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Type III external occipital protuberance hyperostosis, prevalence and morphometric characteristics: a study in bone anatomical sample

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SUMMARY

Although Type III external occipital protuberance (EOP) is a normal variant, its enlargement (hyperostosis) may cause cosmetic discomfort and pain in the occipital region in the supine position or on palpation, even becoming so painful as to require surgical excision; in addition, it is often confused with subcutaneous pseudotumours in the occipital region. Since research on the prevalence of Type III EOP hyperostosis remains limited, the aim of the present study was to determine the prevalence and describe the morphometric characteristics of Type III EOP hyperostosis in a sample of dry craniums from the Colombian population, in order to contribute knowledge of the variability of bone anatomy and its clinical and anthropological implications. One hundred and twenty-six dry craniums of adult individuals were examined. Subsequently, for the Type III external occipital protuberances that presented hyperostosis, their morphometric characteristics were established, such as the vertical diameter of the base (VDB), the transverse diameter of the vertex (TDV), and the major longitudinal diameter (MLD). 2.38% of cases developed EOP Type III hyperostosis, exhibiting two different morphotypes: hook-shaped and pyramidal spinal-shaped. The VDB ranged between 13.21 mm and 18.23 mm, the TDV between 4.18 mm and 6.01 mm, and the MLD between 10.10 mm and 16.59 mm. The morphometric characteristics of EOP have anatomical, clinical, and surgical implications, so these dimensions could be considered in the clinical evaluation of patients with EOP that present cervical pain and occipital headache, avoiding confusion in the diagnosis with subcutaneous pseudotumours in the occipital region.

Key words: Anatomy – Morphometry – Hyper-

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ostosis – Exostoses – External occipital protuberance

INTRODUCTION

The external occipital protuberance (EOP) is a palpable bony prominence located on the posteroinferior surface of the occipital bone, at the level of the superior nuchal line. This anatomical structure serves as an insertion point for the nuchal ligament and the cervical portion of the trapezius muscle, whose role is crucial in the biomechanics of the neck and head (Standring, 2015).

Although the EOP is a common anatomical feature, it can present remarkable variability in shape and size. Thus, Gülekon and Turgut (2003) classified the EOP into three types (Fig. 1) and associated their characteristics to the sex of the individual, with Type I (flat) being more frequent in the female sex; Type II (crest-shaped) being approximately equal between both sexes; and Type III (spine-shaped), a more prominent projection and with a higher prevalence in the male sex. Consequently, EOP has been considered a marker of sexual differentiation in anthropological and forensic studies (Casado, 2017; Burrus et al., 2024).

Albeit Type III EOP is a normal variant that is often asymptomatic, its enlargement (hyperostosis) can cause aesthetic and physical discomfort, such as pain in the occipital region in the supine position or on palpation (Varghese et al., 2017), even becoming so painful as to require surgical excision (Marshall et al., 2015); furthermore, it can be confused with subcutaneous pseudotumours in the occipital region (Gómez-Zubiaur et al., 2019). Its prevalence has been estimated between 14.14% and 50.50% of individuals (Jacques et al., 2020; Cheng et al., 2025). Along these lines, from a clinical perspective, EOP has implications for planning cranial and cervical surgical interventions, as a prominent EOP can influence the selection of appropriate techniques and procedures (Morita et al., 2015).

Considering the above and the limited research on the prevalence of Type III EOP hyperostosis, the objective of the present study was to quantify and describe Type III EOP hyperostosis in a sample of dry craniums from the Colombian population. With the results obtained, we hope to broaden the understanding of this anatomical variant in a specific population, which may contribute to general knowledge about the variability of bone anatomy and its clinical and anthropological implications.

MATERIALS AND METHODS

A descriptive, quantitative, non-experimental and cross-sectional study was carried out. The methodological planning of this research was adjusted to the guidelines established in the AQUA guide for carrying out original anatomical studies (Tomaszewski et al., 2017).

To develop the study objective, 126 dry craniums of adult individuals were examined, corre-

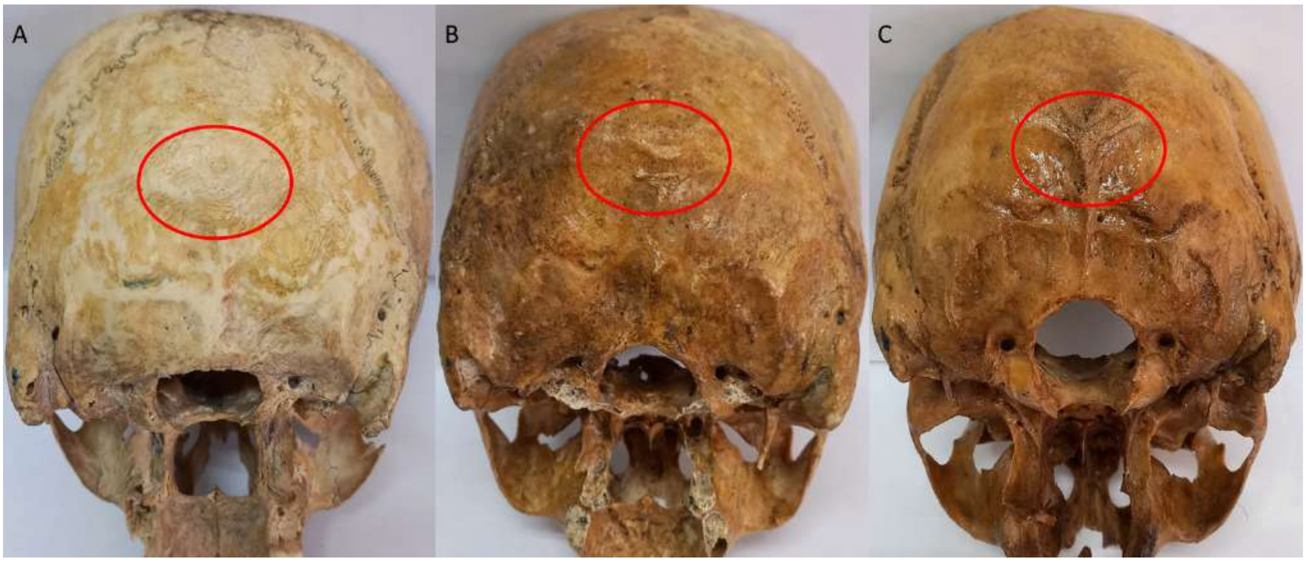

Fig 1.- Classification of the external occipital protuberance. (A) Type I: smooth or flat protuberance. (B) Type II: more prominent crest-shaped protuberance. (C) Type III: spine-shaped protuberance.

sponding to the Anatomy Osteotheques of the Universidad de Caldas, Universidad de Manizales and Universidad Autónoma de Manizales, in Colombia. Of the total sample, only those craniums presenting Type III EOP hyperostosis were eligible for further analysis. The sex of the specimens was not considered in this study.

Subsequently, for Type III external occipital protuberances presenting hyperostosis, their morphometric characteristics were established from the following measurements: (1) vertical diameter of the base (VDB): vertical diameter at the base level of the EOP; (2) transverse diameter of the vertex (TDV): diameter of the vertex of the EOP; (3) major longitudinal diameter (MLD): greatest distance between the base and the vertex of the EOP (Fig. 2).

Each measurement was performed twice by two researchers, who then averaged their results. The measurements were carried out with a TOTAL TMT321501 digital calliper (TOTAL TOOLS CO. Stgo, Chile) to an accuracy of 0.01 mm.

RESULTS

Out of 126 craniums analysed, three (2.38%) exhibited Type III EOP hyperostosis. These craniums presented two distinct morphotypes: in two cases, the shape was hook-like (Fig. 3), while in the third case, it was pyramidal-spinal (Fig. 4).

Two distinct morphotypes were observed, two hook-shaped cases and one pyramidal spinal-shaped case. In the hook-shaped EOP, slight variations in measurements were observed: the first case had a VDB of 15.25 mm, a TDV of 6.01 mm, and a MLD of 16.59 mm, while the second case had a VDB of 13.21 mm, a TDV of 5.86 mm, and a MLD of 12.35 mm. For the EOP that presented a pyramidal spinal-shaped, its VDB was 18.23 mm, the TDV was 4.18 mm and the MLD was 10.10 mm.

DISCUSSION

In our study, Type III EOP hyperostosis was Z Zpresent in 2.38 % of the cases, a considerably low prevalence compared to the results of other investigations, as a prevalence of 14.16% has been reported in French (Jacques et al., 2020), 27.40% in Jordanians (Al-Ryalat et al., 2021), 33.00% in Australians (Shahar and Sayers, 2018), and 50.50% in Chinese (Cheng et al., 2025). Differences are likely due to the origin of the study population.

In this same sense, other factors can influence the development of EOP hyperostosis, such as the cephalic index, with a higher prevalence in mesocephalic and dolichocephalic individuals (Çağlayan et al., 2024). It has also been proposed that poor postural habits (Cheng et al., 2025), related to the prolonged use of portable electronic devices (Shahar and Sayers, 2018) generate an increase in the degree of head protraction, causing greater tension in the EOP, which is the inser-

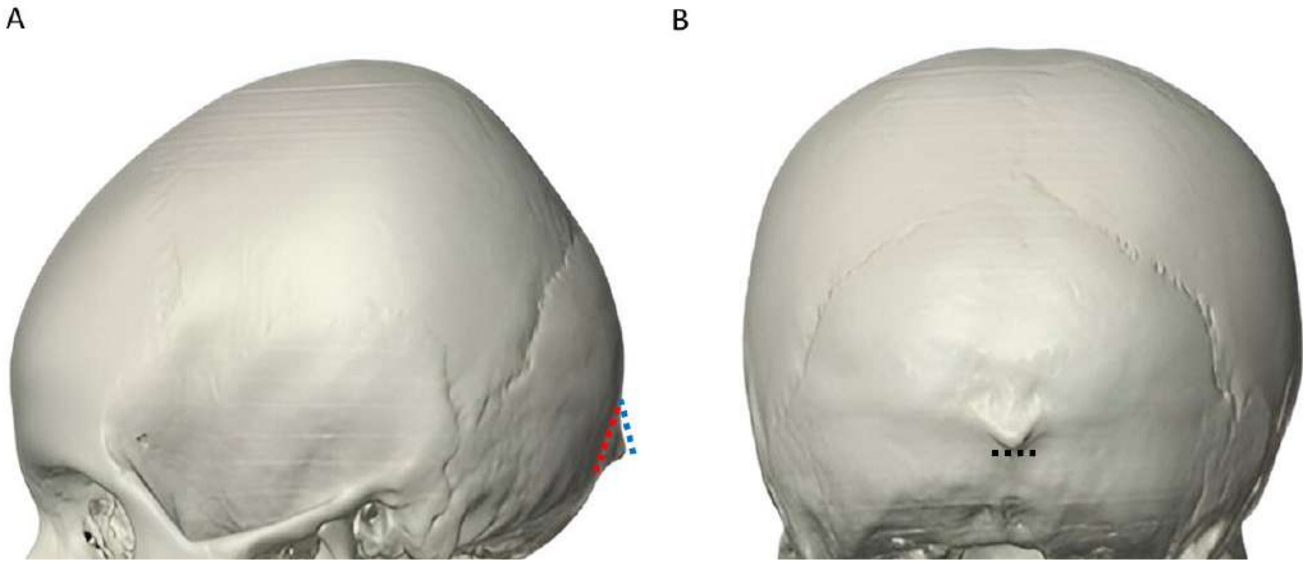

Fig 2.- Morphometric measurements. (A) Vertical diameter of the base, represented by the red dashed line; Major longitudinal diameter, represented by the blue dashed line. (B) transverse diameter of the vertex, represented by the black dashed line.

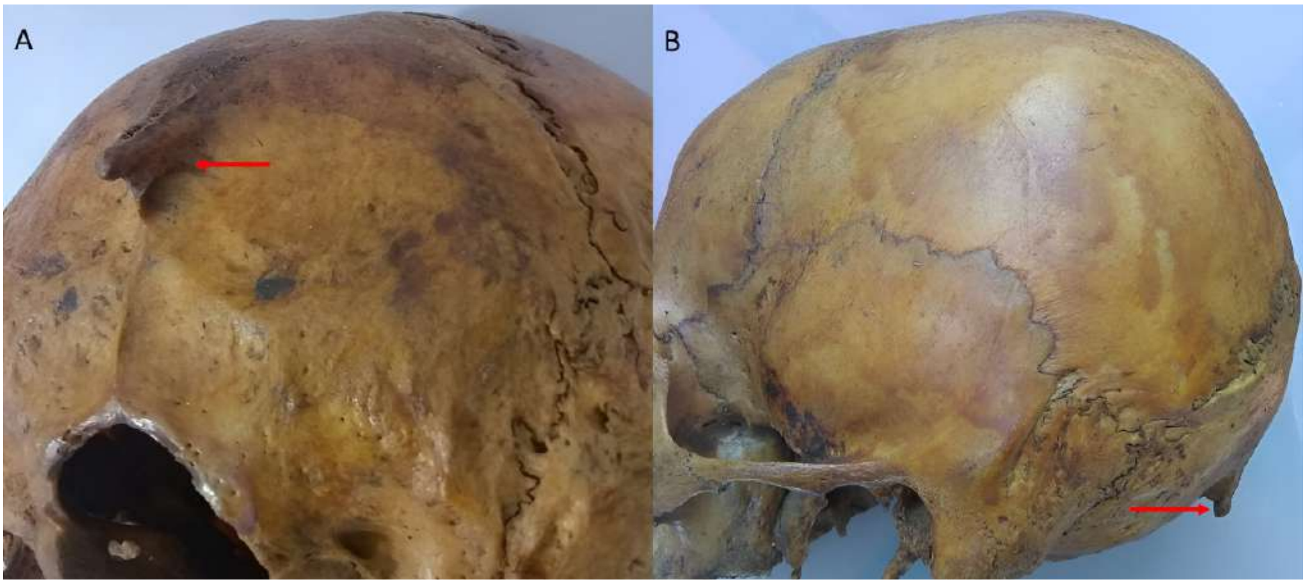

Fig 3.- Type III hook-shaped external occipital protuberance, indicated by a red arrow. (A) Posterior view. (B) Lateral view.

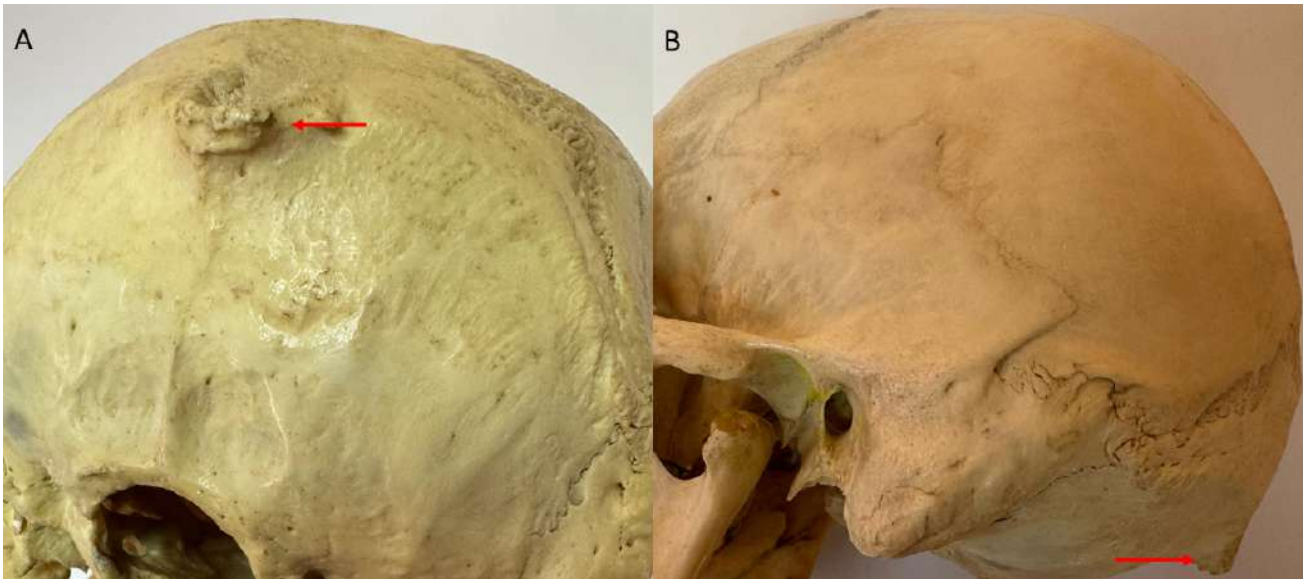

Fig 4.- Type III external occipital protuberance in pyramidal spinal-shaped, indicated by a red arrow. (A) Posterior view. (B) Lateral view.

tion point of the cervical portion of the trapezius muscle and the nuchal line. This could explain the observations made by Jacques et al. (2020) in 445 head CT scans, where EOP hyperostosis was a frequent finding in millennials.

Concerning the morphometry of the Type III EOP hyperostosis, the different morphometric parameters varied according to the morphotype of the EOP, such that the Type III EOP with a pyramidal spinal-shaped, which presented the highest VDB and the lowest TDV and MLD. On the other hand, the hook-shaped EOP had the highest values associated with length. In this regard, since the pyramidal morphotype has a more irregular shape than the hook-shaped morphotype; its development probably arises from an inflammatory process in this region. In this context of morphometric parameters, our data reflect a mean of 15.56 mm for the VDB, which is lower than the value reported by Varghese et al. (2017), who identified a Type III EOP in a female patient with a VDB of 25.90 mm. However, concerning this parameter, as with TDV, we have found a lack of information to contrast, which underlines the need for further research addressing these characteristics of EOP.

Regarding the MLD, our result was less than 14.30 mm, a value determined by Porrino et al. (2021) in 229 cervical spine X-rays, and greater than 8.40 mm, a value indicated by Al-Ryalat et al. (2021) in 4409 head CT scans. Therefore, the value reported for the MLD in our study falls within the threshold reported in the literature. We consider that, like prevalence, the origin of the study population influences the morphometry of EOP. In addition, other demographic factors, such as sex, influence the MLD, with an average of 15 mm for males and 10 mm for females, respectively, as reported (Shahar and Sayers, 2018). This difference could not be assessed in our study, due to the lack of gender identification in the osteotheques, which underscores the importance of considering these demographic factors in future research for a better understanding of the distribution and size of EOP across different populations.

The morphometric characteristics of the EOP have anatomical, clinical, and surgical implications. Given that, a EOP with larger dimensions due to hyperostosis can restrict biomechanical movements of the neck, such as lateral flexion and rotation; in addition, it could compress, at one of the ten points established by Saglam et al. (2024), the greater occipital nerve and the third occipital nerve, causing Type III occipital headache (Singh, 2012). Likewise, the constant pressure of this bony projection on the trapezius muscle causes inflammation and spasms of this muscle, generating discomfort in the posterior part of the neck and, consequently, inflammation of the trapezius muscle could also lead to irritation of the third occipital nerve, since it pierces its aponeurosis. In some cases, a Type III EOP hyperostosis may require surgical excision, as performed by Marshall et al. (2015) in three individuals who presented with subperiosteal stretching due to enlargement of the EOP, which caused pain in the occipital region on palpation.

To the authors' knowledge, this is the first study conducted on Type III EOP hyperostosis in the Colombian population. We believe it is important for healthcare professionals to be aware of the prevalence and specific morphometric variations of Type III EOP hyperostosis, as it may be misdiagnosed clinically during palpation, being confused with pilomatrixoma or calcified cephalohematoma (Gómez-Zubiaur et al., 2019). Regarding surgical procedures, such as cervical-occipital fusion, it is also important to understand the morphometric characteristics of this type of EOP, because it allows for modification of the choice of fixation and instrumentation techniques, which influences the stability of the anchorage and the response of the bone tissue to postoperative mechanical loads (Morita et al., 2015), thus reducing the risk of complications and optimizing surgical results in this critical region.

In conclusion, the prevalence of Type III EOP hyperostosis (2.38%) in the studied sample was low compared to other populations. Two morphotypes were found: hook-shaped and pyramidal spinal-shaped.

In the Colombian population, the means for DVB, TDV, and MLD were 15.56 mm, 5.35 mm and 13.01 mm respectively. These dimensions could be considered in the clinical evaluation of patients with EOP, who present cervical pain and occipital headache, helping to avoid confusion when diagnosing subcutaneous pseudotumours in the occipital region.

It is essential to increase the sample size of the population under study, in addition to advancing the performance of imaging studies, using three-dimensional computed tomography or more accessible tools such as X-rays, in order to characterize other morphometric parameters of EOP and its impact on individuals, considering that these aspects are still poorly documented in the literature.

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