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Topography of the infraorbital foramen in human skulls originating from different time periods

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Background: *The infraorbital foramen (IOF) is present on the maxilla under the infraorbital margin. Its identification is essential in various surgical procedures. The main aim of this study was the morphometric assessment of the position of the right and left infraorbital foramina in relation to specific structural elements of the facial skeleton, their width and direction, and also the determination of the location of these foramina above maxillary teeth in examined male skulls (belonging to European populations) dated to the beginning of the 20th century and the medieval and post-medieval period. This aim concerned also the assessment of the symmetry of the examined foramina (their location and size). An additional goal was to determine differences between the cranial samples concerning the analysed traits.*

Materials and methods: *The six metric and two non-metric traits concerning the IOF were collected from the male cranial samples including modern skulls (n = 87), the medieval and post-medieval skulls (from 13th centuries and 15–17th centuries, respectively; n = 47) obtained from archaeological excavations in Wroclaw, and the sample of the medieval skulls (11–13th centuries, n = 100) from Sypniewo. The sex and age of the specimens were determined using the standard methodology. The appropriate statistical analysis was performed.*

Results: *Significant differences were established for three traits (taken from the left and right side) in the case of modern skulls (diameter of IOF, its distance to the midline, and zygomaticomaxillary suture) and one in the case of medieval skulls from Sypniewo (distance to the midline). In all of the cranial samples IOF most frequently occurred above the first upper molar. The greater diameter of IOF and its shorter distance to the alveolar crest and nasal notch were observed in non-modern skulls compared to modern skulls.*

Conclusions: *The results of this study provide new additional data on the topography of IOF and its asymmetry, confirm the presence of both geographical and chronological differences between populations, and can be used in dental practice, and forensic odontology in the analysis of archaeological bone materials.* (Folia Morphol 2023; 82, 4: 875–884)

Key words: infraorbital foramen, palaeoanthropology, anatomy, asymmetry, maxillary nerve, trigeminal nerve, infraorbital nerve, infraorbital canal, forensic medicine

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INTRODUCTION

The facial skin from the top of the forehead to the chin and laterally to the auricles receives sensory innervation from the branches of the trigeminal nerve. Branches of the fifth cranial nerve also provide sensory innervation of the mucous membranes in the nasal cavity and paranasal sinuses, oral cavity, eyelids, and the teeth [6, 13, 49]. On the anterior side of the facial skeleton there are three holes that transmit important branches of the trigeminal nerve: the supraorbital foramen, the infraorbital foramen (IOF), and the mental foramen. Differences in the location of the supraorbital, infraorbital and mental foramina, as well as the topography of the mandibular canal have important clinical implications in many medical disciplines, including maxillofacial surgery, dentistry, neurology, neurosurgery, radiology, and in anthropological and forensic research [39, 40, 59, 60, 62]. Maxillofacial surgeons consider these differences when planning complex resection procedures of neoplastic lesions in the craniofacial area, in orthognathic procedures, or in trauma surgery [40]. In ophthalmology the infraorbital and supraorbital foramina are topographic reference points important in high-precision eye surgeries [30, 33–35, 38, 42, 51]. The topography of these foramina also has clinical relevance when performing nerve blocks in dentistry, dermatology, plastic surgery and neurology. The accurate localization of these foramina reduces the risk of nerve damage [6, 49]. The IOF is located in the body of maxilla (*corpus maxillae*) under the infraorbital rim (IOR). The IOF is the terminal opening of the infraorbital canal (*canalis infraorbitalis*), which is an extension of the infraorbital sulcus (*sulcus infraorbitalis*) located on the orbital surface (*facies orbitalis*) of the body of maxilla. The infraorbital sulcus and canal transmit the homonymous (infraorbital) vessels and nerve. Studies have revealed variation in the shape and location of the IOF, as well as the presence of accessory foramina in different populations and ethnic groups [45, 56, 64]. The anatomical differences in the position of the IOF might be evidence of the evolution of the human skeletal system, or be an adaptation to the environment developed over many centuries in response to changing climatic conditions [44, 61, 63]. Studies have also demonstrated that ambient temperature can modify the morphology of the facial skeleton during development and growth [28, 50, 52]. Accessory infraorbital foramina have most often been identified in populations from cold climate zones, and least often in populations from the equatorial and tropical zones [64]. Both genetic and environmental factors [48] have a huge impact on the brachycephalisation and gracilisation of the facial skeleton [11, 19, 25]. Brachycephalisation is associated with reduction in the length of the skull, and thus also the length of the body of maxilla. The development of the neurocranium and the simultaneous shortening of its anteroposterior dimension are accompanied by an enlargement of the skull base, which might be manifested by a widening of the middle cranial fossa, and consequently changes in the topography of the IOF [19, 31, 43, 59]. Studies on the topography of the IOF have also identified asymmetry in the position of left and right foramina in different ethnic populations [56, 58, 64]. Due to the clinical relevance of the IOF and practical implications of findings in dentistry [4, 6, 26, 54], maxillofacial surgery, as well as in anthropological analyses of materials from archaeological excavations or in forensic analyses, the aim of this study was to assess anthropometric data on the location and symmetry of the IOF in modern and medieval skeletal material from Poland, and identify potential significant differences in the topography of the IOF in skulls from different time periods [19–24, 31, 39, 43, 48, 59].

MATERIALS AND METHODS

Study material was composed of:

— 87 modern human skulls dated to the beginning of the 20th century, kept in the museum collections of the Department of Anatomy of the Pomeranian Medical University in Szczecin, acquired during archaeological excavations in the cemetery near the church of St. Joseph in Szczecin in 1969–1970;

— 100 skulls from individuals living in the Middle Ages constituting a part of the collection kept at the Department of Human Biology, the University of Wroclaw, acquired during archaeological excavations carried out in 1959–1989 at the cemetery in Sypniewo (necropolis dated to the 11–13th centuries), and 47 skulls from individuals living in Wroclaw in the Medieval and the post-Middle Ages constituting a part of the collection kept at the Department of Anthropology, Wroclaw University of Environmental and Life Sciences, acquired during archaeological excavations in 2004 in the Church of St. Matthias (necropolis dated to the 13th century) and that carried out from 1974 and 1996–1991 in the Church of St.

Christopher in Wroclaw (necropolis dated to the 15–16th centuries).

All skulls belonged to male individuals classified as adultus (age at death 30–35 years) or maturus (50–55 years), and represented European populations in the region of present day Poland.

The age and sex of individuals were determined based on the morphology of the skull [9, 10, 17, 46, 47], the obliteration of cranial sutures [9, 10] and the degree of tooth wear according to the scoring system by Brothwell [9].

The criteria for inclusion in the study were as follows: adult age, male sex, good preservation of the bone material.

The exclusion criteria were as follows: damage to the bone material preventing all measurements, and developmental anomalies of the maxilla.

To define the topography of the IOF we took the following anthropometric measurements (Figs. 1, 2), also used by other researchers [1, 3, 12, 13, 15, 21, 24, 27, 53, 64]:

- distance between the IOF and infraorbital margin — *For.Inf.-Mar.Inf.*;
- distance between the medial margin of the IOF and the nasal notch at the level of the conchal crest — *For.Inf.-Inc.Nasalis*;
- distance between the medial margin of the IOF and the midline — *For.Inf.-L.M.*;
- location of the IOF in relation to dental alveolus — *loc.For.Inf.*;
- distance between the IOF and the zygomatico-maxillary suture — *For.Inf.-Sut.Zyg-Max.*;
- distance between the superior margin of the IOF and the superior margin of the alveolar process of maxilla located below the IOF — *For.inf.-Pr.alveolaris*;
- diameter of the IOF measured at the widest point — *diam.For.Inf.*;
- direction of opening of the IOF — *dir.For.Inf*.

Figure 1. Selected anthropometric parameters of the infraorbital foramen on the front of the skull; A — For.Inf-Mar.Inf; B — For.Inf.-Inc.Nasalis; C — For.Inf.-Pr.alveolaris; E — For.Inf.-Sut.Zyg.-Max.

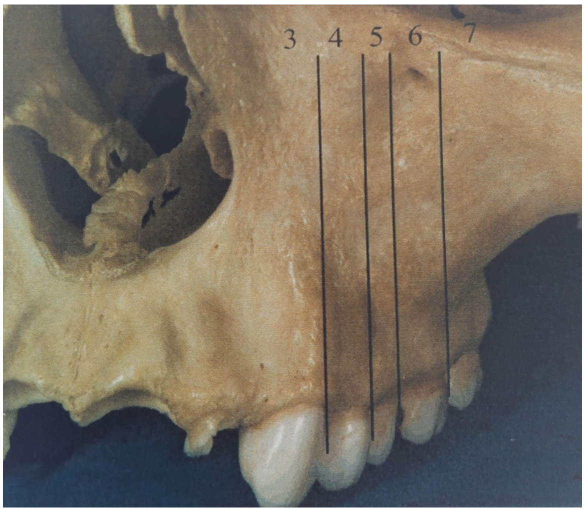

Figure 2. Location of the infraorbital foramen in relation to alveoli on the front of the skull; 3 — canine; 4 — 1st premolar; 5 — 2nd premolar; 6 — 1st molar; 7 — 2nd molar.

Statistical analysis

The distribution of continuous variables was characterized by sample size (n), range (min–max), median (Me), arithmetic mean (M), and standard deviation (SD).

Continuous variables were verified for the normality of distribution using the Shapiro-Wilk test. Normally distributed variables were presented as the arithmetic mean (a measure of central tendency) and the standard deviation (a measure of spread). Non-normally distributed continuous variables were presented as the median (a measure of the central tendency) and the interquartile range.

The qualitative variables for the studied samples, such as edentulism, opening directions of the IOF, were characterized by sample size (n), category (e.g. I — inferior, S — superior, A — anterior, P — posterior, and the observed combination of these categories), and the number and percentage of cases identified for each category.

Measurements were taken by one investigator. The error of measurement was estimated. The probability of type 1 error (level of statistical significance) was adopted at $p = 0.05$.

Two groups of independent variables were compared using Student's t-test or the Mann-Whitney

Table 1. The descriptive statistics of the measurements of the relative position of the infraorbital foramen and its diameter taken from the modern skulls (n = 87) and the results of the comparison between measurements concerning the right and left sides of the facial skeleton

Variable	P value Student's t test	Mean ± SD	Median	Minimum	Maximum
For.Inf.-Mar.Inf. R	> 0.98	7.02 ± 1.46	6.98	3.42	12.18
For.Inf.-Mar.Inf. L		7.02 ± 1.44	6.84	2.64	11.33
For.Inf.-Inc.Nasalis R	> 0.5	20.09 ± 1.88	20.21	16.20	24.77
For.Inf.-Inc.Nasalis L		20.18 ± 1.81	20.00	16.21	25.66
For.Inf.-L.M. R	**> 0.04**	28.00 ± 2.06	27.75	23.59	33.30
For.Inf.-L.M. L		27.62 ± 1.97	27.43	23.20	33.51
For.Inf.-Sut.Zyg-Max. R	**> 0.004**	23.47 ± 2.97	23.57	15.19	32.71
For.Inf.-Sut.Zyg-Max. L		22.96 ± 2.85	23.00	15.67	32.09
For.inf.-Pr.alveolaris R	> 0.95	33.74 ± 3.25	33.71	23.26	42.54
For.inf.-Pr.alveolaris L		33.72 ± 2.93	33.89	26.80	41.35
Diam.For.Inf. R	> **0.003**	3.11 ± 0.77	3.11	1.36	5.07
Diam.For.Inf. L		3.30 ± 0.69	3.33	1.63	5.16

The statistically significant differences were marked in bold. All measurements in millimetres. R — right side; L — left side; SD — standard deviation; rest abbreviations — see text

U test. Two groups of dependent variables were compared using Student's t-test or the Wilcoxon matched-pairs test.

The significance of differences between the frequencies of particular categories of the examined qualitative variables for two independent groups was assessed using Yates's chi-squared test.

Data were processed using STATISTICA PL version 7.1 software [57].

RESULTS

Table 1 presents the summary statistics of the measurements taken in modern skulls and the results of the analysis concerning the presence of the asymmetry in this sample. In the case of the problem of the asymmetry the significant differences were established between the means (right and left) of the following traits: the distance between the medial margin of the IOF and the midline of the skull (the mean value of this trait was higher for the right side of the facial skeleton than on the left side), the distance between the IOF and the zygomaticomaxillary suture (the mean value of this trait was also highest for the right side), and the diameter of the IOF measured at the widest point (the mean value of this trait was higher on the left side than on the right) (Table 1).

In most skulls the IOF was located above the first molar tooth alveolus: in 82.75% of skulls on the right side and in 73.56% of skulls on the left side (Table 2). In most skulls the opening of the infraorbital canal pointed in the anteroinferior direction (A/I) (Fig. 3).

Table 2. Location of the infraorbital foramen (IOF) in modern human skulls in relation to type of tooth (n = 87)

	Location of IOF in relation to type of tooth			
	Right		Left	
	N	%	N	%
4	0	0	0	0
4/5	0	0	0	0
5	13	14.94	17	19.54
5/6	1	1.14	6	6.89
6	72	82.75	64	73.56
6/7	0	0	0	0
7	1	1.14	0	0

4 — 1st premolar; 5 — 2nd premolar; 6 — 1st molar; 7 — 2nd molar; 8 — 3rd molar

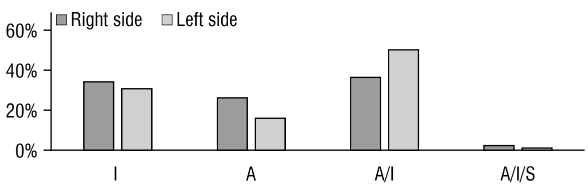

Figure 3. Direction of opening of the infraorbital foramen in modern skulls (n = 87); I — inferior; A — anterior; A/I — anteroinferior; A/I/S — anteroinferior-superior.

The summary statistics of the analysed metric traits of medieval skulls from the Church of St. Matthias and post-medieval skulls from the Church of

Table 3. The descriptive statistics of the measurements of the relative position of the infraorbital foramen and its diameter taken from the non-modern skulls (n = 47) from Church of St. Matthias (medieval skulls) and the Church of St. Christopher (post-medieval skulls) in Wroclaw, and the results of the comparison between measurements concerning the right and left sides of the facial skeleton

Variable	P value Student's t test	Mean ± SD	Median	Minimum	Maximum
For.Inf.-Mar.Inf. R	> 0.42	6.89 ± 1.41	6.76	4.18	10.14
For.Inf.-Mar.Inf. L		6.75 ± 1.65	6.70	3.59	10.25
For.Inf.-Inc.Nasalis R	> 0.34	19.49 ± 2.53	18.91	14.55	27.13
For.Inf.-Inc.Nasalis L		19.26 ± 2.29	18.71	15.41	27.25
For.Inf.-L.M. R	> 0.45	28.27 ± 2.33	27.89	23.59	35.01
For.Inf.-L.M. L		28.08 ± 2.54	27.61	23.04	36.38
For.Inf.-Sut.Zyg-Max. R	> 0.24	22.46 ± 2.74	22.81	17.07	27.66
For.Inf.-Sut.Zyg-Max. L		22.05 ± 3.09	22.26	10.04	29.42
For.inf.-Pr.alveolaris R	> 0.12	31.65 ± 4.14	31.59	23.90	40.97
For.inf.-Pr.alveolaris L		31.22 ± 4.14	30.49	24.53	41.33
Diam.For.Inf. R	> 0.81	3.48 ± 0.70	3.47	1.98	5.01
Diam.For.Inf. L		3.51 ± 0.68	3.48	2.22	5.13

All measurements in millimetres. R — right side; L — left side; SD — standard deviation; rest abbreviations — see text

Table 4. The descriptive statistics of the measurements of the relative position of the infraorbital foramen and its diameter taken from the medieval skulls from Sypniewo (n = 100), and the results of the comparison between measurements concerning the right and left sides of the facial skeleton.

Variable	P value Student's t test	Mean ± SD	Median	Minimum	Maximum
For.Inf.-Mar.Inf. R	< 0.39	7.18 ± 1.57	7.12	3.80	12.95
For.Inf.-Mar.Inf. L		7.08 ± 1.53	7.05	3.33	12.30
For.Inf.-Inc.Nasalis R	> 0.30	19.14 ± 2.10	19.04	12.87	26.37
For.Inf.-Inc.Nasalis L		18.97 ± 1.96	18.88	14.52	23.38
For.Inf.-L.M. R	**< 0.03**	28.03 ± 2.16	28.04	23.07	33.46
For.Inf.-L.M. L		27.63 ± 1.85	27.04	23.10	32.08
For.Inf.-Sut.Zyg-Max. R	> 0.21	23.54 ± 2.43	23.86	18.26	29.69
For.Inf.-Sut.Zyg-Max. L		23.35 ± 2.30	23.57	17.32	28.17
For.inf.-Pr.alveolaris R	> 0.24	31.76 ± 4.14	31.47	22.90	53.44
For.inf.-Pr.alveolaris L		31.46 ± 3.49	31.35	23.00	38.14
Diam.For.Inf. R	> 0.09	3.42 ± 0.69	3.38	2.10	5.54
Diam.For.Inf. L		3.54 ± 0.69	3.47	2.19	5.89

The statistically significant differences were marked in bold. All measurements in millimetres. R — right side; L — left side; SD — standard deviation; rest abbreviations — see text

St. Christopher (representing a historic population of Wroclaw) and skulls from Sypniewo (dated to the mediaeval period) are presented in Tables 3 and 4. Results of the analysis concerning the issue of the asymmetry are also presented in these Tables. There were no significant differences between analysed traits (between left and right sides) in the sample including these groups of the skulls (Table 3). In the case of the cranial sample from Sypniewo the significant difference was established only for the distance between the medial margin of the IOF and the midline of the facial skeleton (this distance was greater on the right side) (Table 4).

In both above-listed cranial samples, the most frequent location of the IOF (on the right and left side) was that above the first molar teeth alveolus (Tables 5, 6).

Thus there was no difference between the above-mentioned trait between modern and non-modern cranial samples.

Table 5. Location of the infraorbital foramen (IOF) in relation to the type of the tooth, non-modern skulls (n = 47) from the Church of St. Matthias (medieval) and the Church of St. Christopher (post-medieval)

	Location of IOF in relation to the type of the tooth			
	Right		Left	
	N	%	N	%
4	0	0	0	0
4/5	0	0	0	0
5	1	2.12	2	4.25
5/6	8	17.02	7	14.89
6	37	78.72	37	78.72
6/7	1	2.12	1	2.12
7	0	0	0	0

4 — 1st premolar; 5 — 2nd premolar; 6 — 1st molar; 7 — 2nd molar; 8 — 3rd molar

Table 6. Location of the infraorbital foramen (IOF) in relation to the type of the tooth; medieval skulls from Sypniewo (n = 100)

	Location of IOF in relation to the type of the tooth			
	Right		Left	
	N	%	N	%
4	0	0	0	0
4/5	0	0	0	0
5	6	6.00	5	5.00
5/6	24	24.00	26	26.00
6	70	70.00	69	69.00
6/7	0	0	0	0
7	0	0	0	0

4 — 1st premolar; 5 — 2nd premolar; 6 — 1st molar; 7 — 2nd molar; 8 — 3rd molar

The most frequent directions of opening of the IOF on the left and right sides were anteroinferior (A/I) in skulls from the Church of St. Christopher and St. Matthias (Fig. 4), and inferior (I) in skulls from Sypniewo, $p < 0.05$ (Fig. 4).

The comparison of modern skulls and non-modern skulls for the location of the IOF revealed a significantly greater distance from the IOF to the nasal notch in modern skulls on the right side ($p < 0.002$) and on the left side ($p < 0.001$), and a greater distance from the IOF to the top of the alveolar process of maxilla in modern skulls on both sides ($p < 0.001$). The diameter of the IOF was greater in medieval and post-medieval skulls (pooled sample): $p < 0.003$ for the right side, and $p < 0.02$ for the left side. There were no significant differences in the location of the

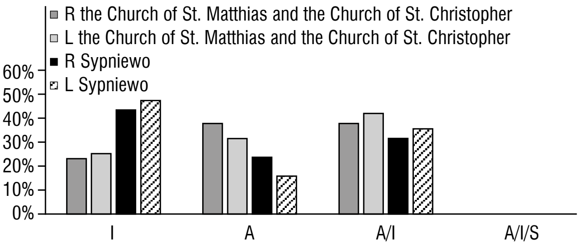

Figure 4. Direction of opening of the infraorbital foramen in non-modern skulls from the Church of St. Matthias and the Church of St. Christopher (n = 47) and in skulls from Sypniewo (n = 100); R — right side; L — left side; I — inferior; A — anterior; A/I — anteroinferior; A/I/S — anteroinferior-superior.

Table 7. Dominance of values of the analysed traits concerning the relative position and parameters of the infraorbital foramen on the left and right sides in modern and non-modern skulls

Variable	Modern skulls	Medieval/non-modern skulls
For.Inf.-Mar.Inf.	Right	Right
For.Inf.-Inc.Nasalis	Left	Right
For.Inf.-L.M.	Right	Right
For.Inf.-Sut.Zyg-Max.	Left	Right
For.inf.-Pr.alveolaris	Right	Right
Diam.For.Inf.	Left	Left

IOF in relation to the alveolar arch. In both samples, the most frequent location of the IOF was above the first molar alveolus. The most frequent directions of opening of the IOF were inferior in medieval skulls, and anteroinferior in modern skulls, but differences between these samples were not statistically significant.

The comparison of skulls for the symmetry of the IOF is presented in Table 7. Accessory infraorbital foramina were not identified in the analysed samples of skulls.

DISCUSSION

The knowledge of the topography of the infraorbital canal and its terminal opening is essential for clinicians, especially dentists and dental surgeons, neurologists and plastic surgeons [8, 30, 36, 37, 38, 40]. Some ethnic differences have been reported in the location of the infraorbital canal and its foramen, including the presence of the accessory IOF [8, 14, 15, 32, 58], and these variants should be considered when planning medical procedures, in anthropometric analyses of bone materials explored during archaeological research, and in the forensic assessment of human remains.

The knowledge of topographical variants and trends in the position of the IOF helps achieve therapeutic success in everyday clinical practice and prevents the risk of misdiagnosis, misinterpretation of X-ray images, reduces the rate of complications, and also improves the outcomes of certain medical procedures and the accuracy of anthropological assessments.

In the sample of the modern skulls the mean distance between the superior rim of the IOF and the IOR was 7.02 ± 1.46 mm for the right side and 7.02 ± 1.44 mm for the left side (Table 1). However, in this study the difference between these means was statistically insignificant. According to results obtained by Kazkayasi et al. [38], Cutright et al. [13], and Agthong et al. [2] in studies on modern human skulls the IOF was lower on the right side, while on the left side the IOF was closer to the orbital rim. In our study the distance between the IOF and midline of the facial skeleton was higher on the right side in two examined cranial samples (including modern skulls and medieval skulls from Sypniewo). The distance between this foramen and the zygomaticomaxillary suture was higher on the right side of the facial skeleton and the widest diameter of the IOF was present on the left side of the facial skeleton only in the sample of the examined modern skulls. No other significant differences (concerning the problem of asymmetry) occurred in the examined samples of human crania. A study by Agthong et al. [2] revealed that the distance from the IOF to the top of the alveolar process of maxilla was almost identical to that measured in our analysis (Table 1). Aziz et al. [5] reported the distance to the IOR about 1 mm greater, and the distance from the IOF to the midline almost identical to that found in our study. Similar parameters were reported by Chung et al. [12] and Cutrig et al. [13]. In studies by Kazkayasi et al. [38] and Rahman et al. [53] the distance between the IOF and the nasal notch was 17.23 ± 2.64 mm, while in the modern skulls analysed in our study it was 20.09 ± 1.88 mm (R) and 20.18 ± ± 1.81 mm (L). Distances from the IOF to the maxillary midline and the IOR reported by Gupta [27] were very similar to those measured in our study. Gupta [27] also provided information on the position of the IOF in relation to the dental alveoli of maxilla: in 56.50% (R) and 50.60% (L) of skulls the IOF was located above the second premolar, and in 32.90% (R) and 24.10% (L) of skulls it was above the line between the second premolar and the first molar. In our study the position of the IOF in relation to the dental alveoli of maxilla in modern skulls was assessed in the frontal view. In most skulls the IOF was located above the first molar alveolus. The second most frequent position of the IOF was above the second premolar (Table 2). Aziz et al. [5] reported the most frequent location of the IOF above the first premolar alveolus. A study by Apinhasmit et al. [3] revealed that in most skulls the IOF was found above the second premolar, and in 27.90% of skulls above the line between the first and second premolars.

In this study, in the case of the comparison between modern and non-modern cranial samples the significant differences concerned the distance of the IOF from the margin of the alveolar process (this distance was greater in modern skulls) and the distance of the IOF from nasal notch (which was also greater in modern skulls than in non-modern). The first of these differences may result from various types of edentulism in the region of measurement and, consequently, from progressive atrophy of the alveolar process of maxilla [4, 16, 53, 63]. Our study also demonstrated significant differences in the diameter of the IOF between the analysed samples of skulls. IOFs were much wider in non-modern skulls, and their diameter was similar to that reported by Gupta [27]. Chung et al. [12] found about 2 mm larger diameters of the IOF compared to values measured by us in medieval and post-medieval skulls, and 1.5 mm larger compared to modern skulls.

In most cases the location of the IOF in relation to the dental alveoli of maxilla in non-modern and modern skulls viewed from the front was above the first molar dental alveoli of maxilla. The second most frequent location of the IOF was between the second premolar and the first molar in medieval skulls and above the second premolar in modern skulls. In human skulls, the IOF analysed in the vertical plane was located above the line between the canine and the first molar [1, 37], but most frequently the IOF was found above and in line with the premolars. However, there is no consensus among researchers as to a higher frequency of the IOF above the first premolar [e.g. 5] or above the second maxillary premolar [e.g. 1, 3, 29].

No accessory infraorbital foramina were identified in our study, which also highlights ethnic differences. Hwang et al. [32] reported a higher frequency of accessory IOF in skulls from populations living above 60 degrees latitude, in cold zones, than in temperate and tropical climates. Zhang et al. [64] found a higher frequency of accessory IOFs in a European population (21.7%) than in an African-American population (10%), while Sokhn [56] reported accessory IOFs in 8.6% of a sample representing a Lebanese population.

Studies on face and skull asymmetry are extremely important because of the need for detailed diagnostics in dental and orthodontic treatment, when planning local anaesthesia [6, 7, 41, 55, 65], or in paediatric surgery to repair cleft lip and palate [18, 33, 39, 42].

CONCLUSIONS

Our analysis revealed differences in the location of the IOF between modern and non-modern skulls, and also with findings reported in the literature, which confirms the presence of both geographical and chronological differences between populations. The comparison of examined populations revealed a greater distance of the IOF from the nasal notch and the margin of the alveolar process of maxilla in modern skulls.

Knowledge of differences in the position of the IOF between local populations is fundamental for the correct interpretation of findings from diagnostic radiological studies in dental practice, and for planning effective anaesthesia and implant placement. This knowledge is also necessary in forensic odontology or analysis of archaeological bone materials.

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