Supraorbital Notch/Foramen, Infraorbital Foramen and Mental Foramen in Thais: Anthropometric Measurements and Surgical Relevance

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Objective: *To determine the morphology and the locations of the SupraOrbital Notch/Foramen (SON/F), InfraOrbital Foramen (IOF), and Mental Foramen (MF) relative to frequently encountered surgical landmarks.*
Material and Method: *One hundred and six Thai adult skulls were investigated.*
Results: *Mean horizontal widths of SON, SOF, IOF and MF were 4.31 1.61 mm, 2.81 0.62 mm, 3.35 0.62 mm and 2.80 0.70 mm, respectively. The SON/F was situated 25.14 4.29 mm lateral to the nasal midline, 26.57 3.92 mm medial to the temporal crest of the frontal bone and 3.15 1.29 mm superior to the supraorbital rim. The IOF was 28.43 2.29 mm lateral to the maxillary midline, 9.23 2.03 mm below the infraorbital rim and 2.15 1.67 mm medial to the zygomaticomaxillary suture. Mean vertical distances from the IOF to the SOF and to occlusal plane of the upper teeth were 44.95 2.96 mm and 42.52 3.89 mm, respectively. The IOF was frequently found in the same vertical line with the second upper premolar and its usual direction of opening pointed downward medially. The MF was a mean of 28.52 2.15 mm lateral to the symphysis menti and most commonly observed in line with the second lower premolar. Its usual direction of opening was in a posterosuperior direction.*
Conclusion: *The results of the present study may assist surgeons to localize important maxillofacial neurovascular bundles passing through these foramina in facilitating surgical, local anesthetic and other invasive procedures.*

Keywords: *Supraorbital notch/foramen, Infraorbital foramen, Mental foramen, Surgical landmark, Thais*

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The SupraOrbital Notch or SupraOrbital Foramen (SON/F), InfraOrbital Foramen (IOF) and Mental Foramen (MF) are important anatomical landmarks to facilitate surgical, local anesthetic and other invasive procedures for oral and maxillofacial surgeons. Efficient knowledge of the regional anatomy is important in order to avoid injuring the neurovascular bundles passing through these foramina and notches. The positions of SON/F, IOF and MF vary among racial groups and genders[1-6]. Kimura[1], in a study of the skulls of whites, blacks, American Indians and Japanese, found that the relative positions of SON/F and showed the differences between these racial groups and between genders. Green[2] reviewed articles and reported a clear racial trend in the anteroposterior position of the MF. The position of the MF in the Mongoloid population was in line with the longitudinal axis of second lower remolar. Their positions in Caucasoid samples were just mesial to those in Mongoloid, Melanesian, and African samples. These findings were supported by the comparative studies

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of the MF position between Chinese and British subjects[3] as well as between whites and blacks[4].

Despite the significance of the SON/F, IOF and MF, little attention has been given to the study of the morphology and the most common locations of these foramina and their associated anatomic characteristics in the Thai population[7-9]. Therefore, Thai adult skulls were chosen to investigate the shape, dimension, orientation, and location of the SON/F, IOF and MF with respect to the surgically encountered anatomical landmarks. Multiple (accessory) foramina of these foramina or notches were also examined. The SON/F, IOF and MF have been assumed to be located on the same sagittal plane[10-12]. Likewise, the authors ascertained that the SON/F, IOF and MF are located on the same sagittal plane.

Material and Method

One hundred and six adult Thai skulls (67 males, 39 females) with known age and gender were selected from the skull collection of the Department of Anatomy, Faculty of Medicine Siriraj Hospital, Mahidol University and the Department of Anatomy, Faculty of Dentistry, Chulalongkorn University. The age of the subjects ranged from 18 to 83 years with a mean of 46.78 ± 16.91 years, and no significant difference was found between age of the genders ($p = 0.722$).

Both sides of each skull were assessed by using direct inspection and measurements of the shape, size, orientation and location of SON/F, IOF and MF. The shape of SOF was recorded as a notch or a foramen, whereas the shape of IOF was determined as an oval, a semilunar or a circular opening. The greatest horizontal widths of each SON, SOF, IOF and MF were measured. Measurements were made to the center of each foramen by using sliding calipers capable of measuring to the nearest 0.01 mm.

The relative position of SON/F was analyzed with measurements made from the nasal midline and the temporal crest of the frontal bone (Fig. 1). The vertical distance between SOF, when present, and the supraorbital rim was also measured. The location of IOF was identified by using the following distances: the horizontal distance from the maxillary midline, the vertical distance from the infraorbital rim, measured at the intersection of the zygomaticomaxillary suture, the horizontal distance from the zygomaticomaxillary suture at the level of the infraorbital rim, the vertical

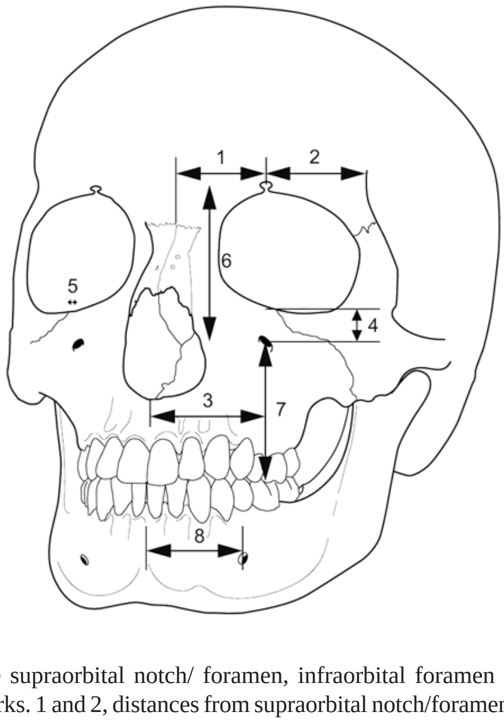

Fig. 1 The measurements of the supraorbital notch/ foramen, infraorbital foramen and mental foramen in relation to important surgical landmarks. 1 and 2, distances from supraorbital notch/foramen to nasal midline and temporal crest of the frontal bone, respectively; 3-7, distances between infraorbital foramen and the maxillary midline, infraorbital rim, zygomaticomaxillary suture, supraorbital notch/ foramen and occlusal plane of upper teeth, respectively; 8, distance between mental foramen and symphysis menti

Table 1. Frequency of the location of infraorbital foramen in relation to upper teeth

Locations	Total	Males	Females
Between the first and second premolars	50 (31.6%)	29 (27.9%)	21 (38.9%)
In the line with the second premolar	85 (53.8%)	62 (59.6%)	23 (42.6%)
Between the second premolar and the first molar	20 (12.7%)	11 (10.6%)	9 (16.7%)
In the line with the first molar	3 (1.9%)	2 (1.9%)	1 (1.8%)
Total	158 (100%)	104 (100%)	54 (100%)

Gender versus location of infraorbital foramen, p = 0.234

Table 2. Frequency of the location of mental foramen in relation to lower teeth

Locations	Total	Males	Females
In the line with the first premolar	5 (3%)	1 (0.9%)	4 (6.8%)
Between the first and second premolars	48 (28.7%)	32 (29.6%)	16 (27.1%)
In the line with the second premolar	95 (56.9%)	61 (56.5%)	34 (57.6%)
Between the second premolar and the first molar	17 (10.2%)	13 (12.0%)	4 (6.8%)
In the line with the first molar	2 (1.2%)	1 (0.9%)	1 (1.7%)
Total	167 (100%)	108 (100%)	59 (100%)

Gender versus location of mental foramen, p = 0.234

distance from SOF and the vertical distance from the occlusal plane of upper teeth (Fig. 1). In relation to the upper teeth, the position of the IOF was graded into four types as listed in Table 1. The direction of opening of the InfraOrbital Canal (IOC) through the anterior surface of the maxilla was recorded as downward medially, downward or medially. In addition, the lengths of the InfraOrbital Groove (IOG) measured from the inferior orbital fissure to the IOC and of the IOC measured from IOG to the infraorbital margin, were determined.

The distance between MF and the symphysis menti (mandibular midline) was measured. The position of the MF was recorded as either in line with the long axis of a tooth or as lying between two adjacent teeth as shown in Table 2[2]. The direction of exit of the mental canal through the buccal cortical plate of the mandible was described as posterosuperior, superior, lateral, anterosuperior, posterior or anterior[13].

Multiple foramina were recorded, with the largest or most prominent foramen being considered as the primary structure for consideration. The locational relationship of SON/F, IOF and MF were also classified into the following types: the IOF or MF was located lateral to the lateral margin of the SON/F, between the medial and lateral margins of the SON/F or medial to the medial margin of the SON/F.

Overall, the complete data of all frequencies and measurements were tabulated and separated with respect to sides and genders. The Statistical Package for Social Science (version 11.0) was used for the analyses. The mean, standard deviation, minimum and maximum for each of the measurements were assessed. A comparison of the mean values of all measurements was made between sides and genders using the paired and unpaired-*t*-test, respectively. The distributions of the IOF and MF location were compared between genders using the Exact test (Monte Carlo Method). Differences between groups were considered significant at $p < 0.05$.

Results

Investigation of 106 Thai skulls revealed that the SON (66.5%) was found more frequently than the SOF (33.5%). Of all cases, 50.0% had bilateral SON, 17.0% had bilateral SOF and 33.0% had a notch on one side and a foramen on the other. The shape of IOF was oval (50.0%), semilunar (29.2%) and round (20.8%). Mean horizontal widths of SON was 4.31 ± 1.61 mm, SOF was 2.81 ± 0.62 mm, IOF was 3.35 ± 0.62 mm and MF was2.80 ± 0.70 mm. There were significant gender differences only in horizontal widths of the IOF and MF ($p < 0.001$).

The linear measurements of the SON/F, IOF and MF with respect to surgically encountered anatomical landmarks are summarized in Table 3. These measurements did not vary according to sides, with the exception that the right MF was located more laterally than the left ($p = 0.004$). There were significant gender differences in all distances ($p < 0.05$) except the SOF-supraorbital rim and IOF-zygomaticomaxillary suture. The measurements in males were longer than those in females (Table 3). Mean lengths of the IOG and IOC were 15.55 ± 4.24 mm and 14.49 ± 5.04 mm, respectively.

As shown in Table 1, the tooth most commonly found in the same vertical line with the IOF was the second upper premolar, followed by between the first and second upper premolars. The location of IOF related to upper teeth did not depend on gender ($p = 0.234$) (Table 1). The direction of opening of most IOF pointed downward medially (87.7%), whereas the remaining pointed downward (12.3%).

Table 2 shows that the majority of MF were located in the same vertical line with the long axis of the second lower premolar, followed by between the first and second lower premolars. According to symmetrical basis of the MF position, 68.8% of the foramina were in the same relative position. There was no gender difference in the distribution of the MF position ($p = 0.234$) (Table 2). The opening of mental canal commonly pointed in the posterosuperior direction (92.0%), followed by the superior direction (3.3%), lateral direction (3.3%) and posterior direction (1.4%).

Multiple foramina were found in 8.0% of SON/F, 3.8% of IOF and 3.3% of MF in Thai subjects. Two foramina exhibited in 6.6% of SON/F, 3.3% of IOF and 2.8% of MF, whereas 1.4% of SON/F, 0.5% of IOF and 0.5% of MF exhibited three foramina. The combination of multiple foramina of SON/F, IOF and MF can be observed as SON/F and IOF, SON/F and MF, and SON/F, IOF and IOF.

The study of the locational relationship of SON/F, IOF and MF demonstrated that most IOF (53.2%) and MF (57.3%) were located lateral to the sagittal plane passing through the SON/F. Both IOF and MF were situated lateral and medial to the sagittal plane passing through the SON/F in 49.1% and 6.9% of total subjects, respectively. The SON/F, IOF and MF were observed on the same sagittal plane in 23.4% of total subjects.

Table 3. Anthropometric measurements related to the supraorbital foramen or notch, infraorbital foramen and mental foramen

Measurements	Total			Males			Females			Unpaired
(mm)	N	Mean ± SD	Range	N	Mean ± SD	Range	N	Mean ± SD	Range	*t*-test
SON/F-NM	209	25.14 ± 4.29	17.35-39.45	133	25.73 ± 4.48	17.35-39.45	76	24.10 ± 3.75	17.82-34.51	p = 0.008*
SON/F-TCFB	207	26.57 ± 3.92	16.14-37.63	131	27.16 ± 4.04	16.57-37.63	76	25.54 ± 3.48	16.14-31.15	p = 0.004*
SOF-SOR	72	3.15 ± 1.29	1.20-6.93	43	3.31 ± 1.37	1.20-6.93	29	2.92 ± 1.14	1.51-6.01	p = 0.203
IOF-MM	212	28.43 ± 2.29	23.42-34.52	140	29.10 ± 2.13	23.76-34.52	78	27.29 ± 2.12	23.42-31.70	p < 0.001*
IOF-IOR	212	9.23 ± 2.03	3.21-14.58	134	9.53 ± 2.23	3.21-14.58	78	8.71 ± 1.51	4.81-12.11	p = 0.004*
IOF-ZMS	212	2.15 ± 1.67	0.00-10.82	134	2.22 ± 1.79	0.00-10.82	78	2.01 ± 1.44	0.00-5.48	p = 0.372
IOF-SON/F	209	44.95 ± 2.96	36.63-51.68	133	45.41 ± 2.88	39.54-51.68	76	44.15 ± 2.94	36.63-50.97	p = 0.002*
IOF-OP	126	42.52 ± 3.89	32.58-50.16	81	43.98 ± 3.26	35.59-50.16	45	39.91 ± 3.59	32.58-48.29	p < 0.001*
MF-SM	212	28.52 ± 2.15	23.39-38.13	134	28.77 ± 2.18	23.73-38.13	78	28.11 ± 2.04	23.39-33.55	p = 0.032*

Abbreviations: SON/F, supraorbital notch or foramen; NM, nasal midline; TCFB, temporal crest of the frontal bone; SOR, supraorbital rim; IOF, infraorbital foramen; MM, maxillary midline; IOR, infraorbital rim; ZMS, zygomaticomaxillary suture; OP, occlusal plane of upper teeth; MF, mental foramen; SM, symphysis menti.
* Significant difference between genders at $p < 0.05$

Discussion

The accurate identification of SON/F, IOF and MF are important for both diagnostic and clinical procedures. Clinically, nerve bundles emerging from these foramina could probably be injured during surgical procedures, resulting in paresthesia or anesthesia. An understanding of the anatomical location of important maxillofacial foramina is of increased importance with the rising popularity of endoscopic procedures with limited visibility[4].

From the present result regarding the SON/F, 50.0% demonstrated bilateral notching, 17.0% bilateral foramina and 33.0% a notch on one side and a contralateral foramen. It showed poor symmetrical relation between the sides. This was consistent with a previous study of skulls from India[10]. They reported the distributions of 49.1% for bilateral SON, 25.9% for bilateral SOF and 25.0% for one notch and one foramen. In other study, bilateral SON was reported at 70% in white, black and Hispanic subjects[14] and 92.5% in white and black subjects[4]

In the present study, the distances from SON/F and IOF to the midline, as well as distances of SON/F-temporal crest of the frontal bone, IOF-infraorbital rim and IOF-zygomaticomaxillary suture were different from those studied in whites and blacks[4]. Additionally, mean distances of SON/F-nasal midline, IOF-maxillary midline and SON/F-IOF in the present study were different from those studied in white, black and Hispanic subjects[14]. Mean lengths of IOG and IOC in the present study were different from those studied in Turkey[15]. These variations might be caused by racial differences which confirm previous reports[1-4].

Palpating the SON alone is not sufficient in locating the supraorbital neurovascular bundles in all cases. One should be aware that neurovascular bundles might exit through SOF well above the supraorbital rim, and that a combination of notches and foramina is possible in the same skull. The measurements of SON/F in relative to the midline and the temporal crest of the frontal bone from the present study may help surgeons to locate this opening and avoid injuring the neurovascular bundles. The data concerning the distance from SON/F to the temporal crest of the frontal bone may be helpful for the surgeon in anticipating the location of SON/F during the routine coronal dissection[4]. It is difficult intraoperatively to exactly identify the midline of the skull. Therefore, the use of the 26.57 mm measurement from the temporal crest of the frontal bone may be a better landmark for performing a coronal approach in Thais.

The mean distance of IOF-infraorbital rim in Thais was longer than those of previous studies[4,14]. Knowledge of the distance from the infraorbital rim may be useful in identifying the danger zone of its location during dissection of the comminuted fracture of the anterior maxillary wall or inferior orbital wall, as well as during other surgical procedures. The mean distance of IOF-occlusal plane of upper teeth in the present study was consistent with the previous report in 66 Thais[7]. The present results indicated that the tooth most commonly found in the same vertical line with the IOF was the second upper premolar. This was distal to the first premolar frequently found in the previous study in white, black and Hispanic cadavers[14].

The closest determination of the IOF location should be utilized when designing access incisions to the orbital floor and rim and planning regional blockage[14]. Kleier et al[16] suggested a technique involved infiltrating an anesthetic solution in an area defined by dropping a vertical line from the palpable SON to about 10 to 15 mm below the infraorbital rim. According to the present results, it may be effective to infiltrate an anesthetic solution in the area that is 1) 28.43 mm lateral to the maxillary midline, 2) 9.23 mm below the infraorbital rim, 3) 2.15 medial to the zygomaticomaxillary suture 4) 44.95 mm below the SON/F in the same vertical line and 5) 42.52 mm above the occlusal plane of the second upper premolar in the same vertical line. The needle should be directed upward laterally.

The mean distance from the MF to the symphysis menti in the present study was not different from those studied in Thais[8] and Chinese[3,17], but, it was longer than those in British[4] and whites and blacks[4].

The present study showed significant gender differences in the distances of SON/F-nasal midline, SON/F-temporal crest of the frontal bone, IOF-maxillary midline, IOF-infraorbital rim, IOF-SON/F, IOF-occlusal plane of upper teeth and MF-symphysis menti ($p < 0.05$). The present study supports the gender differences in the positions of SON/F, IOF and MF reported in different populations[1-4]. From the present result, these measurements were longer in males than in females. Surgeons should be aware of such differences in the localization of these foramina.

In Green's study[2], 45 earlier studies of the location of the MF, performed either on skulls or with radiographs, were revisited. The mean position did vary in different racial groups. These data demonstrated that the most common position of the MF was in the long axis of the second lower premolar on both sides. In addition, the mean position of the MF in Caucasoid samples was just mesial to the longitudinal axis of second lower premolar and more distally placed in Mongoloid, Melanesian, and Negroid samples. The comparative study between Chinese and British subjects by Santini and Land(3) supported Green's study. The modal position of the MF in Chinese samples was along the long axis of the second premolar, whereas in the British samples it lay between the first and second premolars. Cutright et al(4) indicated that there was a tendency for the MF to be located more posteriorly in blacks (posterior to the second premolar) than in whites (between the first and second premolars). Additionally, the analysis of African mandibles indicated that 31.1% of the MF were between the second premolar and first molar(18). However, the most common position of MF in the present study (56.9%) was in line with the long axis of the second lower premolar. This was in agreement with previous studies in Thais, other Asians and Westerners(2,3,5,8,9,13,17,19-24). The remarkable bilateral symmetry was shown between both sides of Thai subjects as in previous studies(22,23). There was no gender difference in the distribution of the MF position in Thais as in North American whites(25) and in Saudi subjects(23).

Most mental canals opened posterosuperiorly in the presented subjects. This was similar to previous studies(6,8,9,18) however, it differed from the posterior direction reported by Montagu(5).

It is recommended that the clinician should expect to find the MF in line with the long axis of the second lower premolar. If the MF can not be localized in this position or in the patient without a reference tooth, the MF can be estimated at the position 28.52 $\pm$ 2.15 mm lateral to the symphysis menti. Although it is more appropriate to relate the MF to lower teeth in the clinical situation, it is perhaps more accurately done by referring to the body of the mandible(19), since the former method is influenced by factors such as malocclusion and mesiodistal tooth size (in turn, dependent on race, diet, and age).

Surgeons should realize that multiple foramina may exist in a minority of the patients, and injury to any branch can result in a sensory deficit(14). Multiple SON/F, IOF and MF have been found in various frequencies among racial groups(5,14,18,22,26-28). Berry(27) studied skulls obtained from several geographic locations and reported a higher frequency of multiple IOF in Mexicans. However, the number of multiple foramina was not documented in that study. The frequency of multiple MF ranged from 1.8% to 16.7% (5,15,18,22,29,30,31). In the present study, multiple foramina appeared in 7.6% of SON/F, 3.6% of IOF and 3.1% of MF. The occurrence of multiple IOF in the present study was lower than those in white and black cadavers(14). The occurrence of multiple MF in the present study was almost equal to that in Japanese(29).

The SON/F, IOF and MF were situated on the same sagittal plane in 23.4% of the presented subjects which was lower than 38.1% in Koreans(32). This situation was contrary to the popular belief that the SON/F, IOF and MF were situated on the same vertical plane(10-12).

Conclusion

The present study adds information to the literature concerning the morphology of the SON/F, IOF and MF, especially in an Asian population. The knowledge of the distances from surgically encountered anatomical landmarks in the present study may assist surgeons to localize these important maxillofacial openings, avoid injury to the neurovascular bundles and facilitate surgical, local anesthetic and other invasive procedures. The data are of direct relevance to clinical practice and teaching.

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รูหรือรอยบากเหนือเบ้าตา รูใต้เบ้าตา และรูข้างคางในคนไทย: การวัดทางมานุษยวิทยาและความสัมพันธ์กับการทำศัลยกรรม

วันดี อภิณหสมิต, สุพิน ชมภูพงษ์, ดอลลี่ เมธาธราธิป, เริงศักดิ์ แสนสุข, วรรณภา เพชรพูนพิพัฒน์

วัตถุประสงค์: *เพื่อศึกษาสัณฐานวิทยาและตำแหน่งของรูหรือรอยบากเหนือเบ้าตา รูใต้เบ้าตา และรูข้างคางในคนไทยที่มีความสัมพันธ์กับจุดกำหนดในการทำศัลยกรรม*
วัสดุและวิธีการ: *ทำการศึกษาในกะโหลกศีรษะผู้ใหญ่ของคนไทย จำนวน 106 กะโหลก*
ผลการศึกษา: *ความกว้างในแนวราบของรอยบากเหนือเบ้าตา รูเหนือเบ้าตา รูใต้เบ้าตา และรูข้างคาง มีค่าเฉลี่ยเท่ากับ 4.31 ± 1.61 มม., 2.81 ± 0.62 มม., 3.35 ± 0.62 มม. และ 2.80 ± 0.70 มม. ตามลำดับ รูหรือรอยบากเหนือเบ้าตาอยู่ข้างต่อแนวกลางของจมูก 25.14 ± 4.29 มม. อยู่ใกล้กลางต่อสันขมับของกระดูกหน้าผาก 26.57 ± 3.92 มม. และอยู่เหนือต่อขอบเหนือเบ้าตา 3.15 ± 1.29 มม. รูใต้เบ้าตาอยู่ข้างต่อแนวกลางของขากรรไกรบน 28.43 ± 2.29 มม. อยู่ใต้ต่อขอบใต้เบ้าตา 9.23 ± 2.03 มม. และอยู่ใกล้กลางต่อรอยประสานระหว่างกระดูกโหนกแก้มและขากรรไกรบน 2.15 ± 1.67 มม. ระยะเฉลี่ยในแนวดิ่งจากรูใต้เบ้าตาไปถึงรูเหนือเบ้าตา และไปถึงระนาบสบฟันบนเท่ากับ 44.95 ± 2.96 มม. และ 42.52 ± 3.89 มม. ตามลำดับ มักพบรูใต้เบ้าตาในแนวเดียวกับฟันกรามน้อยซี่ที่สองบน และรูเปิดชี้ลงล่างและใกล้กลาง รูข้างคางอยู่ข้างต่อแนวประสานคาง 28.52 ± 2.15 มม. มักพบในแนวเดียวกับฟันกรามน้อยซี่ที่สองล่างและรูเปิดชี้ไปทางด้านหลังและขึ้นบน*
สรุป: *ผลที่ได้จากการศึกษานี้จะช่วยให้ศัลยแพทย์สามารถระบุตำแหน่งของเส้นประสาทและหลอดเลือดที่ทอดผ่านรูเหล่านี้ ซึ่งจะเป็นประโยชน์ต่อการผ่าตัด และการให้ยาชา*
