

# Frequency of Enlarged External Occipital Protuberance and its Association with Age and Sex: A Cross-Sectional CT Scan Study

Frecuencia de la Protuberancia Occipital Externa Agrandada y su Asociación con la Edad y el Sexo: un Estudio de Tomografía Computarizada Transversal

Nosaiba Al-Ryalat<sup>1</sup>; Osama Samara<sup>1</sup>; Azmy Hadidy<sup>1</sup>; Mahasen Al-Najjar<sup>1</sup>; Nida' Mubarak<sup>1</sup>; Hamsa Abdulmunem<sup>1</sup>; Fadi Alhadidi<sup>2</sup> & Saif Aldeen AlRyalat<sup>2</sup>

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**SUMMARY:** External occipital protuberance (EOP) is a midline bony protrusion in the occipital bone, the significance of which has gained recent attention in the medical community. Our present study aims to assess the average size of EOP in a Jordanian cohort and its relation to age and sex, while determining the frequency of enlarged EOP in this cohort. The present study was a cross-sectional study that was carried out in a referral hospital in Jordan. We reviewed thousands of CT scans taken with dedicated bone window imaging during the last two years, beginning January 2018. Measurements were taken by trained radiology residents and were then further reviewed by radiology specialists. An EOP was classified as enlarged (EEOP) if it exceeded 10 mm. A total of 4409 patients, 2265 (51.4 %) females and 2144 (48.6 %) males, met our inclusion criteria. Their mean age was  $54.1 \pm 22.2$  years. The mean size of the EOP in these patients was  $8.4 \pm 4.2$  mm (range: 0-56 mm). Out of the 4409-study population, 1210 (27.4 %) presented with EEOP. The prevalence of an EEOP was significantly higher in the male population (33.6 %) when compared with the female population (21.6 %) ( $P < 0.001$ ). The size of the EOP was also significantly related to the age of the patient, with EEOP increasing with increasing age. The mean size of EOP in our Jordanian cohort was  $8.4 \pm 4.2$  mm. The frequency of enlarged EOP was found to be 27.4 % in our cohort, and was significantly more common in males and in older patients.

**KEY WORDS:** External occipital protuberance; CT scan; Bony protrusion; Headache.

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## INTRODUCTION

External occipital protuberance (EOP) is a bony protrusion located on the posterior surface of the occipital bone, and provides attachment points for most medial and superficial muscles posteriorly, including the trapezoid muscle (Germann & Varun Kashyap, 2021). One major significance of this protuberance arises from a neurosurgical point of view. Neurosurgeons must properly identify the attaching musculature pre-operatively so as to avoid their dissection and prevent complications in posterior skull and spine procedures (Kadri & Al-Mefty, 2007). Another important significance is the role of enlarged EOP in the development of occipital neuralgia (Bogduk, 1981; Satyarthee, 2019). Recently, there has been increasing interest in the study of EOP, and several resultant studies have shown a variation in size with age and sex (Shahar & Sayers, 2016; Varghese *et al.*, 2017; Jacques *et al.*, 2020).

Our present study aims to assess the size of EOP in a Jordanian cohort and assess its relation to age and sex. We will also compare the size and frequency of enlarged EOP with other populations from other studies. It is important to note that we used computed tomography (CT) in our assessment, which will provide more reliable measurements compared to X-ray or ultrasound.

## MATERIAL AND METHOD

**Study design:** The present study was a cross-sectional study that was carried out at our tertiary referral center from the period between January 2019 to December 2020. We obtained institutional review board approval from our

<sup>1</sup> Department of Radiology and Nuclear Medicine, The University of Jordan, Amman 11942, Jordan.

<sup>2</sup> Department of special surgery, The University of Jordan, Amman 11942, Jordan.

institution's IRB committee, where consent from participants was waived due to the retrospective nature of the study. The study was conducted in concordance with the latest declaration of Helsinki.

**Participants:** We included head CT scans with dedicated bone window imaging over the last two years (Fig. 1), from January 2018 to January 2020. We only included patients with no abnormalities on the bone window. We excluded patients with confirmed head fractures or prior history of head surgery.

**Data extraction:** Measurements were taken by trained radiology residents at our hospital who were trained extensively on how to perform the measurements properly. Measurements were then confirmed by radiology specialists. The size of EOP was defined as the distance from the most superior point of the EOP to a point on the EOP that is most distal from the skull (Fig. 1). An EOP was classified as enlarged (EEOP) if it exceeded 10 mm. The size-dependent classification system was used to classify EOP into three categories: class 1: < 10mm; class 2: 10 mm ≤ EOP < 20 mm; class 3: ≥ 20 mm (Shahar & Sayers, 2016).

All images were obtained via Siemens, Somatom Definition Flash 128 slice, CT scanner (Siemens Medical Solutions, Forchheim, Germany), with the following parameters: 360-410 mAs, 120 kV, section thickness of 5 mm, and reconstruction increment of 5 mm.

**Statistical analysis:** Statistical analysis was performed using SPSS for Windows release 16.0 (SPSS Inc., Chicago, IL, USA). Descriptive statistics were generated. Chi-square test, Student's t-test, and One-Way ANOVA test were used to examine differences between groups. When a One-Way

ANOVA test was conducted, post hoc multiple comparisons were used to see which pairs of means were statistically significant. Results were considered significant if P-values were less than 0.05.

## RESULTS

A total of 4409 patients, 2265 (51.4 %) females and 2144 (48.6 %) males, met our inclusion criteria. Their mean age was  $54.1 \pm 22.2$  years (range: 1 day-99 years). The clinical indication for the sagittal brain CT was known in 3777 patients, as shown in Table I.

Table I. Clinical indications for the sagittal brain CT.

| Clinical indication | Number | %    |
|---------------------|--------|------|
| To rule out stroke  | 1575   | 41.7 |
| Headache            | 702    | 18.6 |
| Dizziness           | 551    | 14.6 |
| Trauma              | 434    | 11.5 |
| Operative           | 181    | 4.8  |
| Seizures            | 115    | 3.0  |
| For lumbar puncture | 83     | 2.2  |
| Hypertension        | 70     | 1.9  |
| Staging             | 66     | 1.7  |

The mean size of the EOP was  $8.4 \pm 4.2$  mm (range: 0-56 mm). Out of the 4409 study population, 1210 (27.4 %) presented with EEOP. According to size class, 72.6 % were class 1; 25.2 % class 2; and 2.2 % were class 3.

The prevalence of an EEOP was significantly higher in the male (33.6 %) than in the female population (21.6 %) ( $P < 0.001$ ); the mean EOP size in males ( $8.96 \pm 4.2$  mm)

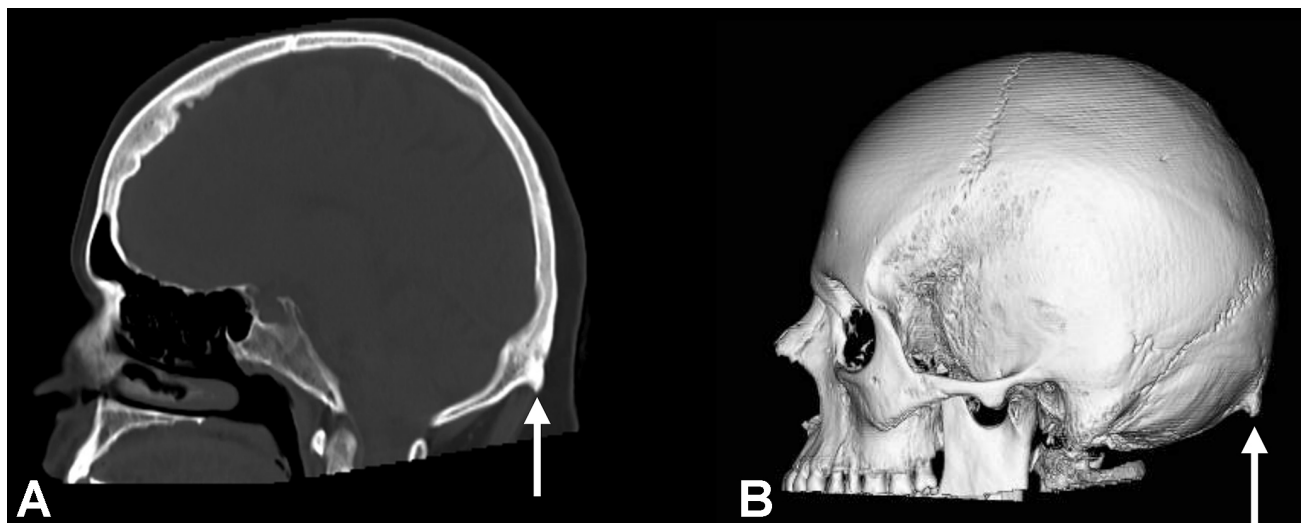


Fig. 1. Bone window CT scan (A), and 3D CT scan showing external occipital protuberance (arrows).

was significantly larger ( $P < 0.001$ ) than that in females ( $7.87 \pm 4.2$  mm). Although the prevalence of EOP class 3 size was similar in males and females, males had significantly higher percentage of class 2 and lower percentage of class 1 EOP ( $P < 0.001$ ).

The size of the EOP was also significantly related to age of the patient, where the mean age of patents who had EEOP was  $58.7 \pm 18.7$  years compared with  $52.3 \pm 23.1$  years in those with no EEOP ( $P < 0.001$ ). Although the mean age of patients with class 3 size of EOP ( $54.7 \pm 17.2$  years) was lower than that of patients with class 2 size ( $59.0 \pm 18.8$  years), this difference was not significant.

Table II shows the mean size of the EOP in the patients according to the clinical indication of the sagittal brain CT. The clinical indication of the sagittal brain CT and its association with frequency of EEOP is shown in Fi-

Table II. Clinical indications for the sagittal brain CT and mean size of EOP.

| Clinical indication | EOP Mean $\pm$ SD in mm |
|---------------------|-------------------------|
| To rule out stroke  | $9.13 \pm 4.6$          |
| Dizziness           | $8.66 \pm 4.0$          |
| Hypertension        | $8.28 \pm 3.3$          |
| Seizures            | $8.20 \pm 5.7$          |
| Headache            | $8.12 \pm 4.1$          |
| For lumbar puncture | $8.00 \pm 4.3$          |
| Trauma              | $7.95 \pm 4.1$          |
| Staging             | $7.50 \pm 4.0$          |
| Operative           | $6.79 \pm 2.9$          |

gure 2. Patients who were referred to rule out stroke and those who were complaining of dizziness had the highest frequency of EEOP. ANOVA test showed that the mean size of EOP in patients complaining of dizziness, headache, and those referred to rule out stroke were significantly higher ( $P < 0.05$ ) than in those referred for operative reasons. Furthermore, patients who were referred to rule out stroke had significantly higher ( $P < 0.05$ ) mean size of EOP than in those who were complaining of headache or trauma. The differences in mean size of EOP between the other clinical groups were not statistically significant.

## DISCUSSION

Our study presented the data on EOP and the frequency of EEOP in a Middle Eastern population, the largest sample ever to be studied for this purpose in this population. We found that the mean size of the EOP was  $8.4 \pm 4.2$  mm, and 1210 (27.4 %) presented with EEOP. We found a significant relation between EOP size and both sex and age, where the prevalence of an EEOP was significantly higher in the male (33.6 %) than in the female population (21.6 %), and the mean age of patents who had EEOP was  $58.7 \pm 18.7$  years compared with  $52.3 \pm 23.1$  years in those with no EEOP.

In a previous study performed using lateral cervical X-rays to measure the EOP, they found a frequency of enlarged EOP (i.e. EOP > 10mm) of 41 %, thus showing a

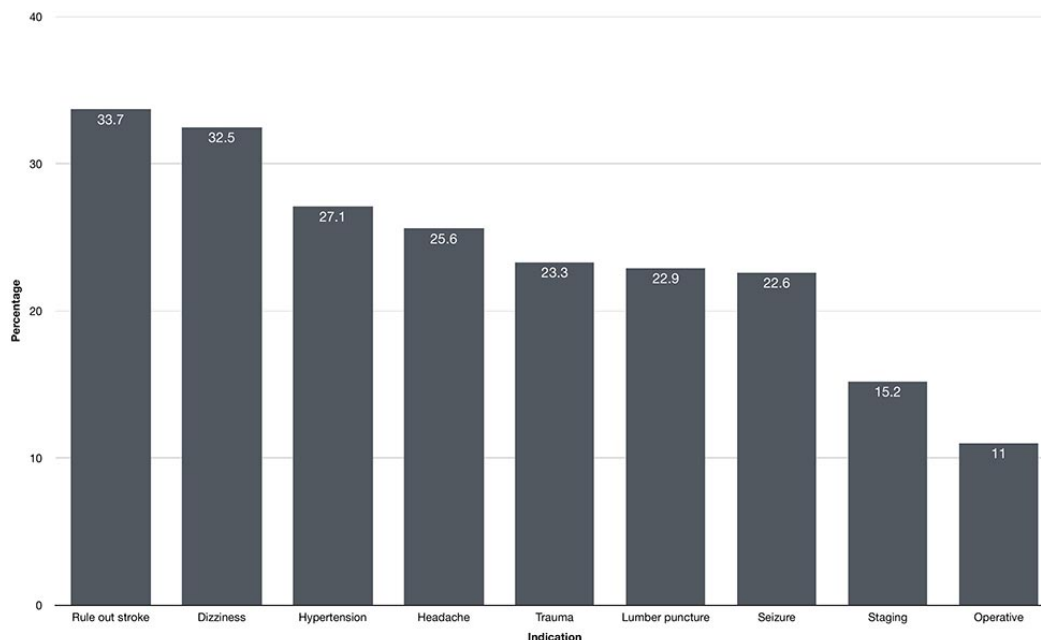


Fig. 2. Prevalence of EEOP according to clinical indication of brain CT.

higher frequency than we found in our present study (Shahar & Sayers, 2016). Most studies showed a higher frequency of enlarged EOP in male populations compared to female populations, a finding confirmed by our study. An explanation could be the higher mechanical demands in males compared to females, in addition to genetic factors (Shahar & Sayers, 2018). In a study performed on healthy adults (Shahar & Sayers, 2016), the frequency of an enlarged EOP was significantly higher in the male (67.4 %) than in the female population (20.3 %). This finding was also shown in a French population (Jacques *et al.*). In regards to age, a recent cross-sectional study on a relatively larger sample size compared to previous studies showed that a larger proportion of patients with enlarged EOP are found in the younger age groups (Shahar & Sayers, 2018). Our study contradicts these findings, where we found a higher mean age for patients with enlarged EOP compared to younger populations.

The main limitation of our current study is its cross-sectional design. A longitudinal design would likely be required to confirm the increase in enlarged EOP with age. Moreover, future studies should consider including populations of different ethnicities, which would further allow for better comparison between EOP and the frequency of enlarged EOP.

In conclusion, this study that included the largest sample population for EOP assessment on CT scan, we found that the mean size of the EOP in our Middle Eastern cohort was  $8.4 \pm 4.2$  mm. In regard to the frequency of enlarged EOP, we found it present in 1210 (27.4 %) of our sample.

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**RESUMEN:** La protuberancia occipital externa (POE) es una protuberancia ósea localizada en el plano mediano del hueso occipital, cuya importancia recientemente ha ganado atención en la comunidad médica. Este estudio tuvo como objetivo evaluar el tamaño promedio de POE en una cohorte jordana y su relación con la edad y sexo, mientras se determina la frecuencia de POE aumentada en este grupo. Se llevó a cabo un estudio transversal en un hospital de referencia en Jordania. Revisamos miles de imágenes radiológicas en tomografía computarizada y visualización de ventanas durante los últimos dos años, a partir de enero de 2018. Las mediciones fueron tomadas por residentes de radiología, y luego revisadas por especialistas en radiología. Un POE se clasificó como aumentado (POEA) si superaba los 10 mm. Un total de 4409 pacientes, 2265 (51,4 %) mujeres y 2144 (48,6 %) hombres, cum-

plieron con nuestros criterios de inclusión. La edad media fue de  $54,1 \pm 22,2$  años. El tamaño medio del POE en estos pacientes fue de  $8,4 \pm 4,2$  mm (rango: 0-56 mm). De la población del estudio 4409, 1210 (27,4 %) presentaron POEA. La prevalencia de una POEA fue significativamente mayor en la población masculina (33,6 %) en comparación con la población femenina (21,6 %) ( $P < 0,001$ ). El tamaño del POE también se relacionó significativamente con la edad del paciente, aumentando el POEA con la edad. El tamaño medio de POE en nuestra cohorte jordana fue de  $8,4 \pm 4,2$  mm. Se encontró que la frecuencia de aumento de POE en nuestra cohorte fue del 27,4 % y fue significativamente más común en hombres y en pacientes mayores.

**PALABRAS CLAVE:** Protuberancia occipital externa; Tomografía computarizada; Protuberancia ósea; Dolor de cabeza.

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Corresponding author:  
Saif Aldeen AlRyalat  
Department of Special Surgery  
The University of Jordan  
Amman 11942  
JORDAN

Email: saifryalat@yahoo.com

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