

Morphometric Analysis of the Supraorbital Foramen and Notch in the Population of Bosnia and Herzegovina

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Abstract

Objective. The aim of this study was to learn about the morphological characteristics of the supraorbital foramen and to determine its precise position in relation to the surrounding anatomical landmarks in the adult population of Bosnia and Herzegovina. **Material and Methods.** For this purpose, 60 skulls from the Bosnia and Herzegovina population of known sex (32 males and 28 females), taken from the osteological collection of the Department of Human Anatomy of the Medical Faculty in Sarajevo, were subjected to morphological and morphometric analysis. Morphometric measurements were performed using a digital vernier caliper (Mitutoyo Corporation, Japan). **Results.** The study showed that most supraorbital nerves exit the orbit through the supraorbital notch (73.8%) and the rest through the foramen (26.2%). Of this number, bilateral supraorbital notches were recorded in 58.33% of cases, a bilateral supraorbital foramen in 18.34% of cases, while in 23.33% of cases a notch was recorded on one side and a foramen on the contralateral side. Morphometric measurements performed to determine the exact position of the supraorbital foramen relative to the surrounding landmarks showed different values in males and females. An accessory foramen was also observed on the examined skulls in 16.67% of cases. **Conclusion.** Detailed knowledge of anatomical variations of the supraorbital foramen is required for safe and successful administration of regional anesthesia, in order to avoid iatrogenic nerve injuries during orbitofacial region surgery.

Key Words: Supraorbital Foramen ▪ Supraorbital Notch ▪ Supraorbital Nerve ▪ Craniofacial Surgery.

Introduction

The supraorbital margin is formed entirely by the squamous part of the frontal bone, which is interrupted at the junction of its sharp lateral 2/3rd and rounded medial 1/3rd by the supraorbital foramen/notch (1). In 25% individuals, the notch is converted into a foramen by ossification of the periosteal ligament crossing it (2), and has been referred to as a supra orbital ligament in the literature (3). The supraorbital notch or supraorbital foramen (SON/SOF) is the passage for the supraorbital artery, veins and nerves in the frontal bone. The supraorbital artery, a branch of the ophthalmic artery, leaves the orbit through the SON/SOF, and divides into superficial and deep branches to

supply the skin and muscles of the upper eyelid, forehead and scalp.

The supraorbital nerve is one of the main cutaneous nerves supplying the forehead and scalp region, and may be injured during various invasive procedures. This nerve is the larger terminal branch of the frontal nerve, and after exiting through the SON/SOF it divides into medial and lateral branches to supply the upper eyelid, conjunctiva and skin of the scalp, up to the lambdoid suture. Supraorbital nerve blocks are commonly performed in the region of the supraorbital foramen during procedures such as closure of facial wounds, biopsies and scar revisions, as an absolute but temporary treatment for supraorbital

neuralgia, and other cosmetic cutaneous procedures. Effective and precise analgesia can only be achieved if one is aware of the most frequent location of the exit of the nerve in this region. Knowledge of the location of the supraorbital nerve is also essential during various endoscopic procedures, which are increasingly being used for cosmetic facial surgery (4, 5). However, cosmetic surgeons are generally reluctant to perform brow lifts and other open, as well as endoscopic surgical procedures in this region, for fear of injuring the supraorbital nerve and subsequent sensory loss (6, 7). Excessive dissection and retraction close to such neurovascular bundles can cause scarring, which may lead to entrapment neuropathies and painful neuralgias (8, 9). According to the standard descriptions in anatomy textbooks, the supraorbital notch/foramen is situated at the junction of the lateral two-thirds and medial third of the supraorbital margin (10, 11).

However, most published studies report that the position and morphometric characteristics of the SON/SOF are not constant. In some skulls, cases have been reported of incomplete foramina, double foramina, a double notch or the absence of all of them (12-18). In the absence of supraorbital foramina or notches, the supraorbital vessels and nerves are more prone to injury due to the sharp supraorbital margin.

Traumatic or iatrogenic injury to the neurovascular bundle at the point of emergence through the foramina may result in bleeding and hypoesthesia, paraesthesia or even anesthesia in the region of supply, depending on the degree of injury (19, 20). Despite its significance, little is known about the morphological details and location of the supraorbital notch/foramen in the adult population of Bosnia and Herzegovina.

Hence, this study was carried out to elucidate the number, dimensions, orientation and position of the supraorbital notch/foramen in relation to the surgically encountered anatomical landmarks in an adult population in Bosnia and Herzegovina.

Material and Methods

Sixty adult human skulls (28 male and 32 female) were used as material in this study. The skulls were taken from the osteological collection of the Department of Human Anatomy, Faculty of Medicine, University of Sarajevo. Skulls of known sex and age (53 ± 21), without visible gross pathology, deformities or traumatic lesions were included in the study.

Both sides of the skull were analyzed visually, and the presence of supraorbital foramina (SOF) or notches (SON) was noted, as well as the presence of accessory foramina or notches (SONA/SOFA), and their number. The position of the SON/SOF relative to the infraorbital foramen (IOF) was noted as lying in the same vertical plane as the IOF or lying laterally or medially from this plane.

Morphometric measurements were performed using digital vernier calipers 0-1000mm, 0.05mm, Metric 530-502 (Mitutoyo Corporation, Japan), with a margin of error of 0.01mm. All the measurements were repeated three times, and the mean was taken for further analysis. Furthermore, the measurements were recorded by the same person, to minimize errors in the methodology.

The following is a description of all the measurements taken (Figure 1):

1. Maximum transversal diameter of the supraorbital foramen (SOF-TD),
2. Maximum vertical diameter of the supraorbital foramen (SOF-VD),
3. Vertical distance between the lower edge of the supraorbital foramen and the upper orbital edge (SOF-SOM),
4. Distance from the medial edge of the supraorbital notch and foramen (SON/SOF) to the midline of the face (SON/SOF -FM),
5. Distance from the lateral edge of the SON/SOF to the temporal crest of the frontal bone (SON/SOF -TCFB),
6. Distance from the SON/SOF side edge to the frontozygomatic suture (SON/SOF -FZS).

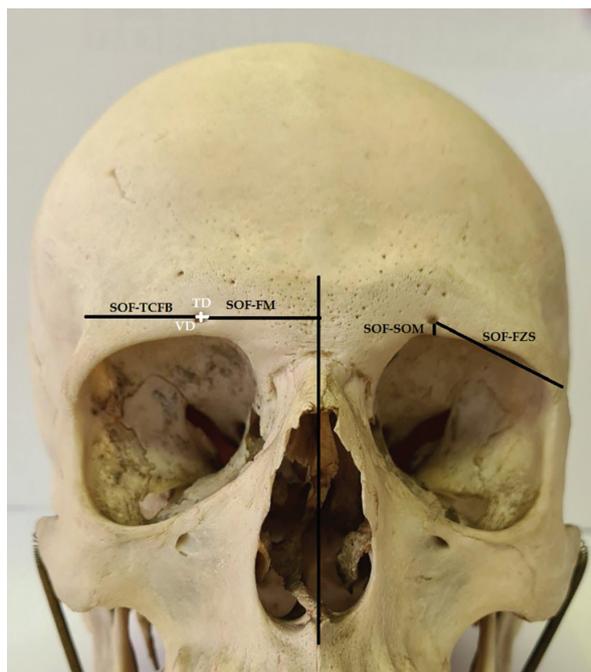


Figure 1. A skull showing the measurements taken to determine the position and dimensions of the supraorbital foramen. SOF=Supraorbital foramen; SOM=Supraorbital margin; FM=Facial midline; TCFB=Temporal crest of the frontal bone; FZS=Frontozygomatic suture; VD=Vertical diameter; TD=Transversal diameter.

Statistical Analysis

All parameters were analyzed using SPSS version 19 (SPSS Inc., Chicago, IL, USA), and data were compiled in Microsoft Excel 2020 (Microsoft Corp., Redmond, WA, USA) and shown in tables. Descriptive analysis was used to estimate the mean and standard deviation. A comparison of the mean values between sides and genders was performed

using the paired and unpaired samples t-test. A P-value less than 0.05 was accepted as the level of statistical significance for this study.

Results

In the present study, supraorbital openings were found in the form of notches (73.8%) or foramina (26.2%) on all 120 sides of the skulls examined. Bilateral supraorbital notches were found in 58.33% of cases, and bilateral supraorbital foramina in 18.34%, while in 23.33% of cases a notch was recorded on one side and a foramen on the contralateral side (Table 1).

An accessory supraorbital foramen was observed in 10 (16.67%) skulls (Table 1), and of these, in three cases accessory foramina were present bilaterally. The most common position of accessory supraorbital foramina in relation to the main SON/SOF was lateral in 61.2% of sides, followed by medial in 28.3%, and superior in 10.5%.

The dimensions of the supraorbital foramen and linear measurements from the SON / SOF to different anatomical landmarks in relation to sex and sides are summarized in Tables 2 and 3, respectively.

In our study, it was noted that the SON/SOF distance from the midline of the face was 24.45 ± 2.75 and 23.79 ± 3.45 mm on the right and left sides, and 24.87 ± 3.63 and 22.46 ± 3.07 mm in males and females, respectively.

The mean SON/SOF distance from the temporal crest of the frontal bone in the Bosnia and Herzegovina population was 30.04 ± 3.48 mm on

Table 1. The Morphological Features of the Supraorbital Nerve Exits

Morphological features	Male: N=28	Female: N=32	Total: N=60
	N (%)	N (%)	N (%)
Bilateral supraorbital notches	20 (71.43)	15 (46.87)	35 (58.33)
Bilateral supraorbital foramen	2 (7.14)	9 (28.13)	11 (18.34)
Unilateral notch and foramen	6 (21.43)	8 (25.00)	14 (23.33)
Bilateral accessory foramen	2 (7.14)	1 (3.13)	3 (5.00)
Unilateral accessory foramen	5 (17.86)	2 (6.25)	7 (11.67)

Table 2. Morphometric Measurements of the Supraorbital Notches/Foramina in Relation to Gender

Measurements	Males (N=28)			Females (N=32)			P [†]
	Mean±SD [*]	Min.	Max.	Mean±SD [*]	Min.	Max.	
Maximum transverse diameter of SON/F (TD)	3.75±1.36	2.39	3.69	3.58±1.04	2.29	2.69	0.940
Maximum vertical diameter of SON/F (VD)	1.98±0.76	1.08	2.73	1.83±0.73	1.02	1.82	0.383
Distance from SON/F to SOM	2.98±1.70	0.77	8.07	2.78±1.31	1.94	4.14	0.071
Distance from SON/F to FM	24.87±3.63	17.89	30.49	22.46±3.07	17.31	31.11	0.002
Distance from SON/F to TCFB	29.71±3.58	20.4	35.6	27.89±3.26	20.63	39.33	0.007
Distance from SON/F to FZS	28.30±2.56	22.88	35.88	27.16±2.74	22.14	32.44	0.015

^{*}SD=Standard deviation; [†]Unpaired Samples t-test; SON/F= Supraorbital foramina or notches; TD= Transversal diameter; VD=Vertical diameter; SOM=Supraorbital margin; FM= Facial midline; TCFB=Temporal crest of the frontal bone; FZS=Frontozygomatic suture.

Table 3. Morphometric Measurement of the Supraorbital Notch/foramina in Relation to Side

Measurements	Total (n=60)			Right (n=60)			Left (n=60)			P [†]
	(Mean±SD) [*] mm	Min	Max	(Mean±SD) [*] Mm	Min	Max	(Mean±SD) [*] mm	Min	Max	
Maximum transverse diameter of SON/ F (TD)	3,65±1,35	2,32	3,25	3,66±1,44	2,15	3,65	3,63±1,25	2,48	2,84	0,486
Maximum vertical diameter of SON/F (VD)	1,99±0,69	1,14	2,39	2,09±0,74	1,03	2,73	1,89±0,64	1,24	2,04	0,081
Distance from SON/F to SOM	2,84±1,43	2,18	6,78	2,88±1,31	3,37	5,27	2,79±1,54	0,98	8,28	0,648
Distance from SON/F to FM	24,12±3,1	15,59	28,79	24,45±2,75	15,43	29,23	23,79±3,45	15,74	28,34	0,383
Distance from SON/F to TCFB	29,54±3,5	18,31	32,96	30,04±3,48	16,81	36,31	29,04±3,52	19,81	29,61	0,361
Distance from SON/F to FZS	27,82±2,64	21,99	33,09	27,99±2,83	22,16	35,66	27,64±2,45	21,81	30,51	0,229

^{*}SD=Standard deviation; [†]Paired Samples t-test; SON/F= Supraorbital foramina or notches; TD= Transversal diameter; VD=Vertical diameter; SOM=Supraorbital margin; FM= Facial midline; TCFB=Temporal crest of the frontal bone; FZS=Frontozygomatic suture.

the right and 29.04±3.52 mm on the left side, and 29.71±3.58 mm in males and 27.89±3.26 mm in females.

The mean recorded value of the SON/SOF distance from the frontozygomatic suture was 27.64±2.45 mm on the right and 27.99±2.83 mm on the left side, and 29.71±3.58 mm in males and 27.16±2.74 mm in females.

In males, higher values of SOF dimensions and linear distances from the SON/SOF to anatomical landmarks were observed compared to females. However, a statistically significant difference was only observed in the distance from the SON/SOF to the temporal crest of the frontal bone, and the distance from the medial edge of the SON/SOF to the midline of the face (Table 2).

Higher values of these dimensions were recorded on the right side compared to the left side, but without statistical significance (Table 3).

The position of the SOF relative to the position of the IOF is shown in Table 4. According to the results of this study, most supraorbital foramina (78.4%) are located medially of the infraorbital foramen, where only 15.8% of subjects had both foramina in the same sagittal plane, and in 5.8% of subjects the supraorbital foramen was located laterally from the infraorbital foramen.

Table 4. Frequency of the Location of the SON/SOF in Relation to the Position of the IOF

Position of SON/SOF in relation to the position of IOF	N (%)
Medial to the IOF	94 (78.4)
Lateral to the IOF	7 (5.8)
In the same vertical plane as IOF	19 (15.8)

SON/SOF=Supraorbital notch/foramen; IOF=Infraorbital foramen.

Discussion

This study provides valuable data on the morphometry and relative location of the supraorbital notch or foramen in the adult population of Bosnia and Herzegovina. Precise identification of the supraorbital notch or foramen is important in therapeutic, diagnostic, anesthetic and surgical procedures of the maxillofacial region (21-24). The appearance of a supraorbital notch (73.8%) was more frequent than the appearance of a foramen (26.2%), which is a result that supports the observations made in some studies (14, 20, 25), but contradicts the observations of Lima et al. (26).

The mean distances from the supraorbital notch or foramen to the anatomical landmarks mentioned above were significantly greater in Bosnia and Herzegovina males than in females. Our results support the gender differences in the position of the supraorbital notch or foramen reported in previous studies (12, 13, 27). Gender differences in the relative position of the supraorbital notch or foramen emphasize the importance of applying data on anatomical variations to an individual subject in a specific population (13).

The mean distances from the supraorbital notch or foramen to the midline of the face, the temporal crest of the frontal bone, and the frontozygomatic suture observed in this study were consistent with those reported in studies by Agthong et al., Gupta et al., and Nanayakkar et al. (13, 14, 28), while differing from those reported in the studies by Webster et al., Chrcanović et al., Chung et al. and Smith et al. (15, 18, 29, 30). It is speculated that these differences could be caused by ethnic or climatic factors, which confirms the results of previous research (12, 13, 27, 31, 32, 33, 34).

We cannot say with certainty which of the above-mentioned factors influenced the various measurements in males and females of the Bosnian-Herzegovinian population, because for such conclusions it is necessary to conduct much more extensive research that would include a larger number of samples and the collection of samples from the entire territory of Bosnia and Herzegovina. The insufficient number of samples

in the present study is a limiting factor that prevents the results from being applied to the entire population of Bosnia and Herzegovina. For these reasons, the goal of our future research will be to conduct a more extensive analysis on the given topic.

Population-specific linear measurements have clinical implications as they may aid in precise localization, thereby avoiding injury to the neurovascular bundle exiting through the supraorbital foramen or notch. Surgically, it can be difficult to locate the midline of the face accurately, and in such cases the distance from the temporal crest of the frontal bone is considered a better anatomical landmark (12).

The standard anatomy texts describe the location of supraorbital and infraorbital foramina on the same sagittal plane (1, 10, 11). Although this is in accord with some European populations, it ignores a large body of evidence with reference to other populations (27, 29). Such diversity in the location of the supraorbital foramen may be attributed to ethnic factors (12, 29). According to the results of this study, the majority of supraorbital foramina (78.4%) were located medially to the infraorbital foramen, only 15.8% of the study subjects displayed both foramina in the same sagittal plane, and in 5.8% of subjects the supraorbital foramen was located laterally from the infraorbital foramen. Our findings are consistent with the corresponding figures of Thais (27) and Koreans (29), highlighting the racial differences in the modal position of the supraorbital foramen in relation to the infraorbital foramina observed in different populations.

The incidence of accessory supraorbital foramina in this population from Bosnia and Herzegovina was found to be 16.67%. The occurrence of multiple supraorbital foramina was shown to vary widely between different populations (14, 17, 25, 33, 35). Multiple facial foramina have been associated with the branching of nerves during development, and may explain cases of failure of infiltrative anesthesia for maxillofacial procedures (36). Furthermore, the existence of multiple foramina in a minority of patients also has clinical

implications, as injury to any branch of the supraorbital nerve that exits through these foramina may result in sensory deficit (34, 37).

Determining the position of neurovascular bundles that pass through the appropriate openings on the face, on the basis of the surrounding landmarks, increases the success of surgical interventions, and reduces the risk of iatrogenic damage to these bundles. For this reason, it is necessary to make a detailed analysis of SON/SOF variations for each population individually.

Conclusion

As far as we know, this is the first study to address the anatomical variations of supraorbital notches or foramina in the Bosnia and Herzegovina population. It is important to emphasize that supraorbital notches or foramina show numerous morphological and morphometric variations, so special attention should be paid during surgical procedures to determine their exact location and thus avoid iatrogenic injuries of the neurovascular structures passing through them.

What Is Already Known on This Topic:

A supraorbital foramen (SOF) or notch (SON) is present at the junction of the lateral two-third and medial one third of the supraorbital margin. According to previous studies, in 25% of cases the supraorbital notch is converted into a foramen by ossification of the periosteal ligament bridging it. The supraorbital foramen/notch transmits neurovascular structures, namely the supraorbital artery, veins and nerve, and supplies the area around the eye, and the skin over the forehead. These neurovascular structures are prone to injury during various procedures performed in their areas of supply, and this will lead to damage of the structures being supplied by them.

What This Study Adds:

Despite its significance, little is known about the morphometric details of supraorbital foramina in the population of Bosnia and Herzegovina. Hence this study was carried out to elucidate the number, dimensions, position and orientation of supraorbital foramina in relation to the anatomical landmarks in dry skulls from Bosnia and Herzegovina.

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critically for important intellectual content: MŠ and APK; Approved final version of the manuscript: AV, ET, MŠ and APK.

Conflict of Interest: The authors declare that they have no conflict of interest.

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