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Biometrics Ethmoid by Computed Tomography

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Summary

The ethmoid bone, is a structure that in the last 20 years was acquiring relevance for anatomists, clinicians, neurosurgeons and otolaryngologists, due to the great development of endoscopic surgical techniques and the multiple anatomical variants that it presents. Descriptive, cross-sectional observational study in which the retrospective consecutive review of the paranasal sinus tomographic studies in axial, coronal and sagittal sections of patients over 20 years of age of the radiology department of the Hospital de Clínicas, of the IPS Central Hospital, the Luque Regional Hospital, the Iribas Clinic and the Calvo Radiological Institute. The present work was prepared to satisfy some concerns such as the depth of the ethmoidal roof predominant by gender in the population studied; the frequency with which symmetry occurs in the ethmoidal ceiling; the frequency with which supraorbital cells are found in the population studied; finally, we intend to establish percentiles by gender of the dimensions of the ethmoid in the adult population. It was found that the depth of the ethmoidal roof was Keros II in both sexes and both nostrils; symmetry was found in 60%; supraorbital cells were found in 27.5% of cases. The measurements made by computed tomography in the ethmoid bones of the patients who participated in this study, do not differ from the measurements made by other authors.

Scope: Results contribute to improving knowledge of our population's anatomical variants to disseminate them, put them into practice and improve the experience in the integral management of patients with medical-surgical pathologies of the paranasal sinuses.

Key words: *Ethmoidal Biometrics; Ethmoidal roof; Ethmoid Width; Supraorbital cells*

Introduction

The anatomy and anatomical variants that the ethmoid may present will continue to be studied by anatomists, radiologists, otolaryngologists and neurosurgeons, taking into account that many of the complications of endoscopic sinus surgeries are avoidable with the sole knowledge of Anatomy and the variables that this bone can present a patient to another [1-3].

There are several complications of endoscopic surgeries that are related to the anatomical variants of this bone. The ethmoidal roof, for example, specifically the olfactory fossa, the object of study by several authors, as it is a vulnerable region to suffer injuries in endoscopic surgery and thus cause one of the major complications, such as cerebrospinal fluid fistula. Keros [4], in 1962, labels the classification of the ethmoidal ceiling, according to the difference in the level of the sieve plate or olfactory fossa; later other authors

were based on this classification, to carry out their specific studies, which is used until our days [5-8].

It is good to note that this classification of Keros should be done for each nasal cavity independently, as it may have asymmetries and these may be relevant when planning a sinus surgery. These asymmetries can be several millimeters apart between one side and another of the depth of the olfactory, or they can be only in shape and have the same depth on each side [9-12].

It is the knowledge of the anatomical variants that helps to avoid complications in endoscopic surgery of the skull base, since these variants may be in close relationship with noble structures. To cite one example, among the major complications, we find the cerebrospinal fluid fistula, which is related to a very low olfactory fossa depth, that is, Keros III [4, 13, 14].

There are anatomical variants of pneumatization, derived from the ethmoidal cells, which some authors call them as extramural migration in the development of the ethmoidal sinus [15, 16]. These variants can produce an obstructive pathology of the paranasal sinuses, but they also constitute a potential danger. Surgical [17, 18]. Within this group of variants we find, for example, supraorbital cells; ethmoidal cell that extends in the supero-lateral direction between the medial wall of the orbit and the roof of the ethmoid. These cells have a frequency that can vary between 5.4% and 15% according to the authors [19-21].

Among the important measures that are related to the ethmoid bone, we find one very useful for the ENT surgeon or neurosurgeon, such as the distance between the ethmoid roof and the nasal floor, since this distance allows us to have an idea of the distance to which is the base of the skull in the surgeries of this region. This distance, which must be measured in each nostril separately, was found in the literature on average, 52.3 mm on the left side and 51.8 mm on the right side, with a variation of approximately ± 5.2 mm. each side [9, 22].

Another measure to take into account in endoscopic surgery is the distance between the roof of the ethmoid and the middle turbinate, which is also part of the ethmoid, receiving the name of the first ethmoidal shell. A distance ranging from 26 mm to 27.7 mm on the left side and 25.9 mm and 28.5 mm from the right side was found in the literature, depending on the depth of the olfactory fossa [9].

The height of the ethmoid is another measure of importance for ENT surgeons, because of the relationship this bone has with the orbit and the structures found in them. There are authors who directly relate the height of the ethmoid to the height of the maxillary sinus and express it in proportions [6].

The length of the ethmoidal roof, another of the measurements of interest to surgeons at the base of the skull, is made from the ethmoid-frontal angle, to the beginning of the rostrum of the sphenoid sinus. Although it is true, it does not have a significant surgical importance when performing a skull base surgery, it complements the previous measurements of the ethmoid, that is, it has an anatomical importance [23].

Another of the measures that have both a surgical and anatomical interest, is the distance between the middle turbinate and the papiraceous lamina of the ethmoid of the same side, since what is sought is to familiarize yourself with the distance between these two structures, to in order to avoid the complications of endoscopic sinus surgeries, such as orbital hematoma and orbital emphysema [13, 14, 24].

For the skull base surgeon, whether an otolaryngologist or neurosurgeon and for didactic purposes, whether for residents of these specialties or for anatomists, there is a fairly important measurement such as the distance between the nostril and the ethmoidal roof, and that endoscopic surgeries are the most used in the last 20 years, one must be in complete knowledge of the depth that can be reached with surgical instruments without causing a lesion in the base of the skull, which can cause morbidity in the patient [25-27].

The present work was prepared to satisfy some concerns such as the depth of the ethmoidal roof predominant by gender in the population studied; the average ethmoid measures according to gender; the frequency with which symmetry occurs in the ethmoidal ceiling; the frequency with which supraorbital cells are found in the population studied; Finally, it is intended to establish percentiles by sex, of the dimensions of the ethmoid in the adult population.

Materials and Methods

Descriptive, cross-sectional observational study in which the retrospective consecutive review of the tomographic studies of paranasal sinuses in axial, coronal and sagittal sections of patients over 20 years of age of the Radiology Department of the Hospital de Clínicas, of the IPS Central Hospital, the Luque Regional Hospital, the

Iribas Clinic and the Calvo Radiological Institute between January and December 2012.

The tomographic cuts were usually made 3 mm thick in the different incidences of images (axial, coronal and sagittal). The images were collected throughout the period on compact discs, then stored on a computer, using the K-PACS Workstation V1.6.0 program, which allowed us, apart from image storage, to make measurements (dependent operator) in millimeters and in all tomographic dimensions.

The following measurements were made: Depth of the olfactory fossa; distance between the roof and floor of each nostril separately; ethmoid bone height; distance between the ethmoidal roof and the free edge of the middle turbinate; distance between the papiraceous lamina and the middle turbinate; minimum and maximum distances between the ethmoidal roof and the anterior nasal spine; width of the ethmoid and the antero-posterior length of the ethmoidal roof. The presence of supraorbital cells was also sought. The measurements were made in each gender separately, obtaining two groups. For the measurement of the olfactory fossa, the Keros classification was used. Keros I was considered when this measurement was less than or equal to 3.9 mm. Keros II when this measurement was between 4 and 7.9 mm and Keros III when the measurement was above 8 mm.

The symmetry of the ethmoidal roof was evidenced by a difference in the measure of each olfactory fossa separately; it was considered asymmetric when a millimeter or more of difference was found between each side of the ethmoidal roof; the same classification of Keros was sometimes taken, but it was considered asymmetric if the difference was one millimeter or more. Tomographic studies of patients under 20 years of age were excluded because they did not yet have a complete development of the paranasal sinuses, or with a history of surgeries, tumors or fractures of the paranasal sinuses or of the skull base, which are stated in the study, in whom the anatomy is altered by said pathological antecedents.

The sample size calculation was made considering the results found in the work of Monjas-Canovas et al [20], where a frequency of 15% supraorbital cells was found, which makes us have a P of 0.15; a total amplitude of the confidence interval of 0.10 and a confidence level of 95%. The minimum sample size for this research work was 196. This figure was reached using the formula on page 102 of the book by Hulley & Cummings [28].

The data obtained were stored in an Excel spreadsheet and analyzed with the statistical programs SPSS and Epi Info 2007, applying descriptive statistics to determine the measures of central tendency and dispersion for the quantitative variables and frequency distribution in the qualitative ones. The results were stratified by age and to establish significant differences, the t student and X2 tests were used at a significance level of <0.05.

All measurements were grouped in a table where the mean and standard deviation found of each of them were presented, by sex, in order to establish standard anatomical parameters for future research and another table in which the percentiles were included found.

Results

Of a total of 200 CT scans, 102 (51%) belonged to male patients. The age range was between 20 and 91 years, with the mean ± standard deviation of 46.3 ± 17.2 years; the mean age ± standard deviation in the female sex was 47.1 ± 16.8 years and in the male sex 45.6 ± 17.7 years; the difference was not significant. Table 1 shows the distribution by sex and age of the study participants.

Age	Male	Female	Total
20-39	43 (42,15%)	32 (32,6%)	75 (37,5%)
40-59	36 (35,3%)	40 (40,8%)	76 (38%)
≥60	23 (22,5%)	26 (26,5%)	49 (24,5%)
Total	102 (51%)	98 (49%)	200 (100%)

Table 1: *Distribution by sex and age of the participants.*

Regarding the depth of the olfactory fossa, it was found that the majority of the population studied had a Keros II type depth, in both sexes and in both nostrils, as can be seen in Table 2:

Keros	Olfactory Pit	Gender		
		MALE	FEMALE	Total
I (0-3,9 mm)	Right	32 (15,7%)	36 (18,3%)	68 (17%)
	Left	24 (11,7%)	27 (13,7%)	51 (12,8%)
II (4-7,9 mm)	Right	60 (29,4%)	57 (29,1%)	117 (29,2%)
	Left	68 (33,3%)	64 (32,6%)	132 (33%)
III (≥8 mm)	Right	10 (4,9%)	5 (2,5%)	15 (3,8%)
	Left	10 (4,9%)	7 (3,6%)	17 (4,2%)
	Total	204 (51%)	196 (49%)	400 (100%)

Table 2: *Distribution by sex of the Keros classification for the olfactory fossa.*

In the right nostril, a depth of 5.2 mm in the male sex and 4.7 mm in the female sex was obtained, which is equivalent to the classification of Keros type II. This difference was evaluated with the t student test and was not significant.

In the left nostril, the depth found in the male sex was 5.4 mm and in the female sex it was 4.9 mm. It also falls within the classification of Keros type II for said pit. The difference in this case between both sexes was not significant either, also using the t-test here to compare the means.

Below is presented in Table 3, the means of the variables used in the study according to sex.

		Media ± DE		P Value
		Male	Female	
Depth Olfactory Fossa	Right	5,3±1,9	4,8±1,7	0,068
	Left	5,4±1,9	4,9±1,8	0,111
Distance Roof-Floor FN	Right	46,9±3,5	44,1±3,6	<0,001
	Left	47,3±3,6	44,3±3,4	<0,001
Ethmoidal Height	Right	31,1±5,2	27,3±5,4	<0,001
	Left	32,1±5,4	28,8±5,7	<0,001
Ethmoidal Roof - Middle Turbinate	Right	25,2±3,8	24±3,1	0,021
	Left	25,4±3,6	24,5±2,9	0,045
Papiráceous Lamina - Middle Turbinate	Right	10,7±2,6	9,9±1,6	0,019
	Left	10,7±2,3	10,1±1,7	0,05
Distance Ethmoidal Roof – Anterior nasal spine	Maxima	70,2±6	64,9±5,1	<0,001
	Minima	54,2±3,9	51,4±3,6	<0,001
Ethmoid Width		25,8±2,9	25±2,7	0,037
Antero-Posterior length ethmoidal roof		32,9±5,8	30,9±5	0,013

Satatistical test used t student, significance <0,05.

Table 3: *Measures of central tendency and ethmoid dispersion according to sex.*

In the statistical analyzes performed with the t-test, according to gender, for the other variables measured, a statistically significant difference was found in almost all measurements made, except for the depth of the olfactory fossa. Regarding the symmetry between the nasal fossa, a total of 200 tomographies were studied, symmetric ethmoidal ceilings in 120 cases (60%) of which were male 63 (52.5%). Of the 80 (40%) asymmetric ceilings, 39 were male (48.7%).

The presence of supraorbital cells was searched in tomographic studies, being identified in 55 tomographs (27.5%) and absent in 145 tomographic studies (72.5%).

Table 4 shows the distribution by sex and age in which Supraorbital cells were found in tomographic studies.

	Supraorbitary Cell		
Age	Male	Female	Percentage
20-39	15/43 (34,9%)	7/32 (21,9%)	22/75 (29,3%)
40-59	9/36 (25%)	9/40 (22,5%)	18/76 (23,7%)
≥60	9/23 (39,1%)	6/26 (23,1%)	15/49 (30,6%)
Total	33/102 (32,4%)	22/98 (22,4%)	55/200 (27,5%)

Statistical test used X^2, significance <0,05.

Table 4: *Frequency of supraorbital cells according to age and sex in the participants.*

The X2 test with a significance level of p <0.05 was used, finding a non-significant difference between sexes for the presence of supraorbital cells (p = 0.117).

For the different age ranges used, it was found that the presence of supraorbital cells in each group, by number of patients per group, was not significant (p = 0.631)

A table was prepared with the percentiles found of the different measurements made for each sex, in order to establish parameters that could help future research on this area.

Table 5 shows the percentiles calculated according to gender for each variable used.

Discussion

Without a doubt, among the most important variables measured by this study was the depth of the olfactory fossa, which was measured for the first time in 1962 by Keros [4]. The predominance of Keros II was obtained and marked in both nostrils and in both sexes, obtaining 29.2% frequency in the right nostril and 33% in the left nostril. These results are consistent with the literature consulted, since it has a great variation that ranges from 16% to 70% for some series [4, 29].

		Gender	Percentiles						
			5	10	25	50	75	90	95
Depth Olfatory right nostril	Right	F	2,1	2,8	3,4	4,5	5,9	7	8,6
		M	2,2	2,6	3,5	5,2	6,9	7,9	8,5
	Left	F	2,1	2,4	3,5	4,9	6,3	7,6	8,3
		M	2,2	2,6	3,9	5,5	6,8	8	8,6
Roof-Floor Distance	Right	F	37,8	39,2	41,7	44,3	46,3	48,6	51
		M	40,9	42,3	44,4	47,1	49,3	51,7	53
	Left	F	38,9	39,7	41,9	44	47	48,8	50,4
		M	41	42,5	44,9	47,4	49,6	52,2	53,9
Ethmoidal Height	Right	F	18,8	20,4	23,2	27,7	31,7	33,8	36,8
		M	21,9	23,7	27,9	31,6	34,5	37,3	39,8
	Left	F	19,3	21,2	24,2	28,6	33,6	36,5	39,3
		M	21,5	24,3	28,5	32,8	36,2	39,1	39,6
Ethmoidal Roof – Middle Turbinate	Right	F	18,2	19,9	22,4	24,2	26	28	28,8
		M	18	20	23,2	25,6	27,3	29,6	31,1
	Left	F	19,4	20,1	22,8	24,6	26,3	28,3	29
		M	19,1	20,5	23,3	25,3	27,9	29,8	31,3
Papiráceous lamina-Midddle Turbinate	Right	F	7,3	7,9	8,7	10,1	11,1	11,7	12,8
		M	7,4	8,1	9,3	10,6	11,7	13,1	14,2
	Left	F	7,6	8,1	8,6	10	11	12,3	13,6
		M	7,5	8,3	9,3	10,7	11,8	13	14
Distance ethmoidal roof- anterior nasal spine	Mínimum	F	45,4	46,9	48	51,5	53,8	57	57,7
		M	47,4	49,9	51,7	54,1	56,9	59,4	60,8
	Máximum	F	57,4	58,6	60,9	64,5	68,4	72	74,9
		M	61,1	62,3	66,6	70,3	73,6	77	80,9
Antero-Posterior lenght ethmoidal roof		F	24,1	25,3	27,5	30,1	33,2	37,4	44
		M	25,1	25,8	29,3	32,1	35,5	39,8	44,7
Ethmoides width		F	20,9	21,5	23,2	24,7	26,8	28,4	30
		M	21,1	22,3	23,6	25,8	27,7	29,6	30,2

Table 5: *Percentiles Calculated for each continuous variable according to sex.*

Regarding the depth of the olfactory fossa, type Keros I, in this series it was the second in frequency, in both sexes and in both nostrils, since it was found on average at 17% for the right nostril and in 12.8% for the left nostril; In some consulted series, quite similarity was found in regard to this olfactory fossa depth, but quite significant differences were found with other series, in which this type was the most frequent, hovering around 81.5% approximately [4, 30].

The importance of the depth of the olfactory fossa lies in the fragility that is generated in the cribiform plate, the surgeon being more likely to complicate an endoscopic sinus surgery; being more explicit, at greater depth, greater possibility of major complications in endoscopic surgery. In this series, the frequency of Keros III was quite low in both sexes and both nostrils, with an average frequency of 3.8% for the right nostril and 4.2% for the left nostril. In the literature consulted, we also found a very wide variation of this type of roof, varying between 0.5% and 64% [29, 30].

Another variable that was taken into account in this study is the distance between the roof and the floor of the nostril. An average of 52.3 mm on the left side and 51.8 mm on the right side was found in the literature consulted, with a variation of approximately ± 5.2 mm on each side. There is a difference in what was found in this series, since there was a significant difference between both sexes, obtaining in the male sex 46.9 ± 3.5 for the right nostril and 47.3 ± 3.6 for the left and in the female sex, 44.1 ± 3.6 for the right nostril and 44.3 ± 3.4 for the left nostril. This difference is due to the fact that in this study the depth of the olfactory fossa was not added to the distance between the ceiling and the floor of the nostril, since the precise limits between the roof and the floor were considered of vital importance, [9, 22].

The height of the ethmoid bone, proved to be a variable difficult to compare with the literature, since there are few published articles that have analyzed this variable, so it was necessary to resort to books of classical anatomy [31] and to treat of otolaryngology [32] to be able to relate this variable. It was found that it varied between 25 and 30 mm on average, regardless of sex. Our series, we can say that fits what is found in these books, since in the male sex it was 31.1 mm for the right side and 32.1 mm for the left side; and in the female sex 27.3 mm for the right side and 28.8 mm for the left side. Averaging both sexes and both nostrils, it is within what is described by literature [31, 32].

The distance between the ethmoidal roof and the free cellar of the middle turbinate was another of the variables studied in this review. For this variable it was found in the literature that the average ranged between 25.9 mm and 28.5 mm for the right side and between 26 mm and 27.7 mm for the left side [9]. In our series, an average of 25.2 mm for the right side and 25.4 for the left side was found in the male sex; in the female sex, these averages were 24 mm for the right side and 24.5 mm for the left. In this case the clarification is made by gender, since the difference was statistically significant. In any case, in both cases the average of this variable turned out to be slightly lower than that found in the literature [9].

With regard to the distance between the middle turbinate and the papyrus lamina, a measurement was not found in the literature that covers all this width, but only one that covered from the middle turbinate to the unciform process, which would be only the medium meatus. An average of 2.69 mm was found for the right side and 2.34 for the left side [33]. As the main objective of this study is to publicize the variants in the ethmoid measurements, for the best orientation in surgical procedures, it would be best to measure the distance between the papiraceous lamina and the middle turbinate, in order to avoid possible complications, since these are the limits in the anterior and posterior ethmoid surgeries. An average of 10.7 mm was found for both sides in men and 9.9 mm for the right side and 10.1 mm for the left side in women. This difference between both sexes was significant.

In order to delimit the distance of the ethmoidal roof at the entrance of the nostril, measurements were made of the minimum and maximum distances of the ethmoidal roof to the anterior nasal spine. The average minimum distance in the male sex was 54.2 mm and in the female sex it was 51.4 mm and the maximum distances found were respectively 70.2 mm and 64.9 mm. A similar measurement was found in the literature consulted, from the anterior nasal spine to the anterior ethmoidal artery, which is near the beginning of the ethmoidal roof, that is, what would be the minimum distance measured by our series. This distance found in the study by MONJAS-CÁNOVAS et al. [20] was 55.5 ± 5.5 mm, which coincides in part with what was found by this series and complements what was found in that series.

The width of the ethmoid, defined as the distance between a papyraceous lamina and another, or by the distance between a tear crest and that of the contralateral side by some authors [34], is found at an average of 25.8 mm for the male sex and 25 mm for the female sex. These parameters coincide with those found in the literature, since it is considered normal for the male sex between 21 and 28 mm, on average 26 mm and for the female sex between 20 and 26 mm, on average 25 mm. Above these values, Grade I, II or III hypertelorism is considered as this separation increases due to the width of the ethmoid [34].

The antero-posterior length of the ethmoidal roof is a measure found in the literature, specifically in the classic books of anatomy [31] and otolaryngology [32], which yielded measures such as 30 mm or between 40 and 50 mm respectively, without detailing the measurement form of this zone. In our series, this measurement was made with the sagittal sections, specifically when the crest galli process was visualized, which is an element that indicates exactly the midline. The measurement was made from the posterior wall of the frontal sinus to the rostrum of the sphenoid sinus. An average for the male sex of 32.9 mm and for the female sex of 30.9 mm was found, which coincides more with the classic descriptive anatomy texts reviewed [31].

The symmetry of the ethmoidal roof was evaluated taking into account a difference of more than 1 mm between both sides, that is, an asymmetric ceiling was considered if the difference found between both olfactory pits was equal to or greater than 1 mm. Several ways of evaluating this symmetry were found in the literature and certain authors divide it according to the difference in depth in mm, for example, from 0 to 1.9 mm; from 2 to 3.9 mm and more than 4 mm difference [9, 10]. There are others who considered a difference above 1 mm in this series to describe the asymmetry, and it was certainly quite frequent in this series consulted, reaching almost all of the participants [11]. In this series, asymmetry was found in 40% of the cases evaluated, with a slight predominance of female sex in these asymmetric roofs.

Finally, supraorbital cells were much more frequent in this series than in the literature consulted, being found in 27.5% in the 200 studies evaluated. The difference with some series that mention it in a 5% frequency [19] and others that mention it in 15% [20] is significant, but some authors make the caveat that could be found in more than 15% of the observed cases, since which is a fairly frequent pneumatization variable among ethmoidal variables [21].

Although it is true, ethmoidal percentiles for adults were not found in the literature, taking into account that our population studied were older than 20 years, an attempt was made to establish a table of percentiles for adults, of ethmoid bone, which could help future research to guide on parameters considered normal. The caveat is made that the ranges included in the percentile table are the most frequently found and it does not mean that if the extreme percentiles are exceeded, it falls into the abnormality.

Conflict of interests

The authors declares no conflict of interest.

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