

Morphometric Study of Five Constant Skull Base Foramina in the Muisca Population of the Tibanica Anthropological Collection of the Universidad de Los Andes

Estudio Morfométrico de Cinco Forámenes Constantes de la Base del Cráneo en la Población Muisca de la Colección Antropológica Tibanica de la Universidad de Los Andes

Nicolás Stozitzky Muñoz & Roberto Javier Rueda-Esteban

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SUMMARY: Among osteological anatomic variations are those of the skull base foramina. These openings have conventionally been classified as either constant or variant. Their presence and dimensions have been associated with certain pathologies and procedural complications. Additionally, variability in these foramina between different ethnic groups has been observed, and it is sometimes possible to identify particular patterns of variability in certain populations. This anthropometric cross-sectional study seeks to determine the principal dimensions (bilateral anteroposterior and lateromedial diameters) of five constant skull base foramina in the adult Muisca population of the Tibanica anthropological collection at Universidad de los Andes. The studied foramina were magnum, jugular, ovale, spinosum, and external opening of the carotid canal. Only dimensions of the external openings of the foramina were recorded, owing to the preservation state of the skulls in the collection. The mean left and right anteroposterior and lateromedial diameters were 3.48 mm, 6.16 mm and 3.25 mm, 6.26 mm for the foramen ovale; 2.38 mm, 2.65 mm and 2.39 mm, 2.66 mm for foramen spinosum; 8.36 mm, 15.41 mm and 8.55 mm, 15.10 mm for the jugular foramen; 5.28 mm, 6.75 mm and 5.48 mm, 6.97 mm for the external opening of the carotid canal; and 33.90 mm, 29.47 mm for the foramen magnum. All foramina were measured twice, no important differences were observed between the results obtained in the first and second measurements. The skull base foramina of the sample studied did not suggest high variability within the population regarding these characteristics. Moreover, we can state that the morphometric profile displayed by the Tibanica collection at Universidad de los Andes is different from the one observed in other populations. Additional studies of anatomic variations in indigenous populations may be needed to make possible similarities and/or differences and their causes evident.

KEY WORDS: Colombia; Cross Sectional Analysis; Skull; Anthropometry; American Native Continental Ancestry Group; Osteology.

INTRODUCTION

The skull base foramina are openings located in the inferior aspect of the cranium. Said foramina allow the passage of several vascular and nervous structures (Drake *et al.*, 2005). Like any other anatomic structure they commonly present variations, especially those regarding shape and size (i.e. morphology and morphometry). Occasionally other foramina are present in the skull base, an aspect that constitutes the other major source of variability in this anatomic region and usually suggests the presence of additional vascular and nervous variations. From an inferior view, there are ten skull base foramina conventionally described as constant: greater palatine, lesser palatine, lacerum, ovale, spinosum, external opening of the carotid

canal, stylomastoid, jugular, mastoid, and external opening of the hypoglossal canal (Drake *et al.*). These structures can be used to establish differences between different populations and ethnic groups, due to the fact that both their morphology and morphometry are particularly variable (Osunwoke *et al.*, 2010; Khan *et al.*, 2012; Osunwoke *et al.*, 2012; Gupta *et al.*, 2014; Kumar *et al.*, 2015; Vidya *et al.*, 2015).

Current morphometric studies of the skull base foramina are centered on the clinical relevance of their variability, particularly on the pathological and procedural complications that may arise from this aspect (Osunwoke *et al.*, 2010; Aviles-Solis *et al.*, 2011; Rodrigues *et al.*, 2011;

Singh *et al.*, 2011; Khan *et al.*; Osunwoke *et al.*, 2012; Gupta *et al.*; Kumar *et al.*; Raval *et al.*, 2015; Vidya *et al.*).

Information of this kind of anatomic characteristics in pre-hispanic populations is scarce. This data would be useful for the comparison of different ethnic groups or for predicting actual skull foramina dimensions in the population that descends from a particular group, due to the fact that these anatomic features are partly determined by genetic factors (Roberts *et al.*, 2004; Bard, 2014).

The present study seeks to establish the morphometric profile of the jugular foramen, foramen magnum, ovale, spinosum and external opening of carotid canal regarding anteroposterior and lateromedial diameters of the adult Muisca skulls of the Tibanica anthropological collection at Universidad de los Andes, Bogotá, Colombia, which actually consists of approximately 600 individuals (Sanabria Medina, 2013).

MATERIAL AND METHOD

Adult skulls from the Tibanica anthropological collection at Universidad de los Andes in which the external opening of at least one of the studied foramina was present were eligible. Occluded foramina and those whose dimensions had been modified by any kind of fracture were excluded (i.e. not all foramina were measured in every eligible skull).

Thirty-seven adult skulls were used for the development of this morphometric descriptive cross-sectional study.

Measurements were obtained by means of two digital calipers, thus all diameters (bilateral anteroposterior and lateromedial) were measured twice.

Oblique measures were recorded for the foramen ovale, classifying length as anteroposterior diameter and width as lateromedial diameter.

Mean diameter and standard deviation were calculated and tabulated for every dimension.

RESULTS

In general the morphometry of the studied skull base foramina represents relatively low variability within the population. Only the magnum and jugular foramina had high standard deviations, indicating low uniformity of those particular characteristics (Table I).

Additionally, we report other variations of skull base foramina as occasional findings: a foramen venosum in two skulls and a unilateral septated foramen ovale in one skull.

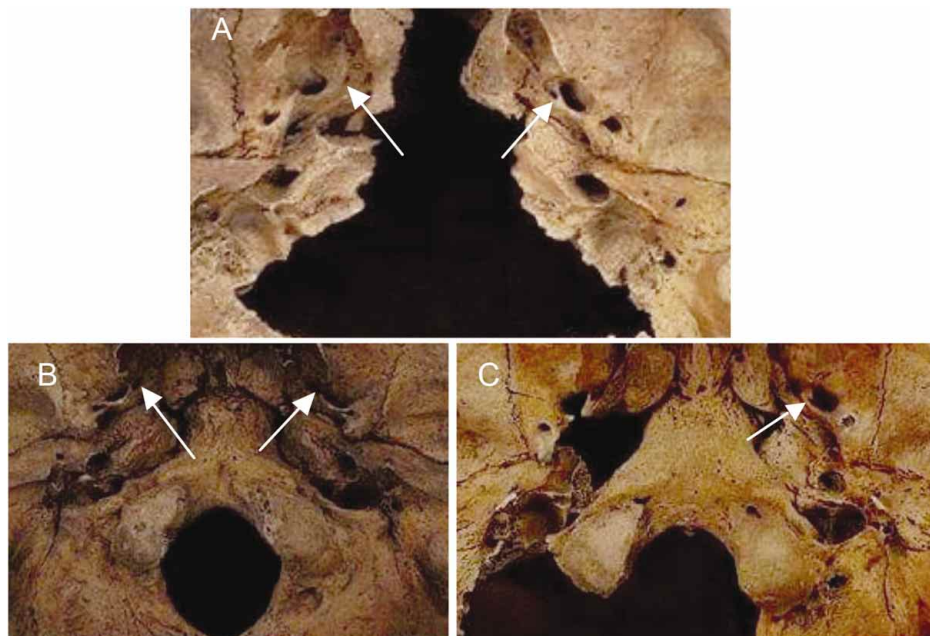


Fig. 1. A and B: Photograph of the skull base showing the foramen venosum (Arrow). C: Photograph of the skull base showing a unilateral septated foramen ovale (Arrow).

Table I. Morphometric measurements of the oval foramen, spinosum foramen, magnum foramen and external opening of carotid canal in the Tibánica collection at Universidad de los Andes. First and second measurements compared to the dimensions of other populations.

Foramen	Diameter			
	Left		Right	
	AP Mean±SD (mm)	LM Mean±SD (mm)	AP Mean±SD (mm)	LM Mean±SD (mm)
Ovale				
1 st	3.46±0.37	6.13±0.91	3.23±0.49	6.23±0.93
2 nd	3.51±0.38	6.19±0.89	3.27±0.49	6.28±0.92
Osunwoke <i>et al.</i> (2010)	3.33±0.66	6.89±0.90	3.37±0.64	7.01±0.96
Spinosum				
1 st	2.36±0.46	2.61±0.47	2.37±0.37	2.64±0.56
2 nd	2.41±0.46	2.69±0.46	2.42±0.37	2.69±0.57
Osunwoke <i>et al.</i> (2010)	2.36±0.53	1.61±0.28	2.34±0.48	1.66±0.26
Jugular				
1 st	8.34±1.36	15.38±2.10	8.52±1.29	15.05±1.44
2 nd	8.38±1.36	15.44±2.10	8.59±1.30	15.15±1.41
Gupta <i>et al.</i> (2014)	9.52±1.55	16.02±2.20	11.22±2.47	16.52±2.03
Osunwoke <i>et al.</i> (2012)	13.39±2.50	7.54±2.17	15.76±2.36	9.34±2.00
Carotid canal				
1 st	5.26±0.51	6.72±0.68	5.45±0.64	6.95±0.72
2 nd	5.31±0.51	6.78±0.68	5.52±0.65	6.99±0.73
Magnum				
1 st	33.88±2.72	29.44±2.20		
2 nd	33.92±2.72	29.49±2.20		
Kumar <i>et al.</i> (2015) Male	36.78±1.52	30.05±2.36		
Kumar <i>et al.</i> (2015) Female	33.22±2.00	29.49±1.66		
Osunwoke <i>et al.</i> (2012)	36.11±2.60	29.56±2.60		

AP: anteroposterior LM: lateromedial SD: standard deviation

DISCUSSION

Morphometric studies of skull base foramina are adequate tools for evaluating variability of these anatomic characteristics within groups and comparing said features between populations (Osunwoke *et al.*, 2010; Khan *et al.*; Osunwoke *et al.*, 2012; Gupta *et al.*; Kumar *et al.*; Vidya *et al.*). The importance of characterizing these anatomical features in different populations not only lies within the clinical and pathological realms, as their morphology and morphometry sometimes represent decisive features of the outcome of certain diseases and procedures, but also provides useful information of groups as ethnicities, their genetic profile and the environmental factors they are probably exposed to (Roberts *et al.*; Bhatia *et al.*, 2005).

The obtained dimensions of the foramen magnum are very similar to those of the Omani female population used by Kumar *et al.* Nevertheless, this is not true for the

male population of this study, which exhibited greater diameters. Furthermore the anteroposterior diameter of foramen magnum of the Tibánica collection is smaller than that of the Nigerian population used by Osunwoke *et al.* (2012). Ironically the lateromedial diameters of these two studied groups are approximately similar.

Regarding the jugular foramen, the diameters recorded in the present study were considerably smaller than those reported by Gupta *et al.* in Indian population. Although the previously mentioned morphometric study described a slightly more variable population, it is highly improbable that this factor disproves the differences found between the two groups (more than 1 mm for all dimensions). Moreover the lateromedial diameter here reported is greater than that observed in the study conducted by Osunwoke *et al.* (2012). However, the same is not true for the anteroposterior diameter.

On the other hand, the morphometric characteristics of the foramen ovale and foramen spinosum of the Nigerian population presented by Osunwoke *et al.* (2010) were smaller in all aspects compared to the sample of Muisca population used in this study.

Additionally, the morphological variations that we found in the skulls of the collection (here reported as occasional findings) are consistent with the literature, which supports the notion that said anatomic variants are rather common (Collipal *et al.*, 2009; Aviles-Solis *et al.*; Rodrigues *et al.*; Singh *et al.*; Raval *et al.*).

In conclusion, the skull base foramina measured in the Tibanica collection at Universidad de los Andes displayed

a relatively low variability within the population. Furthermore, important differences regarding these anatomic characteristics can be observed between the sample used for the present study and those of others conducted around the world. Finally, more studies of anatomic variations in indigenous populations should be carried out with the purpose of establishing differences and similarities between pre-hispanic and modern populations.

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RESUMEN: Entre las variaciones anatómicas óseas, se consideran aquellas referentes a los forámenes de la base del cráneo. Convencionalmente, estos orificios han sido clasificados como variantes o constantes. Su presencia y dimensiones se asocian a ciertas patologías y complicaciones procedimentales. Adicionalmente, se ha observado variabilidad en estos entre distintos grupos étnicos y en algunas ocasiones es posible identificar patrones particulares en poblaciones específicas. Este estudio morfométrico de corte transversal busca determinar las dimensiones principales (diámetros anteroposterior y lateromedial) de cinco forámenes constantes de la base del cráneo en la población adulta Muisca de la colección antropológica Tibanica de la Universidad de los Andes. Los forámenes estudiados fueron: magno, yugular, ovale, espinoso y la apertura externa del canal carotideo. Debido al estado de preservación de los cráneos, se registraron las dimensiones de las aperturas externas de los forámenes. La media de los diámetros izquierdo y derecho anteroposterior y lateromedial fue 3,48 mm, 6,16 mm y 3,25 mm, 6,26 mm para el foramen ovale; 2,38 mm, 2,65 mm y 2,39 mm, 2,66 mm para el espinoso; 8,36 mm, 15,41 mm y 8,55 mm, 15,10 mm para el yugular; 5,28 mm, 6,75 mm y 5,48 mm, 6,97 mm para la apertura externa del canal carotideo; y 33,90 mm, 29,47 mm para el foramen magno. Todos los diámetros se registraron dos veces, no se observó ninguna diferencia importante entre los registros de la primera y segunda medición. En general, las dimensiones de los forámenes estudiados no varían mucho en la colección ósea Muisca de Tibanica. En cuanto a estas características anatómicas, la población utilizada es diferente con respecto a algunas modernas. Por otro lado, se requieren investigaciones adicionales de este tipo con el fin de evidenciar posibles similitudes y diferencias entre poblaciones (prehispánicas y modernas) y determinar sus causas.

PALABRAS CLAVE: Colombia; Estudio de Corte Transversal; Cráneo; Morfometría; Población Pre-contacto; Osteología.

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Correspondence to:
Roberto Javier Rueda Esteban M.D.
Coordinator of Laboratory of Anatomy
Anatomy Research Group for Education
Faculty of Medicine
Universidad de Los Andes
Bogota
COLOMBIA

Email: rj.rueda32@uniandes.edu.co

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