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Surgical anatomy of the turbinal wall of the ethmoidal labyrinth*

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SUMMARY

The upper part of the lateral nasal wall is formed by a common structure or conchal lamina that is attached all along the junction between the ethmoidal roof and the cribriform plate. From this continuous conchal lamina, the different ethmoidal turbinates take their origin. All these structures form a well defined wall that encloses the ethmoidal cells medially and that deserves the name of « turbinal wall of the ethmoidal labyrinth ».

The objectives of this paper were: 1) to precisely define the anatomical landmarks of the turbinal wall of the ethmoidal labyrinth, and 2) to study, from an anatomical point of view, the consequences of the surgical resection of the middle turbinate.

We performed an anatomic study on 12 frozen human heads, cut in a median-sagittal plane, and then photographed with a millimetre scale in order to perform several measurements.

The surface of the turbinal wall of the ethmoidal labyrinth can range from 6.1 to 11.3 cm^2. The resection of the middle turbinate preserves approximately half of the turbinal wall, this being around 4.3cm^2 (range 2.6 to 6.3cm^2).

The conchal lamina appears as the noble sensorial element of the turbinal wall. It can be described as a continuous bone plate, grossly rectangular in shape, measuring approximately 1cm in height and 3.5 cm in length that forms the lateral wall of the olfactory groove. The anatomic study shows that its dimensions can vary from simple to double in different individuals. It seems to us that instead of considering the difference of height between the cribriform plate and the ethmoidal roof (Keros classification), we should consider the vertical height of the conchal lamina as a potential risk factor in ethmoidal surgery.

Key words: nasal turbinates, ethmoid, conchal lamina, lateral nasal wall, surgical anatomy, terminology, nomenclature

INTRODUCTION

The upper part of the lateral wall of the nasal cavity is formed on its superior portion by a common structure or conchal lamina, described in 1922 by Mouret (Mouret, 1922). This bony plate is attached all along the junction between the ethmoidal roof and the cribriform plate. From this continuous bone lamina, all the different ethmoidal turbinates take their origin, one middle and one superior turbinate that are constant, and occasionally a supreme turbinate. These ethmoidal turbinates, with the conchal lamina, form a well defined wall that encloses the ethmoidal cells medially and deserves the name of « turbinal wall of the ethmoidal labyrinth » (Figure 1).

Inferiorly, the lateral nasal wall is formed by an independent bone, the inferior turbinate that attaches to the maxilla and palatine bones. This inferior wall separating the nasal cavity from the maxillary sinus might be named "turbinal wall of the maxillary sinus". These two turbinal walls, ethmoidal superioly and maxillary inferiorly, form altogether the "turbinal wall of the nasal cavity" (Figure 1), which represents the portion of the lateral nasal wall that separates the nasal fossa from the sinuses cavities. Anterior to the “turbinal wall” is the “pre-turbinal wall of the nasal cavity”, which represents the portion of the lateral nasal wall corresponding to the external nose and the face (Figure 1).

The objectives of this paper are 1) to precisely define the anatomical landmarks of the turbinal wall of the ethmoidal labyrinth, and 2) to study, from an anatomical point of view, the consequences of the surgical removal of the middle turbinate.

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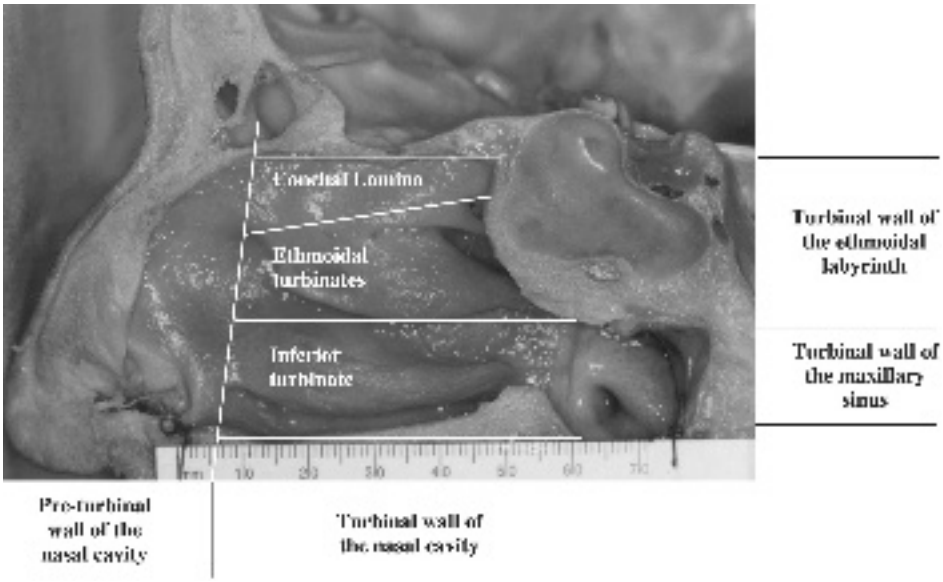

Figure 1. Location of the turbinal wall of the ethmoidal labyrinth on the lateral wall of the nasal cavity.

The turbinal wall is one of the main concerns in ethmoidal surgery. While some authors advocate to preserve the totality of this wall in order to avoid inflicting damage to the olfactory organ (Kennedy, 1998; Rice, 1998), some others propose the systematic resection of the middle turbinate in order to transform the ethmoidal labyrinth into one large sinus widely open into the nasal cavity (Friedman et al., 1986; Jankowski et al., 1997).

MATERIAL AND METHODS

We performed an anatomical study on 12 adult human corpses. The heads were frozen and then cut in a median-sagittal plane. From these 24 head halves, 5 were eliminated because of the poor quality of the cut; these were inadequately frozen, or presented anatomical alterations from previous sinus surgeries.

Nineteen head halves were finally included (7 complete heads, and 5 half heads).

A millimetre scale was sutured on each head half, the zero of the scale being placed at the level of the nasal spine.

Strict lateral view photographs were taken with an instant camera, and these were used as a support for the study.

First, we examined the anatomical configuration of the turbinal wall of the ethmoidal labyrinth, taking a particular interest in the number of ethmoidal turbinates. We also analyzed the symmetry between the two head halves on a same individual.

A second step was the measurement of the constituting elements of the turbinal wall of the ethmoidal labyrinth. To do so, we defined some anatomical points that were placed on the photographs and served as landmarks for all our measurements.

According to the constitution of the turbinal wall of the ethmoidal labyrinth, and notably to the presence or not of a supreme turbinate, we defined the following anatomical points:

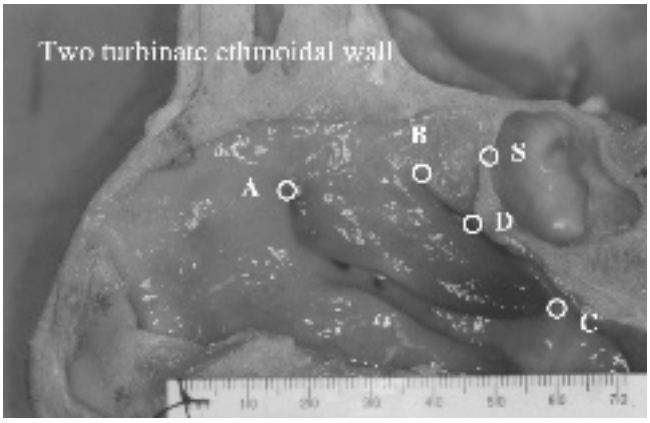

Figure 2. Landmark points on two turbinate ethmoidal walls.

- The point « A » corresponds to the upper point of the ogival opening to the middle meatus cleft. Thus, it is the point of insertion of the head of the middle turbinate to the ascending branch of the maxillary process.
- The point « B » is located in the upper part of the ogival opening of the superior meatus cleft. Thus, it is the point located at the anterior insertion of the superior turbinate on the conchal lamina.
- The point « C » corresponds to the posterior edge of the tail of the middle turbinate.
- The point « D » is placed at the edge of the tail of the superior turbinate.
- The point « S » is located on the anterior wall of the sphenoid, at the intersection with a line running from point A to point B (Line AB).

• Anatomical landmark points on 2 turbinate ethmoidal walls (Figure 2)
- Point A corresponds to the upper point of the ogival opening to the middle meatus cleft. Thus, it is the point of insertion of the head of the middle turbinate to the ascending branch of the maxillary process.
- Point B is located in the upper part of the ogival opening of the superior meatus cleft. Thus, it is the point located at the anterior insertion of the superior turbinate on the conchal lamina.
- Point C corresponds to the posterior edge of the tail of the middle turbinate.
- Point D is placed at the edge of the tail of the superior turbinate.
- Point S is located on the anterior wall of the sphenoid, at the intersection with a line running from point A to point B (Line AB).

• Anatomical landmark points on 3 turbinate ethmoidal walls (Figure 3)
- Points A, B, C and D are defined the same way as in 2 turbinate walls.
- Point E is located at the uppermost point of the ogival opening to the supreme meatus cleft; it is also the point of insertion of the supreme turbinate to the conchal lamina.
- Point S is here located at the intersection of the free margin of the superior turbinate with the anterior wall of the sphenoid.

The different measurements were made with millimetre scales, which were sutured to the head halves during the dissections, and before the shooting of the photographs. This allowed us to approach the real measures by applying a simple arithmetic rule of proportions (rule of three).

The surfaces were measured by using a computer drawing program (Autocad 97-Microsoft) that allowed us to outline the limits of the different studied surfaces. The millimetre grading scales again allowed us to give the measurements an approached, proportional real value.

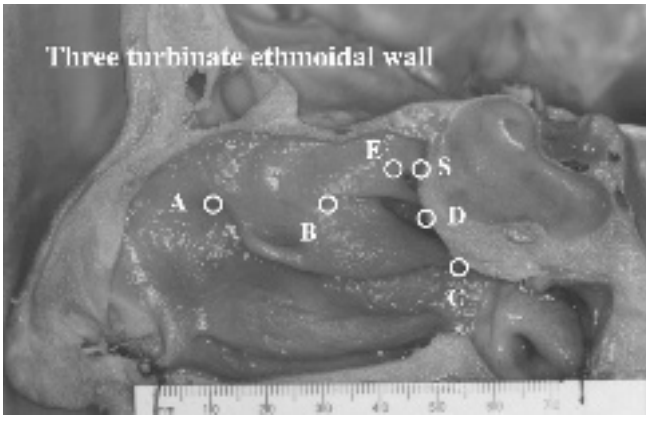

Figure 3. Landmark points on three turbinate ethmoidal walls.
- The points « A », « B », « C » and « D » are defined the same way as in 2 turbinate walls.
- The point « E » is located at the uppermost point of the ogival opening to the supreme meatus cleft; it is also the point of insertion of the supreme turbinate to the conchal lamina.
- The point « S » is here located at the intersection of the line BE with the anterior wall of the sphenoid.

Statistics

The comparison between the different measurements was done with a paired t-test when the obtained numbers were all from the same individual, and with a non-paired series t-test when the study included the whole of the anatomical specimens.

RESULTS

1. Configuration of the turbinal wall of the ethmoidal labyrinth.

As described by Mouret (1922), we found on every specimen a continuous bony plate from which all the ethmoidal turbinates take their origin. This corresponds to the conchal lamina, a constantly found structure that is attached along the junction between the ethmoidal roof and the cribriform plate.

Other structures also found to be constant are the superior and middle turbinates. The turbinal wall of the ethmoid was formed by two turbinates in $^{3}/_{4}$ of the specimens (14 over 19). The supreme turbinate was found less frequently. Approximately $^{1}/_{4}$ of the specimens had a 3 turbinate ethmoidal wall (5 over 19).

On the 7 heads that were complete, the number of turbinates between left and right sides was the same in 6 cases (5 heads with 2 turbinate walls, and one with 3 turbinate walls). There was one case of asymmetric number of turbinates in a same head.

2. Measurement of the constituting elements of the turbinal wall of the ethmoid.

2.1. Comparison between right and left sides.

The following results only concern the 7 heads in which the two sides were suitable for study.

2.1.1. Concha lamina.

The vertical height of the conchal lamina was measured at its anterior (distance HA, the point H being the projecting point on the ethmoidal roof of a vertical line running through point A) and posterior (distance HB) extremities (Figure 4).

The average height of HA is similar to HB (around 9.5 mm), which allows us to describe the conchal lamina as a rectangular structure, but the height of the conchal lamina can vary from simple to double between different individuals (measurements ranging from 6.2 to 13 mm). The distances HA and HB are also statistically different between the right and left sides of a same individual ($p=0.03$), and the difference may go from 0.1 to 5.7 mm for HA, and 0.2 to 4.5 mm for HB (Table 1).

The landmarks that allow the measurement of the length of

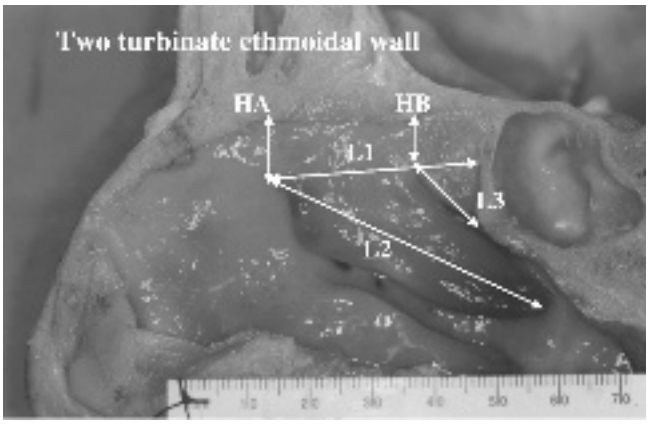

Figure 4. Height (H) and length (L) measurements on two turbinate ethmoidal walls.
HA = anterior height of the conchal lamina
HB = posterior height of the conchal lamina
L1 = length of the conchal lamina
L2 = length of the middle turbinate
L3 = length of the superior turbinate

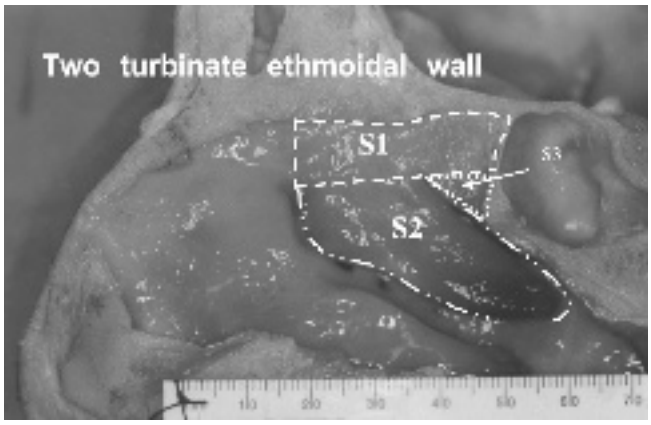

Figure 5. Surface measurements on two turbinate ethmoidal walls.
S1 = surface of the conchal lamina
S2 = surface of the middle turbinate
S3 = surface of the superior turbinate

Table 1. Turbinal wall of the ethmoidal labyrinth - Comparison of the measurements (mean ± standard deviation, [range]) between right and left sides (n=7). The lengths are expressed in millimetres, the surface in square centimetres (cm^2).

n=7	Right (R)	Left (L)	Δ [R - L]	p (R - L)
HA	9.5 ± 2.1 [11.4 ; 6.2]	9.9 ± 2 [11.9 ; 6.9]	2.8 ± 1.9 [5.7 ; 0.1]	0.03
HB	9.6 ± 2.3 [13 ; 6.9]	9.4 ± 2 [12 ; 7.1]	1.7 ± 1.4 [4.5 ; 0.2]	0.03
L 1	35.2 ± 4.3 [40.1 ; 29.8]	32.7 ± 2.2 [36.2 ; 28.9]	3 ± 2.8 [7.1 ; 0.2]	0.03
S1	3.5 ± 0.9 cm^2 [4.7 ; 2.1]	3.3 ± 0.6 cm^2 [4.4 ; 2.6]	0.5 ± 0.6 cm^2 [1.8 ; 0]	0.10
AB	19.6 ± 3.8 [24.2 ; 13.1]	17.2 ± 4.4 [23.3 ; 11.4]	3.6 ± 1.9 [5.8 ; 1.1]	0.02
L2	47.5 ± 2.5 mm [51.5 ; 43.8]	46.4 ± 2.1 mm [49.1 ; 43]	1.5 ± 0.8 mm [2.6 ; 0.8]	0.02
S2	4.5 ± 1 cm^2 [2.9 ; 5]	3.7 ± 0.8 cm^2 [2.6 ; 4.9]	1 ± 0.6 cm^2 [0.3 ; 1.9]	0.04
L3	15.9 ± 3.4 [11.5 ; 20.2]	15.7 ± 19.1 [11.9 ; 19.1]	2 ± 1.2 mm [0 ; 3.4]	0.05
S3	0.5 ± 0.2 cm^2 [0.7 ; 0.2]	0.4 ± 0.2 cm^2 [0.9 ; 0.2]	0.2 ± 0.15 cm^2 [0.5 ; 0]	0.04
S	9 ± 1.9 cm^2 [11.3 ; 6.1]	7.8 ± 1.5 [9.8 ; 6.1]	1.3 ± 1.2 [3.6 ; 0]	0.02

HA = anterior height of the conchal lamina
HB = posterior height of the conchal lamina
AB = length of the line of attachment of the middle turbinate on the conchal lamina
L1 = length of the conchal lamina
L2 = length of the middle turbinate
L3 = length of the superior turbinate
S1 = surface of the conchal lamina
S2 = surface of the middle turbinate
S3 = surface of the superior turbinate
S = surface of the turbinal wall of the ethmoidal sinus
Δ [R - L] = difference between right and left side
p (R – L) = paired t-test

the conchal lamina are different between 2 turbinate (L1=length of the segment ABS, Figure 2) and 3 turbinate ethmoidal walls (L1=length of segment ABD, Figure 3). The difference in length of the conchal lamina (L1) between the right and left sides of the same individual are given in Table 1.
The surface of the conchal lamina (S1) (Figure 5) was outlined by following the landmarks here described: superiorly the ethmoidal roof, anteriorly the vertical line passing through point A, inferiorly the virtual line ABS (or AB-BES on 3 turbinate walls), posteriorly the anterior wall of the sphenoid. The average surface difference between left and right sides of one same individual is little (0.5 ± 0.6 mm^2) and not significantly different on a statistical basis (Table 1). However, in one case, S1 measured 4.4 cm^2 in the right, and 2.6 cm^2 in the left side, giving a difference of 1.8 cm^2. We should keep in mind also that the surface of the conchal lamina can vary from simple to double between individuals (2.1 to 4.7 cm^2 range).

2.1.2. Middle turbinate.
The segment AB represents the line of attachment of the middle turbinate on the concha lamina (Figures 2 and 3). Its length can vary from 11.4 to 24.2 mm, and the difference in length of AB between the right and left sides of an individual can fluctuate between 1.1mm and 5.8 mm (p=0.02) (Table 1).
The segment AC gives the measurement of L2, and is equivalent to the length of the middle turbinate (Figure 4). It can range from 43 to 51.5 mm (average length 47 mm ± 1 mm). The length of the middle turbinate is constantly different between the right and the left side of a same individual, but the difference is weak (0.8 to 2.6 mm, p=0.02).
The surface of the middle turbinate (S2) (Figure 5) is outlined tracing a line starting from point A, following the anterior edge of the turbinate, turning posteriorly to follow the inferior edge to reach the point C, and then following the contour of the tail of the turbinate until finally reaching the point B. Then the area is enclosed by drawing the line AB. The difference of the area S2 between the right and left sides of one individual can vary from 0.3 to 1.9 cm^2 (p=0.04); averaging 1 ± 0.6 cm^2 (Table 1).

2.1.3. Superior turbinate.
The length of the superior turbinate (L3) is given by the segment BD, and can range from 11.5 to 20.2 mm (average length of 15.8 mm). The length L3 is almost constantly different from side to side in the same individual, but the difference is weak (rank 0 to 3.4 mm, p=0.05).
S3 is the surface of the superior turbinate and in a 2 turbinate ethmoidal wall is limited by the following landmarks (Figures 2 and 5): superiorly the virtual line BS, inferiorly the free edge of the superior turbinate, and posteriorly the anterior wall of the sphenoid. On 3 turbinate ethmoidal walls the landmarks are (Figure 3 and 6): superiorly the virtual line BE, inferiorly the free edge of the superior turbinate (BD), and posteriorly the free edge of its tail (DE). The difference in the surface S3 between one individual's left and right sides can vary from 0.2 to 0.9 cm^2 (p=0.04), averaging 0.2 ± 0.15 cm^2.

2.1.4. Surface of the turbinal wall of the ethmoidal labyrinth.
This surface S is outlined by the following landmarks (Figure 7): superiorly the ethmoidal roof, anteriorly a line running through point A continuing downwards with the free edge of the operculum and then on the uppermost portion, inferiorly the free edge of the middle turbinate, and posteriorly the anterior face of the sphenoid. This surface can vary in size from simple to double (from 6.1 to 11.3 cm^2). The average difference between left and right sides of the same head is 1.3 ± 1.2 cm^2 (0 to 3.6 cm) (p=0.02)

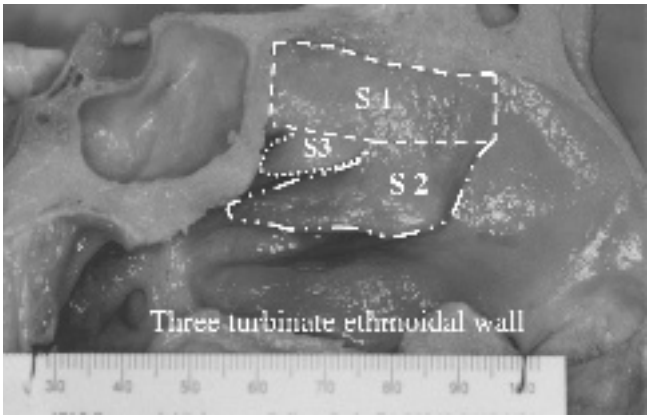

Figure 6. Surface measurements on three turbinate ethmoidal walls.
S1 = surface of the conchal lamina
S2 = surface of the middle turbinate
S3 = surface of the superior turbinate

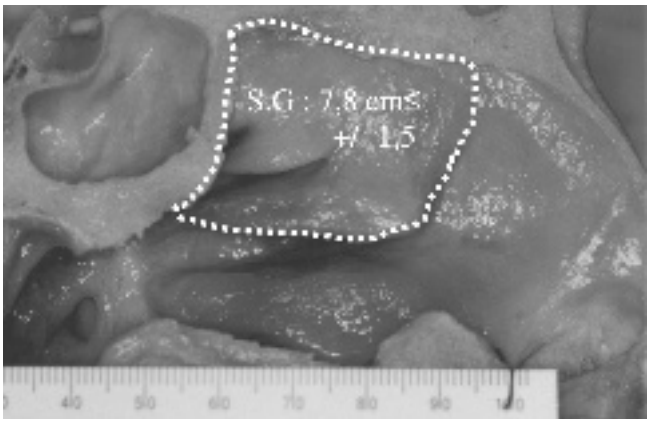

Figure 7. Surface S of the turbinal wall of the ethmoidal sinus.
This surface S is outlined by the following landmarks: superiorly the ethmoidal roof, anteriorly a line running through point A (see Figure 3) continuing downwards with the free edge of the operculum and then on the uppermost portion, inferiorly the free edge of the middle turbinate, and posteriorly the anterior face of the sphenoid.

2.2. Study of the variability between 2 and 3 turbinate walls.
This study was done on 12 head halves, using the 5 isolated head halves, and adding one half of each of the remaining complete heads (so to not include a same individual twice, creating a statistical gap). In this way we could compare the measurements from 8 ethmoidal walls with 2 turbinates, and 4 walls with 3 turbinates.
Globally the measurements from the 3 turbinate walls were superior to the ones obtained in 2 turbinate walls, but probably because of the little number of studied cases, this proved to be statistically significant only for the measurements of the segment AB (the inserting root of the middle turbinate to the conchal lamina, $p<0.001$) and for L1 (the length of the conchal lamina, $p=0.04$). The surface of three turbinate ethmoidal walls was almost 2 cm bigger than the one in 2 turbinate walls (9.9 ± 1.4 versus 8.1 ± 2.1) (Table 2).

Table 2. Turbinal wall of the ethmoidal labyrinth - Comparison between the measurements of two (n=8) and 3 (n=4) turbinate walls. The lengths are expressed in millimetres, the surface in square centimetres (cm^2). (see legend of Table 2) (p = unpaired t-test)

	Two turbinate Ethmoidal wall (n = 8)	Three turbinate Ethmoidal wall (n = 4)	p
HA	**9.1 ± 2.1**	**10.3 ± 1.5**	**0,37**
	[11.4 ; 6.2]	**[11.4 ; 8.1]**	
HB	**8.7 ± 2.1**	**10.8 ± 3.1**	**0.18**
	[12.1 ; 6]	**[13.6 ; 7]**	
L1	**32.3 ± 4.7**	**38.3 ± 2.8**	**0.04**
	[40.1 ; 27]	**[42.4 ; 36.3]**	
S1	**3 ± 0.9**	**3.8 ± 1**	**0.20**
	[4.4 ; 1.7]	**[4.4 ; 2.9]**	
AB	**11 ± 2.3**	**21.7 ± 1**	**<0.001***
	[17.7 ; 8]	**[22.6 ; 20.2]**	
L2	**44.8 ± 5.2**	**48.8 ± 3.9**	**0.20**
	[51.5 ; 34]	**[54.2 ; 46.8]**	
S2	**4.1 ± 1.4**	**4.8 ± 0.3**	**0.40**
	[6 ; 1.6]	**[5.1 ; 4.4]**	
L3	**14.5 ± 3.2**	**19.7 ± 6.3**	**0.80**
	[19.8 ; 10]	**[28 ; 12.9]**	
S3	**0.4 ± 0.2**	**0.5 ± 0.2**	**0.46**
	[0.7 ; 0.1]	**[0.7 ; 0.3]**	
S	**8.1 ± 2.1**	**9.9 ± 1.4**	**0.17**
	[10.6 ; 4.2]	**[11.3 ; 8.4]**	

3. Residual surface of the turbinal wall of the ethmoidal labyrinth after resection of the middle turbinate.
The surgical resection of the middle turbinate is composed by four steps: 1) Section of the inserting root of the middle turbinate on the conchal lamina, following the course of line AB, 2) Downwards luxation of the middle turbinate in order to expose its residual attachment at the level of its tail, 3) Section of the tail of the middle turbinate on the lateral nasal wall, and 4) Extraction of the middle turbinate in one piece through the nostril.
The residual surface of the turbinal wall after the resection of the middle turbinate can then be calculated by the equation: *S – S2=Residual surface*, S being the total surface of the turbinal wall of the ethmoidal labyrinth, and S2 being the surface of the middle turbinate. The proportion of turbinal wall which has been resected can also be calculated by the equation: *S2/S*. These numbers were calculated on the twelve studied head halves. Resection of the middle turbinate represents 49% (range 38-60%) of the total turbinal wall. Its resection preserves around 4.3 cm^2 (range 2.6 to 6.3 cm^2) of the turbinal wall of the ethmoidal labyrinth (Table 3).

Table 3. Residual surface of the turbinal wall of the ethmoidal labyrinth (S-S2) after middle turbinate resection (n=12). (S = total surface of the turbinal wall of the ethmoïdal labyrinth; S2 = surface of the middle turbinate; S2/S = proportion of the turbinal wall, which has been resected).

SPECIMEN	S	S2	S-S2	S2/S
1D	7.1	3.5	3.6	0.49
8D	10.5	5	5.5	0.48
9D	8.7	4.4	4.3	0.50
12D	6.1	2.9	3.2	0.47
15D	10.6	6	4.6	0.57
2G	8.6	5.2	3.4	0.60
4G	8.7	4.4	4.3	0.51
13G	4.2	1.6	2.6	0.38
5D	11.3	5	6.3	0.44
6D	10.9	5.1	5.8	0.47
7D	8.4	4.4	4	0.52
10D	8.9	4.6	4.3	0.52
Mean	*8.7*	*4.34*	*4.3*	*0.49*
Maxi	*11.3*	*6*	*6.3*	*0.60*
Mini	*4.2*	*1.6*	*2.6*	*0.38*
Standard deviation	*2.1*	*1.18*	*1.21*	*0.06*

DISCUSSION

This study allows us to discuss two different topics: the anatomic nomenclature and the resection of the middle turbinate.
The anatomic nomenclature we use to describe the lateral wall of the nasal cavity is somewhat different to the one we find in reference anatomy textbooks (Lang, 1989; Federative committee on anatomical terminology, 1998). Huizing (2003) has recently made some suggestions for improving the incorrect terminology in nasal anatomy. He suggests using either the Cottle-classification or better the anatomical nomenclature: nostril, vestibule, valve area, anterior nasal cavity, and posterior nasal cavity (the latter two divided in inferior, middle and upper meatus). However, in this anatomical nomenclature the limit between anterior and posterior nasal cavity is artificial. The lateral wall of the nasal cavity can actually be described from an anatomical, clinical and surgical point of view in two

parts: anteriorly the pre-turbinal lateral wall, and posteriorly the conchal or turbinal wall of the nasal cavity. In the pre-turbinal lateral wall we find the lateral wall of the nostril, vestibule, valve area, and Cottle's attic area (area 3 of Cottle), which correspond to the external nose and to the face. Posteriorly, the turbinal wall of the nasal cavity is also the medial wall of the sinuses: the ethmoid labyrinth in the upper part, and the maxillary sinus in the lower part. Our paper is focused on the turbinal wall of the ethmoid labyrinth, because of its major implications in endonasal surgery.

The interest of the nomenclature herein proposed is that it looks more adapted to the descriptions of modern medical imagery. Modern nasal endoscopy permits an easy examination of the whole pre-turbinal lateral wall, but of only the inferior half of the turbinal wall of the nasal cavity in most of the patients. (We do not consider in this paper the major place of endoscopy in the examination of the reliefs seen in the middle meatus, which do not belong to the lateral wall of the nasal cavity). The upper half, and particularly the turbinal wall of the ethmoid, is well visualized endoscopically only in a few particular cases. In fact we usually need to use modern imagery like CT scan and/or MRI to better examine this superior wall. So, a common language seems necessary to allow clear communication between anatomists, endoscopic surgeons, and radiologists. The nomenclature, definitions and dimensions described in this paper may serve as propositions.

All the dimensions we present on the turbinal wall of the ethmoidal labyrinth are to some extend arbitrary, as they have been obtained on a restricted number of specimens and on photographs. However, compared to very precise anatomic standards such as those published in the book of Lang (1989), our data seem very close. For instance, the length of the middle turbinate ranges according to Lang between 30-54 mm (mean 40.6 mm), and according to our study between 43-51.5 mm (mean of the right side: 47.5 mm; mean of the left side: 46.4 mm). The length of the superior turbinate lies according to Lang between 7-27 mm (mean 16.8 mm), and according to our study between 11.5-20.2 mm (means: 15.9 and 15.7 mm respectively for right and left side). So, we might be confident in all the other measurements we report, and especially on the surface of the turbinal wall of the ethmoid labyrinth that we leave after resection of the middle turbinate.

The development of Functional Endoscopic Sinus Surgery, concomitantly with the apparition of CT scans, have attracted the clinician's attention to the ethmoidal labyrinth septations and compartments; and also on the anatomical variations that are risk factors during surgery, or those that can have a role in the physiopathology of sinus diseases. The middle turbinate (its anatomy, physiologic role, the interest in its surgical preservation) has been the subject of several controversies (Kennedy, 1998; Rice, 1998). However, only a few works have been dedicated to the description of the superior half of the turbinal wall of the ethmoidal labyrinth, and particularly to the importance of the conchal lamina.

By simply observing the turbinal wall of the ethmoidal labyrinth, it is easy to understand the essential role of the conchal lamina in olfaction: this bony plate is the bearer of the olfactory nerve fibers. In humans, the olfactory mucosa is not characterized by a yellow colored stain as in some animals. This uncertainty in the topography of the olfactory neuroepithelium (Moran et al., 1992) has yielded some fears in the iatrogenous resection of the middle turbinate. Indeed, it is anatomicaly possible for some olfactory nerve fibers descending from the cribriform plate to pass beyond the virtual line AB and to expand all over the medial surface of the middle turbinate. This fact is supported by the work of Feron et al. (1998) that describes the finding of fragments of olfactory neuroepithelium in about the half of 24 biopsies obtained on the medial surface of the middle turbinate, and particularly at two anatomical sites: in the surrounding region of the point A, and in the mid portion of the middle turbinate. In the study by Leopold et al. (2000), the biopsies were guided by data obtained on a previous olfactogram. This work tends to show that just a few olfactory receptors can be found below the line of insertion AB. The paper by Leopold is more compatible with clinical data.

In fact, Biedlingmaier and Whelan (1996) did not find a single trace of olfactory neuroepithelium on twelve middle turbinate heads that they had surgically resected. Friedman et al. (1996) did not find any difference either in preoperative or postoperative UPSIT olfactory scores in 38 patients with normal odor perception in whom a surgical resection of the middle turbinate was done. These scores were also compared with the scores of 26 normosmic patients with no turbinate resection, without finding any statistically significant difference. The systematic resection of the middle turbinate, as reported during a nasalisation surgery, does not affect the capacity of recovering olfaction in patients operated on rhinosinusal polyposis (Jankowski et al., 2003).

In fact, the present anatomical study shows that approximately half of the turbinal wall of the ethmoidal labyrinth is preserved after resection of the middle turbinate, leaving around 4.3 cm^2 of its surface (ranging from 2.6 to 6.3 cm^2). Besides, the classical data estimate that the surface of the olfactory mucosa in humans is around 2 to 4 cm^2 (Moran et al., 1982), and that only half can be found on the turbinal wall of the ethmoidal labyrinth.

The physiologic role of the middle turbinate is somewhat unknown, and its resection has been blamed of causing prolonged periods of post-operative nasal crusting. Only few publications have studied this phenomenon. In our experience, nasal crusting seldomly exceeds the first post-operative month, and when it is the case, a predisposing factor always seems to exist (smoking, mucoviscidosis, professional unhealthy environment, bad hygiene, etc…).

The conchal lamina, on the other hand, appears as the noble sensorial element of the turbinal wall of the ethmoidal labyrinth. It can be described as a continuous bony plate, roughly rectangular in shape, measuring approximately 1cm in height and 3.5cm in length that forms the lateral wall of the olfactory groove of the nasal fossa. The present anatomic study shows that its dimensions can vary from simple to double in different subjects. It seems to us that rather than considering the level difference between the ethmoidal roof and the cribriform plate (Keros classification) (Keros, 1962), we should consider the height of the conchal lamina as a predictive risk factor in ethmoidal surgery. In fact, the smaller the values of distances HA or HB are (6mm being the smaller number reported in our series), the closest to the cribriform lamina the surgical instruments would be during surgery. The height of the conchal lamina is easely measured on pre-operative CT scans.
Indeed the conchal lamina is well visualized on CT scans, but it has only been the subject of few radiologic descriptions (Teatini et al., 1996). Besides measuring its height, the scanner could also allow the clinician to study the pattern of the ethmoidal cells in contact with this lamina. This is important because the surgical dissection needs to be very careful at this level in order to firstly preserve the olfactory fibbers, and secondly to avoid penetrating into the anterior floor of the skull base. In fact, Kainz and Stammberger did show that the junction between the ethmoidal roof and the conchal lamina in the anterior ethmoid is the least resistant zone (Kainz et al., 1989).

In conclusion, our work highlights that the key structure of the turbinate wall of the ethmoidal labyrinth is the conchal lamina. This conchal lamina is in our surgical practice a fundamental landmark and the key structure to preserve when the aim of surgery is a complete but functional exenteration of the ethmoid labyrinth.

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