

# Biometric features of facial foramina in adult Kenyan skulls

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## SUMMARY

Several studies have indicated ethnic, age and sex-related variations in the position and size of the facial foramina. The present study reports the biometric features of the mental foramen (MF), and infraorbital (IO), supraorbital (SO), and zygomaticofacial (ZF) foramina in a sample of adult Kenyan skulls. One hundred and four adult human skulls were evaluated for the sizes, positions, multiplicity, symmetry and geometries of the MF, IO, SO, and ZF foramina. Our observations reveal that the MF was present in all 104 skulls. The distance of the mental foramina from the symphysis menti ranged from 16.5 mm to 34.0 mm. The IO foramina were multiple in 5% of the skulls. The IO foramen was positioned  $6.26 \pm 1.8$  mm from the inferior orbital margin and  $32.87 \pm 3$  mm from the superior alveolar margins, respectively. The distance from the superior alveolar process was greater in males. The distance of the MF, IO and SO from the midline was about 27 mm. ZF were absent in 3-4% of the skulls and multiple in 50% of the skulls. Ten percent of the supraorbital passages were foramina; 60% were notches, while the rest were both notches and foramina. In conclusion, the biometric characteristics of the facial foramina reveal variations in Kenyan skulls. Clinicians operating in this area should

be aware of this anatomy and dimorphic sexual features when anaesthetizing and operating in the facial region.

**Key words:** Mental – Infra-Supraorbital – Zygomaticofacial – Foramina – Kenyans

## INTRODUCTION

The facial foramina, which transmit nerves and blood vessels between the facial structures and the cranium, show positional and metric features at variance with standard descriptions in anatomy textbooks (Sicher et al., 1991; Mwaniki and Hassanali, 1992; William et al., 1995). There are data that show variations with age, sex and ethnic groupings (Chung et al., 1995). In adults, there are no absolute landmarks and in some cases, the facial foramina may not be palpable (Salomao et al., 1990). The mental foramen may be positioned anywhere between the long axis of the canine to the mesiobuccal root of the first premolar (Shankland et al., 1994; Al Jasser et al., 1998); between the first and second premolar apices (Philips et al., 1992), or below the apex of the second premolar (Mwaniki and Hassanali, 1992; Philips et al., 1992; Shankland et al., 1994; Aktekin et al., 2003; Olasoji et al., 2004). These variable positions are also influ-

enced by the landmarks chosen for the measurements and the state of dental wear (Green et al., 1987). The foramen lies at a point 23.6 mm to 28.6 mm from the facial midline (Singh et al., 1992; Chung et al., 1995; Souaga et al., 2004; Smajilagic et al., 2004; Nieva et al., 2004). The infraorbital foramen is variably described to lie superior to the 1<sup>st</sup> and 2<sup>nd</sup> maxillary premolars or perpendicular to the maxillary canines (Aziz et al., 2000; Kazkayasi et al., 2003). It is 10 mm, 7.19 mm and 8.15 mm inferior to the orbital margin in Koreans, Turks and Americans, respectively (Chung et al., 1995; Aziz et al., 2000; Kazkayasi et al., 2003). The distance of the supraorbital foramen from the midline is 26.5 mm and 26.3 mm in American and Thai men and 25.6 mm and 24.2 mm in American and Thai women respectively (Aziz et al., 2000; Agthong et al., 2005).

Asymmetric differences are better determined by measurements than by mere observations (Rossi et al., 2003). Information about the position, number and symmetry of the facial foramina is important in facial surgery and in planning anaesthetic procedures of the face. Knowledge of their precise location invariably reduces the relative risks during these procedures (Salomao et al., 1990; Zide and Swift, 1998; Karakas et al., 2002). There is limited information concerning the morphometry of these foramina in Kenyans, and hence this study was undertaken to provide data on the metric positions and morphological characteristics of the mental, infraorbital, supraorbital and the zygomaticofacial foramina among adult Kenyans.

## MATERIALS AND METHODS

Skulls of adult Kenyans from the Osteology Department at the National Museums of Kenya (NMK), Nairobi were studied. This collection was obtained from the Central Province of Kenya between 1956 and 1971. Intact skulls (n=104) with the 3<sup>rd</sup> molars erupted were used.

The skulls were grouped into males (n=55), females (n=41) and of unknown sex (8). The foramina studied were the mental foramen (MF), and the supraorbital (SO), infraorbital (IO) and zygomaticofacial (ZF) foramina. The number and shape of the foramina were observed directly. Circular and oval rings were developed and superimposed over the foramina to ascertain their shape. The maximum

transverse diameters of the MF, IO, SO and ZF foramina were measured using Namutan<sup>®</sup> digital vernier calipers.

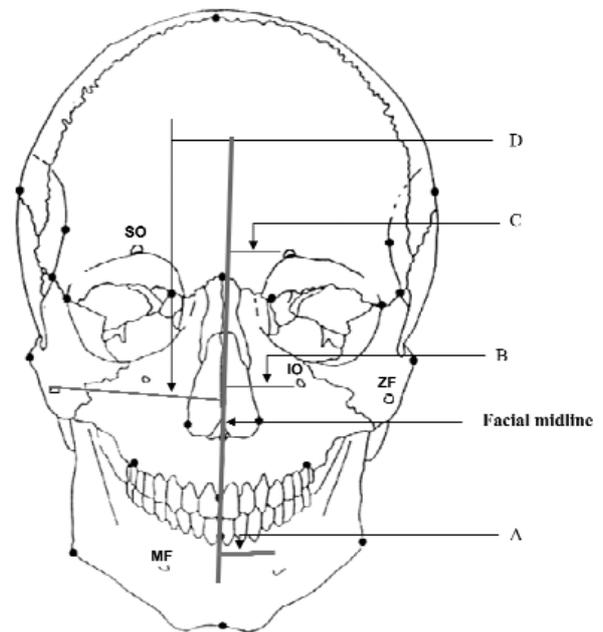


Figure 1. Position of foramina from facial midline.

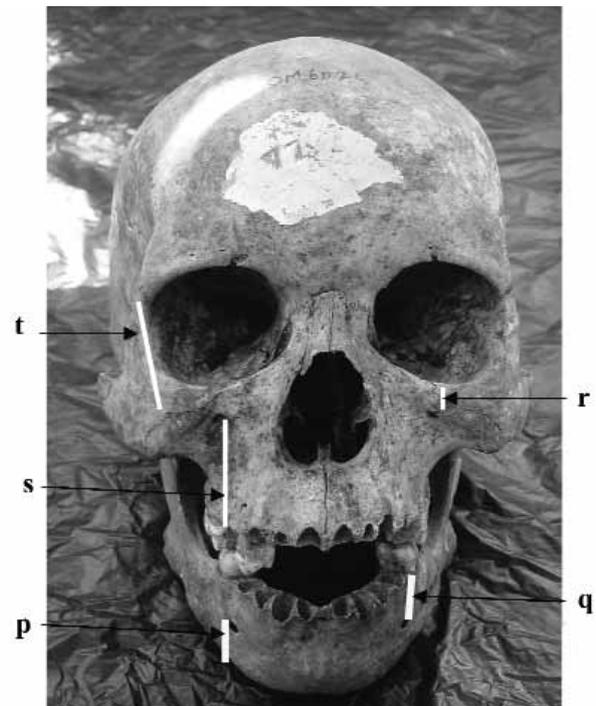


Figure 2. Position of the foramina from other reference points.

The position of the foramina was measured as the horizontal distance from the midline on the right and the left sides to the mid-point of the foramen: A, B, C, D (Fig. 1). The midline of the face was determined as the line joining the midpoint of the glabella, the anterior nasal spine and the symphysis menti. The average

distance of all the foramina (multiple) from the facial midline was determined. The position of the mental foramen was also determined from the inferior mandibular margin (p) and alveolar margin (q) along a line parallel to the median plane (Fig. 2). The position of the infraorbital foramen was determined in relation to the inferior orbital margin (r), and the superior alveolar margin (s). The position of the zygomaticofacial foramen was determined in relation to the frontozygomatic suture (t), as shown in figure 2.

All distances were measured twice, each time by a different observer, taken the mean as the true measure. The collected data were coded and analyzed using SPSS for Windows, version 11.5.0 Chicago, Illinois 2002. The mean position of the foramina and other distances were determined and compared for the sex groups and right and left sides. The independent sample, the paired sample t- test and  $X^2$  were used to compare the means. Pearson's test was used for the correlation of symmetry.

## RESULTS

The mental foramen was present in all mandibles. Most of the foramina were single (Table 1). Duplications of the right and left MF were observed in 14 (13.5%) and 9 (8.7%) mandibles respectively (see Fig. 3). Most foramina were oval in shape (69% right, 66% left) while the rest were round in outline. There was significant correlation between the number of right and left mental foramina in the two sex groups as regards the number of the foramina. The overall mean diameter of the MF was 3.87 mm with a range of 1-7 mm (Table 2). The MF was located at a mean distance of 27.75 mm with a range of 16.5 mm to 34.04 mm from the midline (Table 3).



Figure 3. Multiplicity of the mental foramina (duplicated).

Infraorbital foramina were present in all skulls. The openings were multiple in 4.8% of them. For the right foramen, the average diameter was 4.89 mm for males and 4.24 for females. For the left half of the skull, the mean diameter was 4.43 mm for males and 4.39 for females ( $p = 0.024$ ) (Table 2), and the mean distance from midline was 28.9 mm in males and 28.4 mm in females (Table 3). The position of the right infraorbital foramen was 6.14 mm and 6.36 mm from the orbital margin for males and females respectively. The respective positions were 6.21 mm and 6.33 mm for males and females for the left foramen. The position of the infraorbital foramen with respect to the alveolar process and the inferior orbital margin did not differ between the right and left sides ( $p > 0.05$ ). This distance was significantly longer on the left for males ( $p = 0.011$ ) (Table 4).

The right and left supraorbital passages were present in 93.3% and 94.2% of the skulls respectively (Table 1, Fig. 4). The percentage of skulls with right and left supraorbital notches was 67% and 64.3%, respectively. Supraorbital notches ranged from mere dents on the superior surface of the orbit to near-circular notches. Most passages were single (97.8% right, 80.6% left). The mean diameters were significantly wider for males (4.85 mm vs. 4.61 mm for right and 4.24 mm vs. 4.11 mm left skull,  $p = 0.003$ ) (Table 2). The mean distance from the midline was 27.2 mm males and 26.8 mm females (Table 3).

Zygomaticofacial foramina were present in 96.2 % of the right and left halves of the skulls. Geometrically, the openings were tiny circular indentations on the body of the zygomatic bone. Most ZF were multiple (53.3% right, 42.2% left) (Fig. 5). The diameters were larger for males but the differences were not statistically significant (1.80 mm vs. 1.63 mm for right and 1.81 mm vs. 1.65 mm left,  $p = 0.25$ ) (Table 2). The mean distance from the midline was 55.0 mm males and 53.2 mm females (Table 3).

Table 2. Mean values (mm) and standard deviations for the diameters of the foramina selected.

Sex		MF	IO	SO	ZF
MALE	Right	3.91±1.20	4.89±1.25	4.85±2.21	1.80±0.63
	Left	3.71±1.13	4.43±1.13	4.24±1.77	1.81±0.92
FEMALE	Right	4.01±1.14	4.24±0.88	4.61±1.98	1.63±0.66
	Left	3.82±1.22	4.39±0.78	4.11±1.78	1.65±0.82
P value		0.177	0.177	0.024	0.003

**Table 1.** Number of MF, IO, SO and ZF foramina in the male and female skulls.

FORAMEN	NUMBER OF FORAMINA					
	SINGLE		DOUBLE		TRIPLE	
	Right	Left	Right	Left	Right	Left
MF	90 (86.5%)	93 (90.3%)	14 (13.5%)	9 (8.7%)	0	1 (1%)
IO	99 (95.2%)	97 (93.3%)	3 (2.9%)	5 (4.8%)	2 (1.9%)	2 (1.9%)
SO	76 (78.4%)	79 (80.6%)	15 (15.5%)	17 (17.3%)	6 (6.1%)	2 (2.3%)
ZF	42 (42%)	52 (52%)	35 (35%)	31 (31%)	23 (23%)	17 (17%)

**Table 3.** Distance of the facial foramina selected from the facial midline in males and females.

		Mental	Infraorbital	Supraorbital	Zygomaticofacial
MALE	Right	27.81±2.60	28.85±2.65	27.31±3.74	55.21±3.35
	Left	27.23±2.14	28.91±2.69	27.12±4.02	54.73±5.14
FEMALE	Right	27.67±2.91	28.43±2.38	26.77±4.34	52.92±5.64
	Left	27.81±2.53	28.41±2.38	26.89±3.99	53.53±5.01
P value		0.121	0.121	0.725	0.513

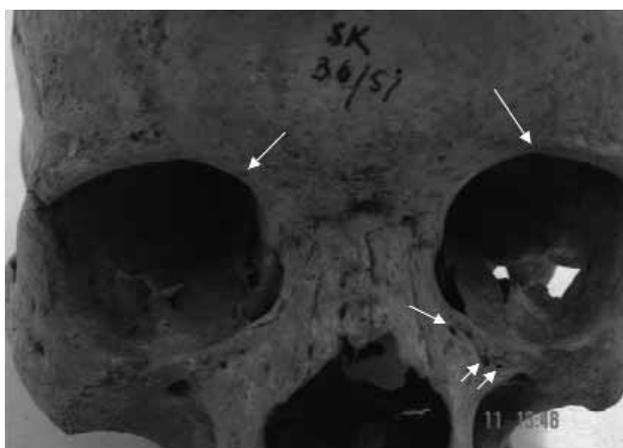
The paired t test was used to derive the p= value.

The MF, IO and SO are located symmetrically at a mean distance of 27 mm from the midline (Table 3).

(Measurements in millimeters. p- distance of MF from the inferior alveolar margin; q- distance of MF from lower mandibular border; r- distance of the IO from inferior alveolar margin; s- distance of the IO from the superior alveolar margin; t- distance of the Zygomaticofacial foramen from the frontozygomatic sutures).

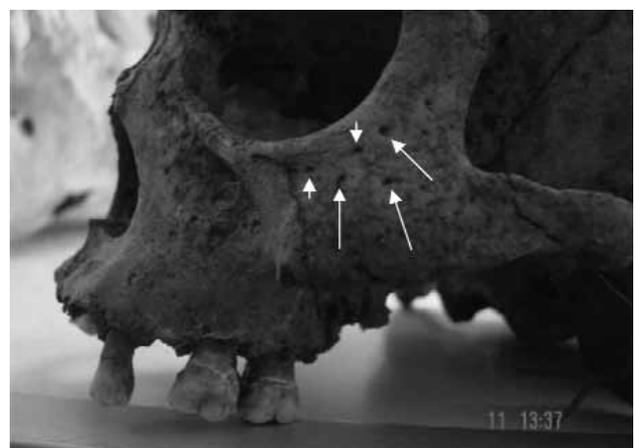
**Table 4.** Distance of facial foramina from other reference points.

		p	q	r	s	t
MALE	Right	16.18±1.92	14.24±2.90	6.14±1.89	32.87±2.972	29.32±3.99
	Left	16.40±2.47	14.38±2.49	6.21±2.05	33.80±2.66	29.32±6.68
FEMALE	Right	15.97±2.53	13.90±1.94	6.36±1.83	31.27±2.80	29.49±3.71
	Left	15.89±1.94	13.02±2.93	6.33±1.73	31.22±3.09	28.77±3.70
		0.756	0.177	0.268	0.011	0.337

**Figure 4.** Frontal view photograph of the skull showing the position of the supraorbital foramina and multiple infraorbital foramina.

## DISCUSSION

The observations of the present study that the mental foramen was present in all mandibles is consistent with previous accounts (Zivanovic; 1970; Chung et al., 1995). The present data on supraorbital notches (peaking at 61%) are similar to those of Gumusburun et al. (2002) and Saylam et al. (2003), who reported rates of 69.9% and 72.9% in their populations. Our results concerning the multiplicity of mental foramina indicate a higher rate than the observation of 6.68% by Zografos et al. (1989) in Greek mandibles, but consistent with other data. The observation of multiple infraorbital foramina supports data from Brazil, America and Egypt (Aziz et al., 2000; Hindy and

**Figure 5.** Skull photograph showing five left zygomaticofacial foramina.

Abdul-Rauf, 1993; Kimura and Evers, 1972). In Kenyans, however, the figures are lower than those obtained for Brazilians, 14%, (Aziz et al., 2000), and Americans, 15%, (Hindy and Abdul-Rauf, 1993). The highest (38%) has been reported among Egyptians (Mangal et al., 2004). In as much as the multiplicity of the IO showed sexual dimorphism, there were no side differences in either sex. The proportion of multiple SO of 25.8-27.6% in this study is comparable to the observation of 24.4% by Gumusburun et al. (2002). In keeping with our results, the latter authors did not observe any significant sex or side difference in the number of the foramina. Other studies, however, have found sexual dimorphism in the multiplicity of the SO (Mangal et al., 2004). Possibly, our small sample limited the detection of sex differences in the number of multiple supraorbital foramina. The ZF showed the greatest multiplicity among the facial foramina in Kenyans. Multiple ZF are seen in about 54% of skulls (Rossi et al., 2003).

Multiple facial foramina have been associated with the branching of nerves during development and may explain cases of failure during infiltrative anaesthesia for maxillofacial and dental procedures (Martins et al., 2003; Loukas et al., 2008). The variation in the number of zygomatic foramina is also linked embryologically to a varying number of ossification centers associated with the zygomatic bone. Although some authors describe only one center (Keibel and Mall, 1910), others have reported as many as three (LeDouble, 1906), which appear in the 8th week and fuse at approximately 22 weeks of fetal life.

The mean diameter of the MF of 3.75 mm observed in the current study is also consistent with reports of Indians; 2.93 mm (Oguz and Bozker, 2002) and Caucasians; 3.59 mm (McIver et al., 1973). The corresponding figures among Nigerians in West Africa seem to be the highest, (males) 5.03 mm and (females) 4.99 mm (Olasoji et al., 2004). The Kenyan data on the position of the MF from the mandibular midline are similar to those from the Ivory Coast (Souaga et al., 2004), Caucasians, 27.61 mm (Nieva et al., 2004) and Chinese, 28.06 mm (Mela et al., 1999). The MF in Kenyans are farther from the facial midline in comparison with Indians, 23.6 mm (Singh et al., 1992), Koreans, 24.4 mm (Chung et al., 1995) and Bosnians, 25 mm (Smajilagic et al., 2004).

Hanihara and Ishido (2001) have described a position for the MF 15.5 mm from the inferior margin of mandible in males and 14.0 mm in females (Mela et al., 1999) from different populations. The present study recorded longer distances (16.22 mm in males and 15.96 mm in females). The Indian data indicate a position 14 mm from the inferior margin of the mandible (Singh et al., 1992). Regarding the position of the mental foramen from the alveolar margin, our results are similar to Korean data, but lower than those reported for Indians (Singh et al., 1992). Methodological differences with different reference points during measurements may explain the inconsistent positions. The size of the mandible, age of patient, whether edentulous or not, the instruments used, and the presence of extortions are other factors likely to impact the results (Roberts et al., 2005). Santini and Land (1990) have suggested that the position of the mental foramen from the inferior margin of the mandible is subject to ethnic differences. Our data do not point to any sex or side differences in the localization of the MF, a result that reinforces the view of Mela et al. (1999) that the mental foramen does not show sex or side differences.

The diameters of the IO were symmetrical but showed a significant sex difference, which may be related to larger vessels and nerves traversing the passage in males. Although some studies indicate that there is diversity in the location of the infraorbital foramen with age, side, race and sex (Rossi et al., 2003), no significant sex and side differences in the location of the IO from the facial midline were noted in our study. It is possible that such differences are related to dentition and diet. Pertinent to this suggestion is the observed asymmetry in the distance between the infraorbital foramen and the facial midline in infants and fetuses, before dentition (William et al., 1995).

In the current study, the position of the IO was 6.14-6.33 mm from the inferior orbital margin. This distance is reported to vary from 4 mm to 12 mm, the classical description placing it at 10 mm (Chung et al., 1995). Data from different populations (6.2 mm) show that the position of the infraorbital foramen from the inferior orbital margin is statistically greater for Caucasians, 8.5 mm (Kimura et al., 1972). This may be explained in terms of the longer faces in this population, although differences in feeding habits and

speech are probably also important factors. In support of the latter suggestion is the observation that the left infraorbital foramen lies significantly superior in a transverse plane to the right infraorbital foramen in cleft palate skulls (Triadafilidi et al., 1990).

The wider mean diameters and standard deviations of the supraorbital transcranial passages in this study may be attributed to the combined measurements of both the foramina and notches. A notch as wide as 10 mm was observed in one specimen. The poorly defined margins of some notches might also have led to this wide discrepancy. We observed asymmetry in the dimensions of the right and left supraorbital passages, with wider openings on the left side. No sex differences were found. The present study reveals a sex difference in distances of the IO from the superior alveolar process. This sexual dimorphism could be an important anthropologic measure.

In conclusion, the biometric features of the facial foramina show variations in Kenyan skulls. The variable number, ostial geometric variations, sexual dimorphic features, and location of the facial and mandibular foramina should be considered during infiltrative anaesthesia and surgery of the orofacial region.

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