clinical settings. The cephalic index is a reliable measurement for determining skull shape. The index can be determined using various methods, including CT and MRI. This observational study was conducted on 40 dry skulls of adult South Indian patients for anthropometric indices. For osteometric measurements, parameters were measured using vernier and spreading callipers in millimetres (mm). High-resolution scan measurements of computed tomography and magnetic resonance imaging-brain were performed on the radiology samples. The cranial, orbital, and auriculo-vertical indices were measured. The cephalic indices were calculated using the Hrdlika method. Findings indicated dolichocephalic skulls as the most prevalent among females (40% in dry skulls, 44% in CT scans), while meso orbit predominated in males (48% in skulls). Meso- and micro-orbits were equally prevalent in CT and MRI scans, contrasting with dry skulls. Statistically significant differences in maximum cranial length were noted between dry skulls and MRI scans (p=0.041). The study revealed variations in craniometric indices among different populations, revealing common skull types in South Indian populations and providing valuable data for various fields.

INTRODUCTION

The anthropometric measurements of skeletal bones play a key role in the identification of sex, which helps the anatomist and clinician for assessment in wars, road and train accidents and deliberate mutilation, disfigurement, pounding, or gauging of the body.[1] Cranial index, orbital index, and auriculo-vertical index, which are reliable and accurate, are commonly used. The skull is preferred for identification because it is resistant to fire, explosion, and mutation. The cephalic index was defined by a Swedish professor, Anders Retzius (1796–1860), and was first used in physical anthropology to classify ancient human remains found in Europe. The cranial index (CI) is the ratio of the maximum width of the head to the maximum length multiplied by 100.[2] The Cephalic index indicates the shape of the skull, including head length and width. Head length is the distance from the glabella to the opisthocranion, and head width is the distance between two neurones that provides information regarding individuals' appearances to estimate the age of the foetus, sexual dimorphism, and individual inheritance.[3] Cephalic Index can be determined by anthropometric methods, dry skull measurements, and computerised tomography (CT) and magnetic resonance imaging (MRI) scans. The cephalic index is a reliable measurement for anthropologists.[4]

Craniometry helps to assess growth and is used in various clinical practices in paediatrics, forensic medicine, plastic surgery, oral surgery, and dentistry for diagnostic purposes. Various factors, such as ecological, geographical, racial, gender, and age, affect the dimensions of the human body. Head shapes can be categorised as dolichocephalic, mesaticephalic, brachycephalic, and hyperbrachiocephalic or cranial indices based on the cephalic index.[5] The study showed mesocephaly among normal Indians, but brachycephaly has been

observed in mentally disabled individuals. Many research studies show a significant difference in cephalic index among various populations.[6] By formulating standard sizes, Anthropometric study of the head is useful in designing various head and face equipment like helmets, headphones, goggles, etc.[7]
The cephalic index is an accurate tool to determine the shape of the skull, enabling the neurosurgeon to assess pre-and post-operatively, and paves the way for planning for surgery. In this study, the cephalic index among the South Indian population was evaluated.[8,9] Quantitative analysis of the human skull's growth, shape, and size, especially the foetal skull, is important. Efforts have been made to associate these craniometric variations to characterise different races geographically. Several metric parameters were used to compare the shapes and sizes of the skulls. One such craniometrical parameter is the "Cranial Index (CI)". Van introduced the Cranial Index or Cephalic index (in living individuals) as a percentage of the width to length of the skull. Width is the distance between the most prominent points on the side of the skull. The length is the distance from the glabella and the most prominent point at the back of the cranium, mainly the occipital protuberance.[9]

Aim

This study aimed to determine the prevalence of various skulls in the South Indian population by assessing various craniometric indices.

MATERIALS AND METHODS

This observational study used 40 dry skulls as anthropometric indices in adult South Indian patients.

Osteometric Samples

For osteometric measurements, 40 dry skulls were studied for anthropometric indices. Parameters were measured using vernier and spreading callipers in millimetres (mm).

Inclusion Criteria

Adult skulls with fused sutures were included in the study.

Exclusion Criteria

Damaged and eroded skulls and deformed or anomalous skulls were excluded.

Radiology Samples

High-resolution scan measurements of computerised tomography and magnetic resonance imaging of the brains of South Indian adult patients were performed and analysed. One hundred computerised tomography scans and 100 magnetic resonance imaging scans of the patients were performed, and the parameters were measured in millimetres.

Inclusion Criteria

Normal computerised tomography and magnetic resonance imaging scans without a deformed skull were included.

Exclusion Criteria

Patients with congenital malformations of the skull, history of RTA/neurosurgery, skull bone tumour, and existing neurological disorders were excluded.
Dry skulls were classified as male or female based on their identification features. Male skulls are heavier, the bone is thicker, and the areas of muscle attachment are more defined than those in females. In female skulls, the supraorbital margin is sharper; in male skulls, it is rather round and dull. Eye sockets are square-shaped in male skulls and round in female skulls. The superciliary arch and zygomatic bones were more pronounced in the male skulls. The mandible of a female is more rounded, whereas a male's is squared. The gonial angle (the point at which the mandibular corpus and ascending ramus meet) is closer to 90° in males, whereas in females, it is greater, up to 110° to 120°.
Maximum head length measures the straight distance between the glabella & opisthocranion; Maximum head breadth (EURYON) is the distance between the most lateral points on the parietal bones or sides of the head. The orbital height was defined as the distance between the upper and lower margins of the orbital cavity. The orbital breadth was defined as the distance between the midpoints of the medial and lateral margins of the orbit. Auriculo bregmatic length is the distance between the external acoustic meatus and bregma.

Cephalic index (cranial index): The skull length was measured from the Glabella to Opisthocranion. The glabella is the point above the nasal root between the eyebrows and is intersected by the midsagittal plane. The posterior-most point on the posterior protuberance of the head in the midsagittal plane was the opisthocranion.

Orbital Index: Orbital parameters were measured using a digital Vernier calliper, accurate up to 0.01 mm for the following parameters. Orbital height (OH) was measured as the maximum vertical distance between the superior and inferior orbital margins. Orbital width (OW) or orbital breadth was measured as the distance between the medial and lateral walls of the orbits.

Auriculovertical index: The auriculo-vertical index, also called the vertical cephalic index (VCI), is calculated using auriculo-bregmatic length and maximum cranial length. The maximum auricular head height/auriculo-bregmatic length is the distance between the external acoustic meatus and the bregma's highest vertex point.

Statistical Analysis

All the data were entered into MS Excel and analysed. The data were expressed in frequency and percentage. The cephalic indices were calculated using the Hrdlika method.

RESULTS

Among the 25 dry skulls, 12 dry skulls (48%), 50 computerised tomography scan images, 22 images

(44%), and among the 50 magnetic resonance imaging scan images, 30 images (60%) were identified as dolichocephalic. The dolichocephalic type identified in the dry skull and computerised tomography scan was more than 40%, but in the magnetic resonance imaging scan, it was approximately 60%. Although the difference was not statistically significant (p=0.0571), it may be due to technical errors, including some soft tissue thickness while taking the measurements.

The mesocephalic type was identified by computerised tomography, accounting for 20 images (40%) among 50 computerised tomography, nine images (18%) among 50 magnetic resonance, and seven dry skulls (28%) among 25 dry skulls. The brachycephaly type was identified in 3 skulls (12%) among 25 dry skulls, seven images (14%) among 50 computerised tomography scan images, and two images (4%) among 50 Magnetic Resonance Imaging scan images.

The least types identified in dry skulls were hyper brachycephalic, hyper dolichocephaly, and ultra dolichocephaly, accounting for one dry skull each (4%) among 25 dry skulls. Computerised tomography and magnetic resonance imaging did not reveal the hyperbrachycephalic skull type. The hyperdolichocephalic skull type was identified in 8 (16%) of 50 magnetic resonance imaging scan images, while one image (2%) was identified among 50 computerised tomography scan images. The ultra-dolichocephalic skull type was not identified by computerised tomography scan; one image (2%) was among the 50 magnetic resonance imaging scan images.

In females, the dolichocephalic skull was the most common type, accounting for six dry skulls (40%) among 15 dry skulls, 21 images (42%) among 50 computerised tomography scan images, and 24 images (48%) among 50 Magnetic Resonance Imaging scan images. The next most common skull type was mesocephalic, identified in 5 dry skulls (33.3%) among 15 dry skulls, 16 images (32%) among 50 computerised tomography scan images, and 17 images among 50 magnetic resonance imaging images. The hyper-dolichocephalic type was identified in one dry skull (6.7%) among 15 dry skulls. In contrast, it was identified in five (10%) images among 50 computerised tomography images and six images among 50 magnetic resonance imaging scan images. Hyperbrachycephalic was identified in one dry skull (6.7%) among the 15 dry skulls but not in the computerised tomography and magnetic resonance imaging scan images. [Table 1]

The meso-orbit is the most common type in males, based on the orbital index. It was identified in 12 skulls (48%) among the 25 dry skulls, 28 (56%) among the computerised tomography scan images, and 32 (64%) among the 100 magnetic resonance scan images. The difference in orbital indices between the dry skull and computerised tomography scan images was not statistically significant (p=0.0689). In contrast, there was a statistically significant difference between the dry skull and magnetic resonance imaging scan images (p=0.048).

In the female, the most common orbit type based on the orbital index was the meso orbit. It was identified in 9 skulls (60%) among 15 dry skulls and 26 images each (52%) among 50 computerised tomography images and magnetic resonance imaging scans. This was followed by micro-orbit identification in five skulls (33.3%) among 15 dry skulls and 12 images each (24%) among 50 computerised tomography scans and magnetic resonance imaging scan images. The mega orbit was least identified in dry skulls, accounting for one skull (6.7%) among 15 dry skulls and 12 images each (24%) among 50 computerised tomography and magnetic resonance imaging scan images. Therefore, both meso- and micro-orbits were equally identified in computerised tomography and magnetic resonance imaging scans. [Table 2]

The hypsicephalic skull type was the most common in males based on the auricular vertical index. All 25 dry skulls (100%) were hypsicephalic, while it was identified in 48 images (96%) among the 50 Computerised Tomography scan images and 43 images (86%) among the 50 Magnetic Resonance Imaging scan images. The orthocephalic type was identified in 2 (4%) of 50 computerised tomography images and 7 (14%) of 50 Magnetic Resonance Imaging scan images. This type was not identified in the dry skulls.

Hypsicephalic was women's most common skull type, accounting for all 15 dry skulls (100%). At the same time, it was identified in 45 images (90%) among the 50 computerised tomography scan images and 48 images (96%) among the 50 magnetic resonance imaging scan images. The orthocephalic type was identified in 5 (10%) of the 50 computerised tomography images and two (4%) of the 50 magnetic resonance imaging scan images. This type was not identified in the dry skulls. [Table 3]

The mean head length in the dry skull was 166.19 ±7.68 mm; that in the skull was 182.44±4.73; and that in the CT scan skull was 175.22 ±7.78 mm. The mean head breadth in dry skulls was 125.45±6.58 mm; in the MRI scan skull was 133.78±4.793 mm, and in the CT scan skull was 131.54±3.03 mm. The mean orbital height in the dry skull was 30.89±2.062 mm; in the MRI scan skull, it was 31.49±36.07 mm; and in the CT scan skull, it was 30.23±1.16 mm.

The mean orbital breadth of the dry skull was 37.42±2.55 mm, the MRI scan skull was 36.07±1.323 mm, and the CT scan skull was 34.58±1.26 mm. The mean auriculo-bregmatic length of the dry skull was 126.41±4.21 mm, the MRI scan skull was130.83±4.58, and the CT scan skull was 127.18±5.10 mm. The mean of the maximum cranial length of the dry skull scan was 166.19±7.68 mm, the MRI scan skull was 182.46±4.75 mm, and the CT skull scan was 175.22±7.78 mm.

The mean auriculo-bregmatic length across the three modes showed minimal differences. Still, the maximum cranial length showed statistically significant differences between the dry skull and magnetic resonance imaging scan (p=0.0411). [Table 4]

Table 1: Classification of the skull by the cranial index according to gender

		Male	Female
Dry skull (n=40)	Brachycephalic	3(12%)	2(13.3%)
	Dolichocephalic	12(48%)	6(40%)
	Hyperbrachicephalic	1(4%)	1(6.7%)
	Hyperdolichocephalic	1(4%)	1(6.7%)
	Mesocephalic	7(28%)	5(33.3%)
	Ultradolichocephalic	1(4%)	0
Computerised tomography scan skull (n=100)	Brachycephalic	7(14%)	8(16%)
	Dolichocephalic	22(44%)	21(42%)
	Hyperdolichocephalic	1(2%)	5(10%)
	Mesocephalic	20(40%)	16(32%)
Magnetic resonance imaging scan skull (n=100)	Brachycephalic	2(4%)	3(6%)
	Dolichocephalic	30(60%)	24(48%)
	Hyperdolichocephalic	8(16%)	6(12%)
	Mesocephalic	9(18%)	17(34%)
	Ultradolichocephalic	1(2%)	0

Table 2: Classification of the skull by the orbital index according to gender

		Male	Female
Dry skull (n=40)	Mega orbit	3(12%)	1(6.7%)
	Meso orbit	12(48%)	9(60%)
	Micro orbit	10(40%)	5(33.3%)
Computerised tomography scan skull (n=100)	Mega orbit	16(32%)	12(24%)
	Meso orbit	28(56%)	26(52%)
	Micro orbit	6(12%)	12(24%)
Magnetic resonance imaging scan skull (n=100)	Mega orbit	11(22%)	12(24%)
	Meso orbit	32(64%)	26(52%)
	Micro orbit	7(14%)	12(24%)

Table 3: Classification of the skull by the auriculo-vertical index according to gender

		Male	Female
Dry skull (n=40)	Hypsicephalic	25(100%)	15(100%)
Computerised tomography scan skull (n=100)	Hypsicephalic	48(96%)	45(90%)
	Orthrocephalic	2(4%)	5(10%)
Magnetic resonance imaging scan skull (n=100)	Hypsicephalic	43(86%)	48(96%)
	Orthrocephalic	7(14%)	2(4%)

Table 4: Comparison of parameters between the dry skull, MRI scan skull and CRT scan skull

		Mean ± SD
Head Length (mm)	Dry skull	166.1900±7.68317
	MRI scan skull	182.4457±4.79256
	CT scan skull	175.2281±7.78165
Head breadth (mm)	Dry skull	125.4585±6.58127
	MRI scan skull	133.7846±3.83727
	CT scan skull	131.5479±3.03218
Orbital height (mm)	Dry skull	30.8975±2.06250
	MRI scan skull	31.4906±1.31657
	CT scan skull	30.2369±1.16457
Orbital breadth (mm)	Dry skull	37.4290±2.54769
	MRI scan skull	36.0794±1.32312
	CT scan skull	34.5839±1.26483
Auriculo-bregmatic length (mm)	Dry skull	126.4163±4.21089
	MRI scan skull	130.8384±4.58254
	CT scan skull	127.1839±5.10980
Maximum cranial length (mm)	Dry skull	166.1900±7.68317
	MRI scan skull	182.4657±4.75924
	CT scan skull	175.2281±7.78165

DISCUSSION

Our research focused on the measurement of cranial indices and the classification of skulls into various types based on these indices. The average cranial index observed in both males and females in our study was 75.72, which closely resembled findings from a recent investigation among the Telangana population, where the mean cranial index was 75.21.10 Interestingly, studies conducted among the North Indian and Nigerian populations showed

ISSN (O): 2687-5365; ISSN (P): 2753-6556

slightly lower mean cranial indices of 72.56 and 72.54, respectively, compared to our study.[11,12]

In terms of gender differences, the mean cranial index was 75.09 for males and 76.77 for females in our study. Although there was a minor discrepancy, the variation was deemed insignificant (p=0.071). Our results aligned closely with findings from the Telangana population study, where males had a mean cranial index of 75.32 and females had 75.42.[10] Conversely, our study showed higher mean cranial indices compared to the North Indian population, with males at 72.54 and females at 72.06.[11]

Regarding orbital indices, we found a mean of 82.74 for both males and females, significantly higher than that observed in the Telangana population. Specifically, the mean orbital index for males in our study was 81.98, resembling results from a study among the South Indian population (81.13) but notably higher than the Telangana study (74.47). Females exhibited a mean orbital index of 84.02 in our study, comparable to another study's findings (82.32) but significantly higher than the Telangana study (76.62).[10,13]

For auriculo-vertical indices, our study reported means of 75.35 for males and 77.59 for females, surpassing values observed in the Andhra Pradesh population study.[14] Additionally, our study's mean orbital indices for males (88.10) and females (87.03) were higher than those reported in studies among the Ghanaian and Nigerian populations.[15,16]

Analyzing skull types, we found dolichocephalic to be the most common among males (48%) and females (40%), followed by mesocephalic. These findings were consistent with observations from the Telangana population study for males but differed slightly for females. Conversely, among the Punjab population, mesocephalic was the predominant skull type for both genders, resembling our findings to some extent.[10,17]

In terms of orbital skull types, the meso orbit was most prevalent among both males (48%) and females (60%) in our study. This trend contradicted findings from the Nigerian population study, where a mega orbit was dominant.[18] However, our results were consistent with a South Indian study, where meso orbit was prevalent, although differing from another study where micro orbit was common.[19,20]

Understanding the prevalence of skull indices is vital for diagnosing craniofacial syndromes and posttraumatic deformities. Moreover, establishing normal values in specific regions aids in standardizing skull classifications for future research. The variability in craniofacial growth patterns across populations holds significance in anthropology, palaeontology, and forensic medicine. Utilizing various imaging techniques, we further identified hypsicephalic as the most common skull type based on auriculo-vertical indices, which corresponded with findings from the Andra Pradesh population study. Similarly, dolichocephalic was prevalent based on cephalic index in computerized tomography scan images, contrasting with findings from the Ghanaian population study.[15,16]

CONCLUSION

The plasticity of craniometry under the influence of genetics, race, geography, and climate provides a great opportunity to understand the evolutionary pattern of the skull. Our study showed variations in craniometric indices such as cephalic index, orbital index, and auriculo-vertical index compared with other populations of different geographical areas, sexes, and races. The most common skull type was dolichocephalic, as determined by the cephalic index; the most common orbital type was the meso orbit, as determined by the orbital index; and the most common skull type was hypsicephalic, as determined by the auriculo-vertical index in the South Indian population. The data provided by this study will be useful for anthropologists, anatomists, cop surgeons, plastic surgeons, ophthalmologists, and dentists. This study provides a solid platform for craniometric index research to a higher level.

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