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Morphometric Analysis of the Supraorbital Foramen in the South African Population

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Kajal Ramkissoon[1], Akaashni Bhika[2], Muhammad Bobat[3], Risimati Ephraim Rikhotso[4]

ABSTRACT

Introduction

The supraorbital notch (SON) or supraorbital foramen (SOF) houses the supraorbital neurovascular bundle which supplies the scalp, skin and muscles of the upper eyelid. Surgeons operating in the region may be cautious about performing surgical procedures in this region due to the increased risk of injury.

Aim

To assess the morphological characteristics of the supraorbital foramen in the South African population

Methods

108 dry skulls were examined, to determine the following morphometric data: width of SON/SOF and position of SON/SOF relative to the nasal midline and frontozygomatic suture. Left and right sides were compared and differences between the sexes was considered.

Results

The SON (44%) was the most commonly identified passageway, followed by the SOF (27%), absent SON/SOF (19%), double foramen (5%), co-occurrence (4%), and double notch (1%) respectively. This study localised the SON/SOF approximately 26.87 mm ± 4.21 from the nasal midline to SON/SOF in females, and 28.20 mm ± 3.68 in males. When using the frontozygomatic suture as a reference point, SON/SOF lies 28.42 mm ± 3.00 medially in females and 29.83 mm ± 2.80 in males. Positional distances were significantly greater in males than females. No significant differences were observed between the left and right sides. The width of SON was approximately 4.16 mm ± 1.81, and the diameter of SOF was approximately 2.60 mm ± 1.14.

Conclusion

Accurate anatomical knowledge of the neurovascular architecture and foramina localisation can help avoid iatrogenic injury.

Keywords

Anatomy, Morphology, South Africa, Supraorbital notch, Supraorbital foramen.

Authors' Information

1. K Ramkissoon, BChD (UWC), PgDip(UP), MScDent (Wits), Registrar in Maxillofacial & Oral Surgery, Department of Maxillofacial and Oral Surgery, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa, ORCID: 0009-0001-9327-9690.
2. A Bhika, BChD, BSc (MedSci), BScHons (Cell Biology), MSc (Anat) (UP) PhD (Wits), Lecturer in Morphological Anatomy, Department of Anatomical Sciences, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa, ORCID: 0000-0003-0280-075X
3. MA Bobat, BDS (Wits), MDent (Wits), FCMFOS (SA), Consultant in Maxillofacial & Oral Surgery, Department of Maxillofacial and Oral Surgery, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa, ORCID: 0000-0002-0550-6911
3. RE Rikhotso, BDS, MDent, FCMFOS(SA), Ph, Head of Department of Maxillofacial & Oral Surgery, Department of Maxillofacial and Oral Surgery, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa, ORCID: 0000-0003-1751-8503

Corresponding author:
Name: Dr Kajal Ramkissoon
Address: 7 York Road, Parktown, Johannesburg 2193, South Africa
Email: kajal.ramkissoon1@gmail.com
Telephone: 083 407 6766

Authors' Contributions:

1. K Ramkissoon – study design, data collection, data analysis, data interpretation and drafting of the manuscript
2. A Bhika, MA Bobat, RE Rikhotso – study conception & supervision of the entire work

INTRODUCTION

The supraorbital foramen (SOF) is an elongated bony aperture above the orbit and below the forehead. When the passage is encircled by bone, it is referred to as the supraorbital foramen, however, when partly enclosed in bone, it is called the supraorbital notch (SON)[1]. The supraorbital foramen or supraorbital notch is located along the supraorbital margin on the frontal bone[2]. The terminal point houses the supraorbital nerve, artery and vein. This nerve forms the largest branch of the frontal nerve, extending from the ophthalmic division of the trigeminal nerve (Cranial Nerve V). The supraorbital nerve is bounded by the orbital roof and levator palpebrae muscle[3]. The nerve subdivides into two branches: a medial (superficial) branch which journeys through the frontal foramen or notch, providing sensation to the medial part of the upper eyelid, medial forehead, and bridge of the nose; and a thicker lateral (deep) branch which usually exits through the SON/SOF providing sensory innervation to the skin of the forehead (extending from the parietal to the temporal regions[4]. The supraorbital artery forms a branch of the ophthalmic artery, originating from the internal carotid artery. After passing through SON/SOF, it separates into the superficial and deep branches that supply muscles and skin of the forehead, scalp and upper eyelid. The supraorbital vein joins the supratrochlear vein at the medial angle of the eye to form the angular vein which continues through the face as the facial vein[5].

Comprehensive knowledge of the regional anatomy of the supraorbital nerve, vessels, and exit passageway is crucial in combination with modern diagnostic and therapeutic methods and surgical procedures in the supraorbital region[4]. This includes procedures such as corneal neurotization, anterior orbital approach, supraorbital injections, treatment of migraine headaches, fronto-glabellar reconstruction flap, upper eyelid surgeries (e.g., blepharoplasty), and any

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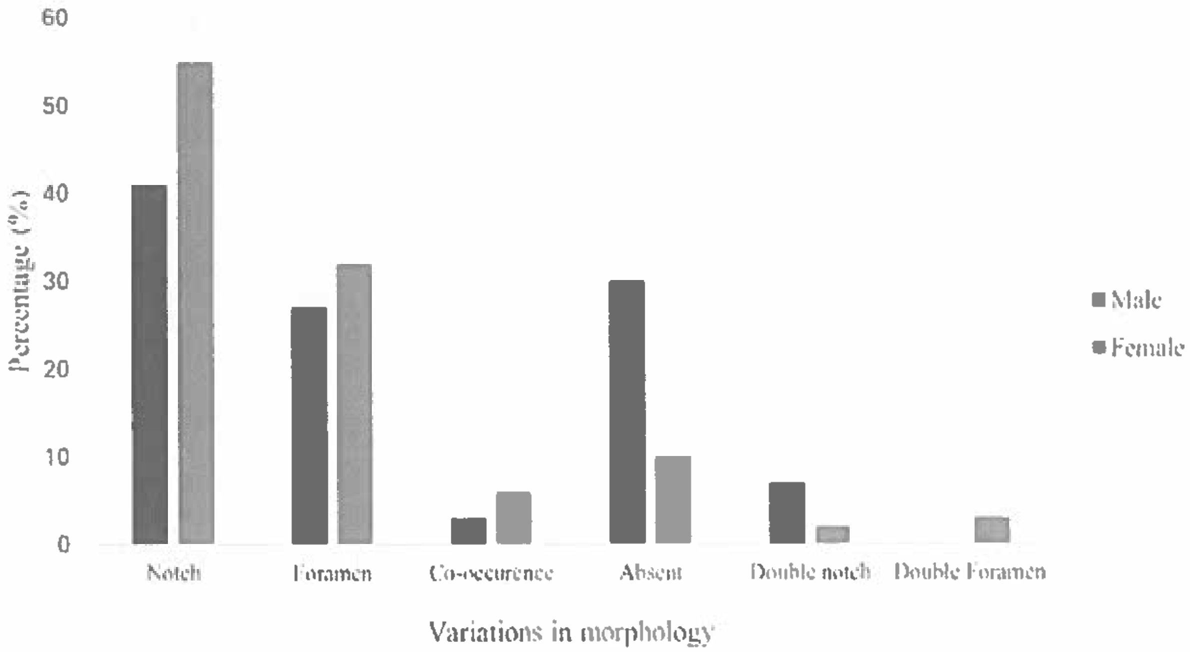

Figure 2: Frequency distribution amongst sexes in the South African population.

Data analysis:
Data was captured on Microsoft Excel 2021 (Microsoft Corporation). Data was then exported to Statistical Package for Social Service (SPSS) (Version 28). Descriptive statistics of the data was utilised to determine the minimum, maximum, mean and standard deviation of the groups under analysis. Thereafter, a Shapiro-Wilk test was used to test for the normality distribution of the data. A t-test was used to analyse differences observed in the measurements between the right and left sides of the skull and the differences observed between sexes where the data was normally distributed.

A Mann-Whitney U test was used if data was non-parametric. The significance level was set at $p \leq 0.05$.

RESULTS

The study population consisted of 108 specimens, 54 males and 54 females. The age of the crania ranged from 20 years to 90 years, with a median age of 50 years old.

The reliabilities for each measurement were above 0.8, indicating good reliability.

Different morphologies including the supraorbital notch (SON), supraorbital foramen (SOF), absent SON/SOF, double foramen, co-occurrence, and double notch were identified in our sample population (Figure 2). When comparing the frequency in the distribution of morphologies in a South African population SON (44%) was the most commonly identified passageway, followed by the SOF (27%), absent SON/SOF (19%), double foramen (5%), co-occurrence (4%), and double notch (1%) respectively (Figure 3).

Figure 3 (a): image depicts SON

Figure 3(b): image depicts absent SON/SOF

Figure 3(c): Image depicts SOF

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TABLE VII: SOF/SON POSITION IN MALES VS FEMALES

	Distance to nasal midline (NM-SOF) (NM-SON) (mm)		Distance to frontozygomatic point (SOF-FZR) (SON-FZR) (mm)	
	Females	Males	Females	Males
Min	17.96	17.30	21.79	23.08
Max	40.52	35.67	35.67	40.36
Median	26.87	28.41	28.10	29.83
Mean	26.87	28.20	28.42	29.63
P-value	0.008	0.002*		

* p-value p≤0.05

DISCUSSION

The study sought to determine the existence of various morphologies of the SON/SOF along with the dimensions of the SON/SOF and position relative to the nasal midline and frontozygomatic point, in the South African population. This was done using osteometric measurements taken with a digital vernier caliper.

Numerous studies exist, reporting on the relative position and size of the SON/SOF. In general, most studies found the notch to be more prevalent[6,8]. The presence of a foramen rather than a notch suggests that the supraorbital neurovascular bundle is in a relatively stable position and thereby at greater risk during surgical dissection, as it is more likely to be stretched during retraction. Therefore, extra care must be exercised during the reflection of flaps, where the supraorbital foramen is present[9]. According to Tomaszewska *et al*[10], the frequency of SON is greater in warmer climate regions than in cold regions. The study identified a high frequency of SOF (35.4%) in cold climates and a low frequency of SOF (18.8%) in warm conditions. The frequency of SON was greater in warm climates (59%) and lowest in cold climates (44%). This would provide a larger exit route for the supraorbital vessels and may be due to thermoregulatory processes. The supraorbital vein is more exposed and therefore susceptible to heat loss when passing through the SON10. The warm climatic conditions could be a possible factor in the greater frequency of SON than other exit passageways in our study.

Without the SON/SOF, the supraorbital vasculature is more susceptible to injury due to the sharp supraorbital margin[9]. According to Tezer *et al*[11], the foramen and absent SON/SOF cannot be palpated, however, the notch can be palpated during physical examination. In our study, 19% of cases identified an absence of SON/SOF, in the South African population. The risk of neurovascular damage is thus greater in subperiosteal interventions, such as endoscopic facelifts and migraine surgeries, when there is an absence of SON/SOF[11].

Very few studies have reported the incidence of double notches. Hong *et al*[12] conducted a study using 3D CT images and identified 0.8% double notches on the right side and 0.4% on the left side. In this study, only 3.7% of double notches were found on the right side in females, which is considerably higher than the study conducted by Hong *et al*[12]. There were no double foramen identified in males, which is similar to the study conducted by Hong *et al*[13]. Knowledge of the presence of accessory foramina is important to surgeons as additional nerve bundles may emerge from these openings. The occurrence of accessory supraorbital nerves may render anaesthetic blocks unsuccessful[13].

The size of the SON/SOF in this study is smaller in diameter than in other studies[5,6]. The difference in our findings might be due to population affinity differences between the studied population15. No significant differences were found between the left and right sides, in our study.

This indicates that our study had a greater SON-NM / SOF-NM distance than other studies[6,8]. In addition, Ilayperuma *et al*[6] described sex differences in the position of SON/SOF, in agreement with our study. The study emphasized the importance of applying anatomical variation data to each subject within a population[6]. Males displayed a significantly greater SON-NM / SOF-NM distance than females, in our study. On average, female individuals are smaller in cranial size and overall more gracile in comparison to males. Del Bove *et al*[15] explained that the glabellar region, nasal region and supraorbital torus are sexually dimorphic[15]. This may explain the greater SON-NM / SOF-NM distance in males than females.

Ashwini *et al*[5] reported a mean of 29.34 mm ± 0.32 on the right, and 28.7 mm ± 0.29 on the left side. Voljevica *et al*[9] found a mean of 28.30 mm ± 2.56 in males and 27.16 mm ± 2.74 in females. These findings indicate that the data does not deviate markedly from previous studies. Ashwini *et al*[5] suggested SON-FZR / SOF-FZR to be a more reliable parameter, as it can be accurately located on the skin. The frontozygomatic suture can be palpated on the skin at a notch along the lateral orbital margin, along the plane of the end of the palpebral fissure[5].

In our study, the distances of SON-NM / SOF-NM and SON-FZR / SOF-FZR were significantly larger in males than females. Similar findings of shorter distance in females than males have been previously reported by Agthong *et al*[16], whereby NM-SOF was smaller on the left side in females. Thus, our findings suggest that sex should be considered when locating SON/SOF, as the distance to midline may be greater in males than in females[16]. The shape of the human cranium and distribution of the supraorbital structures may be influenced by genetic and environmental factors[14].

Palamenghi et al[17] explored the potential of cranial non-metric traits, such as SON/SOF. The study determined that SON/SOF was not sufficiently unique to be regarded as individualizing. Whilst our study did identify significant positional differences of SON/SOF, between males and females, a larger sample size is required to evaluate the accuracy of this tool, as a sex estimator[18]. When this data is available, the morphological features and positional data may be used for sex estimation, or to narrow down potential matches and strengthen tentative or presumptive identifications, in conjunction with other methods.

Based on the findings, it is recommended that surgeons operating in the supraorbital region consider the following guidelines:

1. Pre-operative examination must include palpation in the supraorbital region to identify SON/SOF, as the SON is a palpable structure.
    a. If SON is palpated–maintain a 2mm safety zone around the area.
    b. If no SON is palpated and there is a risk of injury to structures based on the procedure performed – consider using adjunct tools (CT/CBCT/MRI imaging) as appropriate.