Retrospective Study

Studies of Supraorbital Notch and Foramen Using 3-Dimensional Facial Bone CT Scans

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Background: The supraorbital foramen or notch is located at the superior orbital rim. Previous studies have reported anatomical variations in these structures. However, the results varied depending on races and the measurement method used.

Objective: The purpose of this study is to identify the morphological features of supraorbital foramen or notch based on locational relationship using images of 3-dimensional (3D) facial bone CT scans.

Study Design: Retrospective study.

Setting: University hospital emergency department.

Methods: Identification and analysis of patients who have undergone facial bone 3D CT were performed using Clinical Data Warehouse v 2.5 (CDW, Planit Healthcare, Seoul, Korea). The search word that we used with the CDW for analysis was "facial bone 3D CT".

First, the region of the supraorbital rim was examined to clarify whether or not the supraorbital foramen or notch was present. Second, the diameter of the supraorbital foramen or notch was measured. Lastly, the distance from midpoint (nasion) to the supraorbital notch or foramen was measured.

Results: The supraorbital notch was found more frequently than the supraorbital foramen. Among supraorbital double types, the coexistence of notch and foramen was found more frequently than the coexistence of notch and notch or foramen and foramen. The diameter of supraorbital notch was wider than the supraorbital foramen, which was located more laterally from the nasion than the supraorbital notch.

Limitation: The actual size of the facial image or the skull size of the patient was not considered, which might affect the distance of supraorbital notch or foramen from the midline.

Conclusion: Supraorbital notch was more frequently found than the supraorbital foramen. The supraorbital notch had a wider diameter and was more centrally located than the supraorbital foramen.

Key words: Diameter, facial bone CT, supraorbital notch, supraorbital foramen

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Significant anatomical variations associated with the morphology, occurrence, and location of supraorbital nerve exits from the frontal bone have been reported (1). During maxillofacial surgery, potential damage to the supraorbital nerve or adjacent blood vessel is possible. Previous studies have demonstrated the importance of the anatomical characteristics and location of supraorbital foramen/notch to avoid such damage (2,3). For nerve block of the facial region, ultrasound is commonly used for the identification of foramen or notch (4-6). However, incomplete or unsuccessful nerve block can result even under ultrasound guidance. Understanding the anatomical features and the locational relationship

of the supraorbital foramen or notch are essential to minimize the risk of failure.

The supraorbital foramen or notch is located at the superior orbital rim. The anatomical variations found in these structures have been reported by previous studies using cadavers and dry skulls. However, such studies demonstrated varying results depending on races and the measurement method used (7,8).

Recently, the 3-dimensional (3D) technology used in computed tomography (CT) scans enabled reliable and more accurate measurement of parameters, especially involving craniofacial structures. High reliability of measured parameters has been proven in previous studies. Intra-observer and inter-observer variations defined on facial bone 3D CT were smaller compared with cephalograms (9,10). Since the 3D reformulation process makes possible easy and delicate comprehension of bony structures, more reliable and accurate measurement is possible (10,11).

The purpose of this study is to identify the morphological features of supraorbital foramen or notch with locational relationship using images of 3D facial bone CT scans.

Methods

Patients

This study was performed in a retrospective manner after approval of our institutional review board (2021-05-010). Patients who were evaluated with facial bone 3D CT following facial injury between January 2020 and March 2021 were included. Since every patients had a prior history of facial trauma before CT scanning, all the patients diagnosed with an actual facial fracture were excluded. Also, patients who underwent previous surgery or manifested congenital anomalies in the orbit and frontal region were excluded in this study.

Identification and analysis of patients who have undergone facial bone 3D CT were performed using Clinical Data Warehouse v 2.5 (CDW, Planit Healthcare, Seoul, Korea) using the key words "facial bone 3D CT."

Measurements

All images were reconstructed 3-dimensionally using a 3D image reconstruction program INFINITT PACS M6 (INFINITT Health care, Seoul, Korea). Each image slice was obtained at 3 mm thickness. Analysis and measurement of parameters were performed using images transmitted digitally via the Picture Archiving and Communication System (PACS).

For the evaluation of included images, 2 of authors (SHK and KJS) who had at least 3 years of experience in pain practice performed this analysis and measurement of parameters.

First, the region of the supraorbital rim was examined to determine the presence of supraorbital foramen or notch. Second, the diameter of supraorbital foramen or notch was measured. Lastly, the distance from midpoint (nasion) to the supraorbital notch or foramen was measured (Fig. 1). The diameter and distances were measured using a length-measurement instrument installed in INFINITT PACS M6. The morphologic features were divided into single notch, single foramen (Fig. 2), double foramen, double notch, and presence of both foramen and notch (Fig. 3), or absence of both foramen and notch (Fig. 4).

Medical records were carefully reviewed to obtain a detailed history of facial trauma and demographic characteristics.

Statistics

Values are presented as mean (SD). Student t test was used to compare the mean values between male and female patients. All statistical values were 2-tailed, and P values < 0.05 were considered statistically significant. Statistical evaluations were performed using SPSS v 22.0 (IBM, NY, USA).

Results

All study parameters were measured twice by 2 of the authors. The inter-grader reliability of the 2 graders was assessed by the κ value (0.91-0.94). All of the data showed a normal distribution. The right and left sides of hemi-face in 244 patients using 3D facial bone CT were analyzed. The 244 patients included 163 male patients (66.8%). The mean age of male and female patients was 52.3 years and 53.5 years, respectively.

Single supraorbital notch or foramen was most commonly found on the face bilaterally. The incidence of the single notch type was 1.5-fold higher than the single foramen type (Table 1, Fig. 2A, B). Among the supraorbital double types, the coexistence of notch and foramen was more frequent than the coexistence of notch and notch or foramen and foramen (Table 1, Fig. 3A-C). Less than 5% of patients demonstrated an absence of foramen or notch (Table 1, Fig. 4).

The diameter of supraorbital notch was wider than that of supraorbital foramen. The supraorbital fora-

men was located more laterally from nasion than the supraorbital notch (Table 2, Fig. 4).

Among the 244 patients, 195 (79%) patients displayed bilateral existence of supraorbital notch or foramen. However, the remaining 49 (21%) patients showed a notch on one side and a foramen on the contralateral side.

The distance from nasion to the supraorbital foramen differed significantly between men and women.

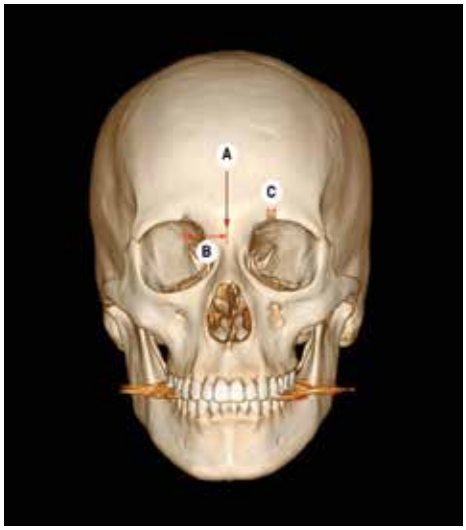

Fig. 1. *Facial bone 3D CT image showing measurement of parameters. (A) Red arrow indicates nasion (midpoint). (B) Distance from the center of supraorbital notch or foramen to the nasion. (C) Measurement of diameter of supraorbital notch or foramen.*

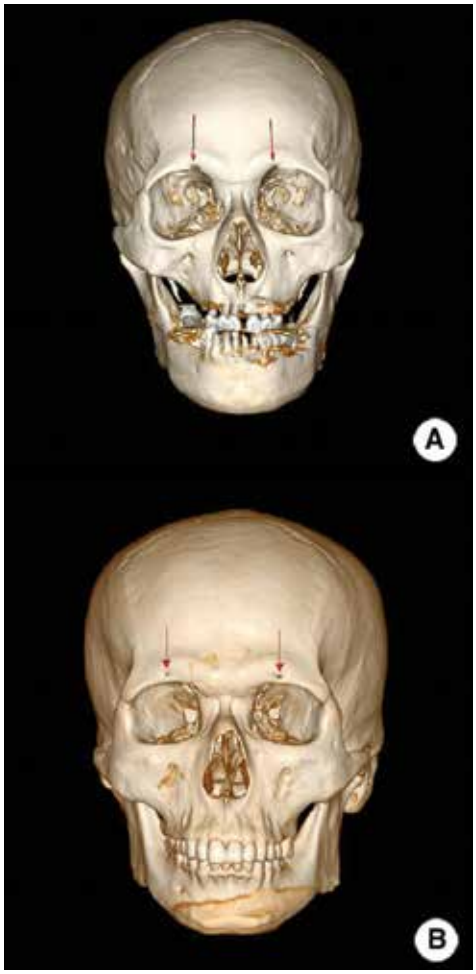

Fig. 2. *Red arrow indicates supraorbital notch (A) and supraorbital foramen (B).*

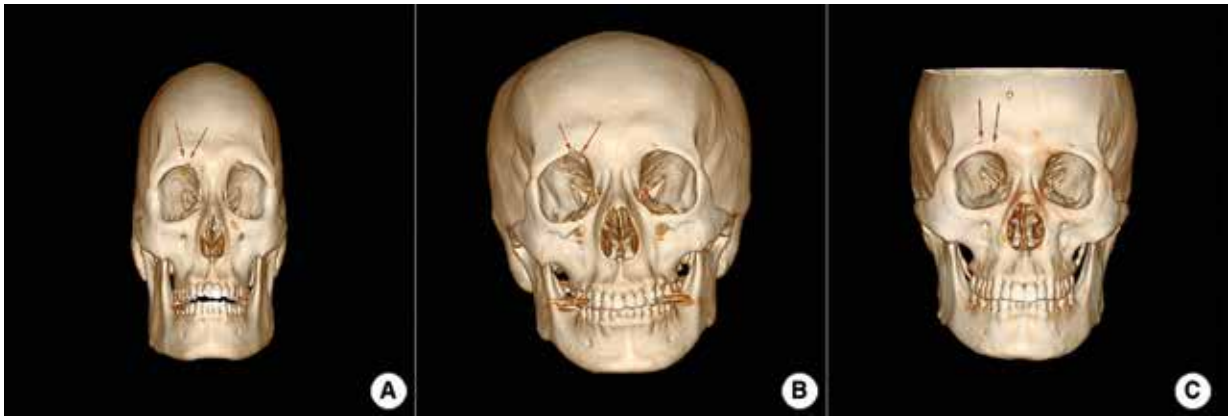

Fig. 3. *Facial bone 3D CT image showing supraorbital double types. Red arrow indicates the coexistence of supraorbital notch and foramen (A), notch and notch (B), and foramen and foramen (C).*

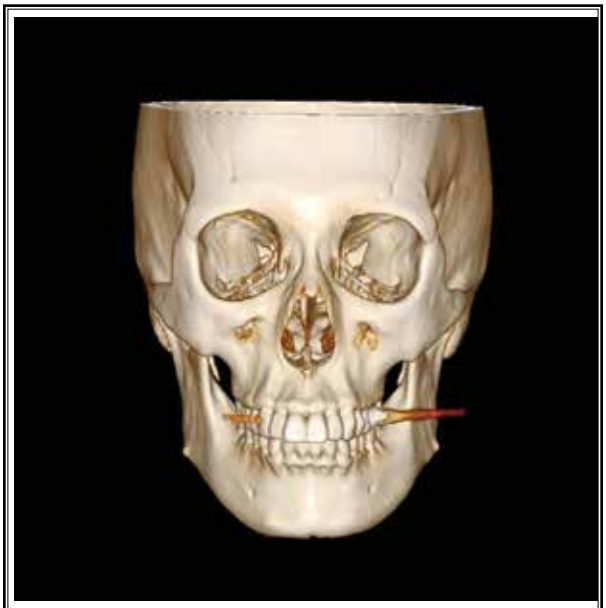

Fig. 4. *Facial bone 3D CT image showing absence of supraorbital notch or foramen.*

Table 1. *The morphologic characteristics and incidence of supraorbital foramen or notch.*

Type	Right	Left
	n (%)	n (%)
Single		
Single notch	131 (53.7)	130 (53.3)
Single foramen	85 (34.8)	87 (35.7)
Double		
Notch/foramen	13 (5.3)	8 (3.3)
Notch/notch	2 (0.8)	1 (0.4)
Foramen/foramen	3 (1.2)	4 (1.6)
Absence	10 (4.1)	12 (4.9)
Total	244 (100)	244 (100)

Values are mean (SD)

Table 2. *Diameters and distances from the nasion to the supraorbital foramen or notch.*

	Right	Left
	Mean (SD), mm	Mean (SD), mm
Supraorbital foramen		
Diameter (mm)	2.85 (0.77)	2.78 (0.66)
Distance from nasion (mm)	26.8 (4.08)	26.0 (2.80)
Supraorbital notch		
Diameter (mm)	3.60 (1.28)	3.57 (1.96)
Distance from nasion (mm)	23.4 (2.75)	22.9 (3.16)

Values are mean (SD)

The supraorbital foramen was located more laterally from the nasion in men than in women (men 27.7 mm vs women 25.3 mm, $P = 0.015$).

The diameter of the supraorbital notch showed significant differences between men and women. The supraorbital notch was wider in men than in women (men 3.79 mm vs women 3.22 mm, $P = 0.019$). However, the distance from nasion to the supraorbital notch and the diameter of supraorbital foramen did not differ significantly between men and women.

Discussion

Analysis of morphological features revealed a higher frequency of single supraorbital notch than the single supraorbital foramen. The incidence of supraorbital notch was 1.5-fold higher than the supraorbital foramen. A higher incidence of supraorbital notch was also demonstrated by previous studies using cadavers or dry skulls (1,3,12-14). In contrast to the current study findings, the supraorbital foramen was found more frequently than the supraorbital notch in facial bone 3D CT scans (11,15).

The incidence of overall supraorbital double types was less than 10%. Among supraorbital double types, the coexistence of notch and foramen was most common, which was consistent with a previous study results (11). The absence of foramen or notch was less than 5% in this study. However, Woo et al (11) reported a 2-fold higher incidence compared with the present study results.

The supraorbital notch was wider in diameter and more centrally located than the supraorbital foramen. The notch shape does not have any inferior bony margin compared with the foramen type, implying that the inferior part of the notch is opened towards the superior orbital rim (14). The differences in diameter between supraorbital notch and foramen are attributed to the morphological differences. The wider diameter and more central location of supraorbital notch were similar to the results reported previously (8,11-14).

The diameter and distances of the supraorbital foramen or notch from the facial midpoint showed significant differences between male and female patients. The diameter of supraorbital notch was wider in men than in women. The distance of supraorbital foramen to the midpoint of face was farther in men than in women. Another study reported that this difference in distance could also be found when analyzed according to different races (3). The distance between supraorbital foramen and facial midpoint was increased significantly with age (15).

The differences of supraorbital notch or foramen between genders found in this study can potentially help during the regional blockade of supraorbital nerve. If we are using ultrasound or blind technique to identify the supraorbital foramen in female patients, one should examine more central side of the supraorbital rim, since the supraorbital foramen is located more centrally in female than male.

The supraorbital nerve is the terminal branch of the first division of trigeminal nerve. This nerve comes from the supraorbital foramen or notch and is widely distributed in the entire forehead. Facial surgeries such as forehead and eyebrow lifts can potentially damage the supraorbital neurovascular bundle (11,15). Our study results can be used to reduce the risk of such injury during facial surgery.

Supraorbital nerve block can be performed widely to relieve pain in the forehead due to herpes zoster or trigeminal neuralgia (16,17). In the operating room, regional block of the face is performed for the purpose of reducing pain postoperatively (18). The anatomical features and the location of the supraorbital notch or foramen play a key role in ensuring the safety and success of the supraorbital nerve block.

There was an effort to distinguish the supraorbital notch and foramen using ultrasound. The sonography demonstrated 100% sensitivity in differentiating a supraorbital notch and foramen. The transverse view of the foramen revealed a bony acoustic landmark corresponding to the rim of the foramen, whereas this finding was absent with a notch (19). Although the quality of nerve block does not differ depending on the local anesthetic injection into the foramen or the notch, an effort to differentiate a supraorbital notch or foramen is important. If an unsuccessful or incomplete nerve block is encountered, one should consider the possibility of double foramen or notch and absence of foramen or notch.

Limitations

This study includes several limitations. First, we did not consider actual face size by the photograph or skull size of the patient, which might affect the distance of the supraorbital notch or foramen from the midline. Second, we did not evaluate differences based on morphology and location according to the age. Third, this study involved only Asians. Therefore, the result of this study has some limitation to explain the morphology and locational relationship of supraorbital notch or foramen in other ethnic groups. Lastly, in conjunction with facial bone CT, a further study using ultrasound is needed to differentiate the supraorbital notch or foramen.

Conlusion

In conclusion, supraorbital notch was more frequently found than the supraorbital foramen. The supraorbital notch was wider in diameter and was more centrally located than the supraorbital foramen.

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