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Original Article

Morphometric analysis of the foramen magnum in the Peruvian population

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ABSTRACT

Background: The foramen magnum, as an anatomical structure, holds clinical and functional significance due to its strategic location in the craniovertebral transition. A detailed understanding of its dimensions and shapes is crucial for better comprehension of related pathologies and for enhancing neurosurgical techniques within a specific population. The objective is to measure precise morphometric reference points of the foramen magnum in individuals of Peruvian ancestry, aiming to establish specific anatomical patterns and potential variations within this population.

Methods: The study was conducted on 17 unidentified skulls donated to the NeuroZone3D Research Center, utilizing an inelastic and soft measuring tape as the tool. Our report considered direct anthropometric measurement techniques with data collection performed by a single researcher.

Results: Distinct morphometric characteristics were observed in the foramen magnum of the Peruvian population compared to other studies. The average measurements of the skull base revealed a foramen magnum with a mean length of 33.80 mm and a width of 28.70 mm, along with right condyles measuring 25 mm in length and 14.10 mm in width, and left condyles measuring 23.80 mm in length and 13.90 mm in width.

Conclusion: The morphometric analysis of the foramen magnum in the Peruvian population provides valuable insights into specific anatomical features within this ethnic group. These findings could have significant implications across various medical and surgical disciplines, from interpreting diagnostic images to designing more precise therapeutic interventions tailored to this population.

Keywords: Anatomical variations, Anthropometric measurements, Foramen magnum, Morphometric analysis, Neurosurgical techniques

INTRODUCTION

The foramen magnum, an anatomical structure located at the base of the skull, has sparked notable multidisciplinary interest across various academic fields, ranging from forensic anthropology to neurosurgery and evolutionary biology.[20,29,30] This interest has been manifested through a series of morphometric and morphological investigations that have delved into the significance of the foramen magnum for a detailed understanding of human anatomy.

The foramen magnum is a fundamental anatomical region that serves as a critical point of connection between the spinal column and the central nervous system.[39] Its relevance lies in its close relationship with vital human body structures, such as the brainstem and the spinal cord, enabling the safe and protected passage of essential neural structures between the skull and the spinal column.[37]

A detailed understanding of the dimensions and morphological variations of the foramen magnum is crucial in medical practice, especially in neurology and neurosurgery.[6,35] Moreover, variations in its size, shape, or associated pathologies can have significant clinical implications.[40] Cases have been documented where abnormalities in the foramen magnum are associated with neurological disorders, congenital malformations, or conditions affecting the circulation of cerebrospinal fluid, underscoring its clinical relevance in diagnosis and treatment.[1-3,10]

Variability in the dimensions and characteristics of the foramen magnum in different ethnic populations has been documented,[13,14] emphasizing the importance of investigating and understanding specific anatomical features within a population. The purpose of this present study is to establish the morphometric profile of the foramen magnum in the Peruvian population, aiming to contribute to medical and surgical knowledge significantly and allow a better understanding of craniovertebral morphology within the Peruvian ethnic context.

MATEIALS AND METHODS

Study sample

The study sample comprises 17 cadaveric specimens from institutional osteological collections in Peru. These specimens, mostly donated to the NeuroZone3D Research Center, represent various geographical origins.

Classification methods

For study purposes, the 17 specimens were classified by the NeuroZone3D Research Center and its collaborators without considering age or sex. This decision was made due to the complexity of tracking and the lack of evidence supporting these characteristics.

Data collection

Measurements were conducted using conventional measurement techniques with a soft, inelastic measuring tape (Perfect Measuring Tape Company, USA). A single researcher assessed each skull, determining six cranial measurements according to widely recognized nomenclature[4,12,15,21,41] with assistance from other authors.

Statistical analysis

The collected data were tabulated and analyzed using Microsoft Excel. The results of cranial measurements are presented as mean, median, standard deviation, minimum, and maximum values.

Cranial reference points: Neurozone3D skull base protocol

The NeuroZone3D protocol represents a cranial reference system used to measure human skull dimensions. Based on recognized literature in neurosurgery, its primary objective is to unify consistent definitions that contribute to consensus in broad discussions about neuroanatomy, thus providing a supportive tool for the scientific community.

Within this protocol, six cranial measurements were prioritized at the skull base, including the length and width of the foramen magnum, as well as the condyle of the occipital bone. Detailed information on cranial measurements, their abbreviations, and specimen identification are provided in Tables 1 and 2 and Figure 1.

RESULTS

Cranial measurements from 17 skulls revealed significant variations in the dimensions of the foramen magnum and the condyles. For the foramen magnum, lengths ranged from 30.00 mm to 38.00 mm, with widths varying between 25.00 mm and 33.00 mm. Regarding the condyles, the average length of the right condyle was 25.00 mm, ranging from 21.00 mm to 30.00 mm, while the left condyle showed an average length of 23.80 mm, varying between 18.00 mm and 33.00 mm. Concerning width, the right condyle had a mean of 14.10 mm, fluctuating between 12.00 mm and 17.00 mm, whereas the left condyle averaged a width of 13.90 mm, ranging from 11.00 mm to 17.00 mm [Table 3].

When evaluating the skull base, the foramen magnum exhibited an average length of 33.80 ± 2.28 mm and a width of 28.70 ± 2.21 mm. Regarding the condyles, the right condyle showed a length of 25.00 ± 2.29 mm and a width of 14.10 ± 1.57 mm, while the left condyle recorded an average length of 23.80 ± 3.46 mm and a width of 13.90 ± 1.48 mm. The overall average length measurements for both condyles yielded a value of 19.68 ± 2.90 mm, while the average width was 11.18 ± 1.54 mm [Table 4].

DISCUSSION

For the first time, the collection at the NeuroZone3D Research Center in Peru provides detailed measurements of the foramen magnum and condyles in cadaveric specimens [Table 5]. In comparison, studies from Colombia

Table 1: Definitions of neuroanatomical cranial structures at the skull base (*).

Term	Abbreviation	Definition
Cranial measurement point		
Basion	ba	Basion encompasses a small region in the midline at the most anterior extension of the foramen magnum. Its reference position varies slightly depending on the measurement taken. It can be the posterior face of the anterior margin of the foramen magnum or the lowest mid-point of the anterior margin of the foramen magnum.
Opisthion	o	Opisthion is a cranial measurement point found along the midline at the inferior aspect of the skull. It is located on the occipital bone at the posteromedial margin of the foramen magnum.
Inion	i	The midpoint is between the tips of the superior nuchal lines and the base of the external occipital protuberance (not the tip of the protuberance).
Opisthocranion	op	Opisthocranion is the most posterior midline point of the occipital bone, instrumentally determined as the greatest length of the cord from the glabella, usually above the external occipital protuberance.
Neuroanatomy		
Occipital condyle	oc	Occipital condyles are two oval processes projecting downward and found along the lower aspects of the lateral part of the occipital bone. They are located anteriorly to the condylar fossae, medially to the jugular processes, and laterally to the foramen magnum.
The articular facet of the occipital condyle	fac	Articular facets are smooth, convex, and inferolaterally directed articular areas on the occipital condyles. They articulate with the superior articular facets of the atlas (first cervical vertebra), forming the atlantooccipital joints.
Pharyngeal tubercle	tf	The pharyngeal tubercle is a small prominence found along the midline on the inferior aspect of the basilar part of the occipital bone. It provides an insertion site for the pharyngeal raphe.
External occipital crest	crt	The external occipital crest (median nuchal line) is the crest found along the squamous part of the occipital bone. It extends anteroinferiorly along the midline, from the external occipital protuberance to the foramen magnum. The external occipital crest divides the nuchal plane into the right and left halves and provides an insertion site for the nuchal ligament.
Condylar fossae	fo	The condylar fossae (condyloid fossae) are the two depressions found along the inferior aspects of the lateral parts of the occipital bone. They are located posterior to the occipital condyles and lateral to the foramen magnum. They accommodate the posterior margins of the superior articular facets of the atlas (first cervical vertebra) during head extension.

(*): Adapted from Caple and Stephan 2016, Milella *et al.* 2021, Haas 1951, Lucena *et al.* 2019, and Zimelewicz *et al.* 2015.[4,12,15,21,41]

Table 2: Description of cranial measurements from the NeuroZone3D skull base protocol.

Measurement	Description
Length of the foramen magnum	Refers to the longitudinal dimension, that is, the measurement from one end of the foramen magnum to the other along its longest axis.
Width of the foramen magnum	Represents the transverse measurement from one side of the foramen magnum to the other, perpendicular to its length.
Length of the occipital condyle	Denotes the dimension from one end of the occipital condyle to the other along its longest axis.
Width of the occipital condyle	Refers to the transverse measurement of the occipital condyles.

and Brazil[15,19,33] revealed similar measurements for the foramen magnum; however, they did not detail condyle measurements, limiting the comprehensive comparison between these anatomical samples. The NeuroZone3D Research Center collection stands out for its specific focus on both measurements, contributing to a more comprehensive understanding of craniovertebral morphology compared to studies from Colombia and Brazil.

Anatomical studies of the foramen magnum in Nigeria revealed significant measurements in African specimens. Osunwoke and Oladipo[27] analyzed a broader group of 120 specimens, obtaining an average length of 36.11 ± 2.60 mm and a width of 29.56 ± 2.60 mm. On the other hand, Ukoha *et al.*,[36] with a smaller number of samples, 90 males and ten females, revealed slightly greater lengths in men with an average of 36.26 ± 2.30 mm in length and 30.09 ± 2.50 mm in width, while women showed slightly smaller measurements with an average length of 34.39 ± 3.88 mm and a width of 28.16 ± 1.90 mm. Both studies provide valuable information, but the breadth of the sample studied by Osunwoke and Oladipo provides a more generalized view of these measurements, although specific data on the condyles were not presented.

Anatomical studies conducted across various regions of Asia have unveiled intriguing patterns in the measurements of the

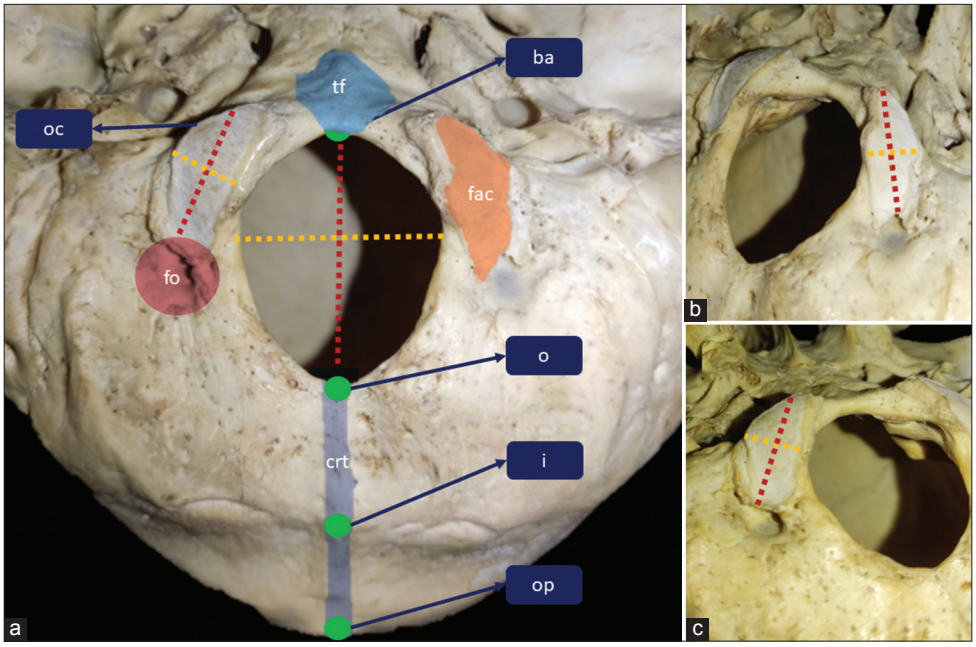

Figure 1: Inferior view of the skull with anatomical landmarks and measurements between the average distances of cranial points. (a) Skull base in an inferior view: cranial reference points are highlighted in green, red dashed lines indicate length measurements (ba, basion; o, opisthion; i, inion; y op, opisthocranion), and a yellow line measures the width of the occipital condyles (oc) and the foramen magnum. The shaded orange color delineates the articular facet of the left occipital condyle (fac), while a light blue tone outlines the pharyngeal tubercle (tf) on the occipital bone. Additionally, a red shading marks the right condylar fosase (fo), and a dark blue hue highlights the external occipital crest (crt)of the occipital bone. (b) The left occipital condyle is shown with approximate measurements of length (red dashed line) and width (yellow line). (c) The right occipital condyle is depicted with approximate measurements of length (red dashed line) and width (yellow line) of the structure.

Table 3: Cranial measurements of the foramen magnum in millimeters from Peruvian specimens.

	Foramen magnum length	Foramen magnum width	Right condyle length	Right condyle width	Left condyle length	Left condyle width
Skull 1	31.00	26.00	22.00	15.00	18.00	15.00
Skull 2	33.00	27.00	25.00	12.00	23.00	13.00
Skull 3	35.00	30.00	27.00	16.00	30.00	17.00
Skull 4	36.00	27.00	25.00	15.00	26.00	14.00
Skull 5	34.00	28.00	25.00	17.00	27.00	15.00
Skull 6	30.00	26.00	25.00	16.00	26.00	13.00
Skull 7	34.00	27.00	30.00	14.00	33.00	15.00
Skull 8	32.00	27.00	23.00	14.00	23.00	13.00
Skull 9	36.00	31.00	23.00	16.00	23.00	14.00
Skull 10	34.00	29.00	24.00	17.00	23.00	16.00
Skull 11	33.00	28.00	24.00	15.00	24.00	12.00
Skull 12	36.00	31.00	24.00	14.00	24.00	13.00
Skull 13	38.00	33.00	25.00	12.00	22.00	14.00
Skull 14	36.00	31.00	28.00	15.00	28.00	15.00
Skull 15	30.00	25.00	28.00	13.00	22.00	14.00
Skull 16	32.00	27.00	21.00	16.00	23.00	15.00
Skull 17	34.00	29.00	26.00	13.00	24.00	11.00

foramen magnum and condyles, particularly when examining differences between men and women in these measurements.

In the study conducted in Oman by Kumar *et al.*[14] in 2015, a significant disparity between sexes was evident: men exhibited

Table 4: Cranial Measurement: Quartile, median, mean±standard deviation, minimum, and maximum values in millimeters from Peruvian specimens.

	Values		Quartile 1	Median	Quartile 3	Mean	Quartile 4	SD
	Min	Max						
Foramen magnum length	30.00	38.00	32.00	34.00	36.00	33.80	38.00	2.28
Foramen magnum width	25.00	33.00	27.00	28.00	30.00	28.70	33.00	2.21
Right condyle length	21.00	30.00	24.00	25.00	26.00	25.00	30.00	2.29
Right condyle width	12.00	17.00	14.00	15.00	16.00	14.10	17.00	1.57
Left condyle length	18.00	33.00	23.00	24.00	26.00	23.80	33.00	3.46
Left condyle width	11.00	17.00	13.00	14.00	15.00	13.90	17.00	1.48

SD: Standard deviation, Min: Minimum, Max: Maximum

significantly larger dimensions in the foramen magnum (36.78 ± 1.52 mm in length and 30.05 ± 2.36 mm in width) compared to women (33.22 ± 2.00 mm in length and 29.49 ± 1.66 mm in width). This discrepancy points to a distinctive anatomical difference between genders in this Asian region.

Conversely, multiple investigations in India[24,28,31,32] have shown a similar trend where, generally, men tend to have larger measurements in both length and width of the foramen magnum and condyles compared to women. Although variability in the data is observed, this persistent discrepancy between sexes is a notable finding. It possibly suggests gender-based anatomical differences within the Indian population based on their region of origin.

A recent study conducted in Thailand demonstrated similar results, showing a clear disparity between men and women in measurements.[34] Men exhibited considerably larger dimensions in the foramen magnum and condyles compared to women, aligning with trends observed in other Asian studies. Even in Saudi Arabia, the same trend is observed in terms of the length and width of the foramen magnum, as well as the dimensions of the condyles.[18] These collective data from various Asian countries suggest consistency in anatomical differences between genders in the region, which could have significant implications not only in neurosurgery but also in various medical and research fields related to anatomy and medicine.

The anatomical analysis of the foramen magnum and condyles has been the subject of numerous studies in Europe, revealing significant variability in the measurements obtained. In Olivier's work,[26] average measurements of the foramen magnum were found to be 35.70 ± 2.72 in length and 30.84 ± 2.15 in width. Detailed condyle measurements were also presented with values of 23.75 ± 2.74 in length and 11.50 ± 1.20 in width. A subsequent study conducted by Catalina-Herrera at the University of Seville broke down measurements by gender.[5] In men, the average measurements of the foramen magnum were 36.2 ± 2.60 in length and 31.1 ± 2.60 in width, while in women, these measurements were slightly smaller, with values of 34.30 ± 2.04 in length and 29.6 ± 1.53 in width. Years later, analyses of the foramen magnum were expanded considering gender differences,[8,11,16,17,25,38] showing significant variations, while other studies specifically focused on condyle measurements,[9,23,25] providing a detailed but more limited perspective of these anatomical structures.

The addition of this present study conducted in Peru provides specific data on the foramen magnum and condyles in this region of America. The obtained values rank on the lower average compared to other previously mentioned studies, both in America and other regions. This observation emphasizes the need to consider anatomical variability not only among different geographical locations but also within the same region, highlighting the importance of future research to understand morphological diversity in craniovertebral morphology.

The significance of craniotomy varies considerably depending on the geographical region and specific anatomical characteristics of each population. Detailed anatomical studies in different countries have revealed significant variations in the dimensions of the foramen magnum and condyles, emphasizing the need to consider local anatomical peculiarities in neurosurgical interventions.[7] For instance, analyses in Europe have highlighted variations between genders in foramen magnum measurements,[5,8,9,11,16,23,25,26,38] while in Asia, distinct differences between men and women in various cranial measurements have been observed.[14,18,24,28,31,32,34] These anatomical discrepancies can influence surgical techniques, emphasizing the relevance of an approach tailored to the region and/or geographical area to enhance the outcomes of craniotomies.

The creation of indices tailored to each type of skull based on the region or country emerges as an innovative and crucial strategy in the field of neurosurgery. These indices could establish specific parameters for each region, considering the anatomical differences found in detailed anatomical studies.[7,22] By developing customized indices according to geography, surgical techniques could be enhanced, allowing for more precise planning adapted to the unique anatomical

Table 5: Measurements of the foramen magnum and occipital condyles in cadaveric specimens by geographical location.

Geographical location	Author	Institution	Year	Number of specimens	Foramen magnum length	Foramen magnum width	Right condyle length	Right condyle width	Left condyle length	Left condyle width	Condyle length	Condyle width
America	Yataco-Wilcas *et al.*	Colección del Centro de Investigación NeuroZone3D – Perú	2023	16*	33.80±2.28	28.70±2.21	25.00±2.29	14.10±1.57	23.80±3.46	13.90±1.48	19.68±2.90	11.18±1.54
America	Stozitzky Muñoz and Rueda-Esteban[33]	Colección Tibanica de la Universidad de los Andes - Colombia (a) (°)	2016	37*	33.92±2.72	29.49±2.20	No data	No data	No data	No data	No data	No data
America	Manoel *et al.*[19]	Department of Morphology, Piracicaba Dental School, State University of Campinas – UNICAMP, Piracicaba, SP, Brazil	2009	139 M	35.70±0.29	30.30±0.20	No data	No data	No data	No data	No data	No data
				76 F	35.10±0.33	29.40±0.20	No data	No data	No data	No data	No data	No data
America	Lucena *et al.*[15]	Department of Morphofunctional Sciences, Universidade Federal do Ceará, Fortaleza, CE, Brazil	2019	88 M	35.01±3.03	30.12±2.95	No data	No data	No data	No data	No data	No data
				71 F	33.92±3.19	28.91±2.83	No data	No data	No data	No data	No data	No data
Africa	Osunwoke and Oladipo[27]	Department of Anatomy, Faculty of Basic Medical Sciences, College of Health Sciences, University of Port Harcourt, Nigeria.	2012	120*	36.11±2.60	29.56±2.60	No data	No data	No data	No data	No data	No data
Africa	Ukoha *et al.*[36]	Department of Anatomy, Nnamdi Azikiwe University, Nnewi Campus, Anambra State, Nigeria	2011	90 M	36.26±2.30	30.09±2.50	No data	No data	No data	No data	No data	No data
				10 F	34.39±3.88	28.16±1.90	No data	No data	No data	No data	No data	No data
Asia	Kumar *et al.*[14]	Human Structure and Neurobiology Department of Oman Medical College, Sohar, Oman. (°)	2015	19 M	36.78±1.52	30.05±2.36	No data	No data	No data	No data	No data	No data
				17 F	33.22±2.00	29.49±1.66	No data	No data	No data	No data	No data	No data
Asia	Radhakrishna *et al.*[28]	Department of Anatomy, Yenepoya Medical College, Yenepoya University, Mangalore, India.	2012	55 M	34.04±2.36	28.63±1.89	No data	No data	No data	No data	No data	No data
				45 F	31.72±2.14	26.59±1.64	No data	No data	No data	No data	No data	No data
Asia	Singh and Talwar[32]	Department of Anthropology, Panjab University Chandigarh, India	2013	26 M	33.54±2.80	27.77±2.10	No data	No data	No data	No data	No data	No data
				24 F	32.31±3.24	27.21±2.99	No data	No data	No data	No data	No data	No data
Asia	Santhosh *et al.*[31]	Department of Forensic Medicine, JJM Medical College, Karnataka, India.	2013	63 M	34.37±2.38	28.98±2.22	No data	No data	No data	No data	No data	No data
				38 F	33.80±2.56	27.60±2.67	No data	No data	No data	No data	No data	No data
Asia	Nagwani *et al.*[24]	Department of Anatomy, Era's Lucknow Medical College and Hospital, India	2016	120*	34.68±2.88	27.24±2.48	No data	No data	No data	No data	No data	No data
Asia	Thunyacharoen and Mahakkanukrauh[34]	Faculty of Medicine, Chiang Mai University, Thailand.	2023	80 F	32.84±2.31	28.57±2.68	22.30±2.73	12.16±1.50	23.21±2.53	12.92±1.63	No data	No data
				80 M	34.80±2.31	30.84±2.68	24.08±2.12	13.11±1.62	25.24±2.88	13.82±1.63	No data	No data
Asia	Madadin *et al.*[18]	Forensic Medicine Division, Department of Pathology, College of Medicine, King Fahd Hospital of the University, University of Dammam, Saudi Arabia	2017	100 M	37.21±2.15	31.65±2.25	21.10±1.50	10.58±1.08	21.11±1.72	10.72±1.16	No data	No data
				100 F	36.10±2.65	30.60±2.47	19.94±1.81	10.27±1.30	20.05±1.82	10.48±1.31	No data	No data
Europe	Gruber *et al.*[11]	Institute of Anatomy, University of Zurich, Switzerland (b)	2009	49*	36.60±2.80	31.10±2.70	No data	No data	No data	No data	No data	No data
Europe	Natsis *et al.*[25]	Department of Anatomy, Medical School, Aristotle University of Thessaloniki, Greece. (c)	2013	143*	35.53±3.06	30.31±2.79	25.60±2.91	13.09±1.99	25.60±2.70	13.01±1.98	No data	No data
Europe	Olivier[26]	Laboratoire d'Anthropologie biologique de l'Universite de Paris	1975	125*	35.70±2.72	30.84±2.15	No data	No data	No data	No data	23.75±2.74	11.50±1.20
Europe	Catalina-Herrera[5]	Departamento de Anatomía, Facultad de Medicina, Universidad de Sevilla, España.	1987	74 M	36.2±2.60	31.1±2.60	No data	No data	No data	No data	No data	No data
				26 F	34.30±2.04	29.6±1.53	No data	No data	No data	No data	No data	No data
Europe	Lyrtzis *et al.*[16]	Department of Anatomy and Surgical Anatomy, School of Medicine, Faculty of Health Sciences, Aristotle University of Thessaloniki, Greece	2017	141*	35.05±2.57	30.17±2.69	No data	No data	No data	No data	23.66±2.84	11.77±1.52
				68 F	33.86±2.31	28.97±2.32	22.95±2.96	11.43±1.47	23.23±2.71	11.46±1.51	No data	No data
				73 M	36.16±2.29	31.32±2.51	24.33±2.57	12.10±1.50	24.07±2.59	12.21±1.66	No data	No data
Europe	Ulcay and Kamaşak[38]	Kırşehir Ahi Evran University, School of Medicine, Department of Anatomy, Kırşehir, Turkey	2020	60*	33.81±7.57	28.65±1.78	No data	No data	No data	No data	No data	No data
Europe	Naderi *et al.*[23]	Department of Anatomy, Dokuz Eylul University School of Medicine, Turkey	2005	202*	No data	No data	23.60±2.50	10.6±1.40	23.20±2.40	10.6±1.40	No data	No data
Europe	Gapert *et al.*[8,9]	The St. Bride's documented skeletal collection	2009	82 M	35.91±2.41	30.51±1.77	24.95±2.53	12.01±1.41	25.16±2.51	12.05±1.69	No data	No data
				76 F	34.71±1.91	29.36±1.96	23.30±2.28	11.42±1.21	23.74±2.44	11.57±1.16	No data	No data
Europe	Macaluso[17]	Georges Olivier's skeletal collection	2009	36 M	35.38±2.27	30.72±2.11	No data	No data	No data	No data	No data	No data
				32 F	34.90±2.26	29.40±2.63	No data	No data	No data	No data	No data	No data

M: Male, F: Female. Annotations: *No differentiation by sex, age, or geographical origin. °Authors' definitions considered length as anteroposterior distance and width as lateromedial distance. a: The second measurement was used for comparison per the authors of this article's decision. b: Specimens ranging from the Pleistocene to modern times were measured; 110 transverse diameters of the foramen magnum and 111 sagittal diameters were obtained. c: The maximum width value of the occipital condyle was used, defined as the distance from the articular edges along a line perpendicular to the major axis

characteristics of each population. This personalized approach could reduce risks during cranial interventions, optimizing the effectiveness of procedures and improving postoperative outcomes in neurosurgical surgeries.

CONCLUSION

The morphometric analysis of the foramen magnum and condyles in a sample of the Peruvian population revealed distinctive anatomical characteristics compared to studies conducted in other regions of the world. Significant variations were observed in the dimensions of the foramen magnum and condyles, showing slightly smaller average measurements in this population. These findings highlight the importance of considering anatomical diversity within a specific region when planning neurosurgical interventions and clinical diagnoses. The development of indices tailored to the craniovertebral morphology of each population could be crucial to enhancing the precision and effectiveness of surgical techniques, reducing risks, and optimizing postoperative outcomes in neurosurgical procedures.

Ethical approval

The Institutional Review Board approval is not required.

Declaration of patient consent

Patients' consent not required as patients' identities were not disclosed or compromised.

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Conflicts of interest

There are no conflicts of interest.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

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