Differentiation between Posterior Sinuses Using the Medial Orbital Floor as a Landmark

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Abstract

Objectives This study aims to evaluate the difference in height between the floors of the posterior ethmoid and sphenoid sinuses with respect to the medial orbital floor (MOF) to confirm this difference as a landmark for identification of the posterior sinuses. It also aims to describe this difference regarding the type of pneumatization of the sphenoid sinus (conchal, presellar, and sellar).

Design A cross-sectional study was conducted.

Study Center The study was conducted at the Department of Radiology of Hospital de Clínicas de Porto Alegre, a tertiary care university hospital in Southern Brazil.

Materials and Methods A standardized and computerized analysis of 100 tomography scans of sinuses (200 sides), in patients older than 18 years, was carried out.

Results Mean vertical distance (height) from the MOF to the floor of the posterior ethmoid and sphenoid sinuses was 0.72 ± 1.85 mm and 9.48 ± 3.81 mm, respectively. There was no statistically significant difference as compared with sex and side. We found conchal-type sphenoid sinus pneumatization in 1.5% ($n = 3$), presellar in 13.5% ($n = 27$), and sellar in 85% ($n = 170$), whereas the vertical distance between the MOF and the floor of the sphenoid sinus was 2.04 ± 0.81 in the conchal-type sinuses, 5.71 ± 2.49 in the presellar sinuses, and 10.21 ± 3.52 in the sellar sinuses. No sphenoid sinus showed its floor above the MOF, regardless of the type of pneumatization.

Discussion and Conclusion The present study demonstrates that there is a difference between the floor of the posterior sphenoid and ethmoid sinuses in adults, which is more evident when the sphenoid sinus is well pneumatized. These data suggest that the difference in height between the floors of the sinus investigated in our study may be considered during endoscopic sinus surgery to guide adequate localization, but the surgeon should be aware of the type of pneumatization of the sphenoid sinus to use this landmark.

Keywords
- medial orbital floor
- posterior ethmoid sinus
- sphenoid sinus
- endoscopic sinus surgery
- landmarks

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Introduction

The history of endoscopic sinus surgery (ESS) began in 1901, when Hirschmann used a modified cystoscope to examine paranasal sinuses (PNS). Since the 1950s, Messerklinger, Stammberger, and Wigand have described different surgical techniques for endoscopic sinus approach. Many advances have been made after that, with the emergence of new surgical materials and imaging studies, providing better understanding of sinuses anatomy and, thus, making it possible to perform more advanced surgeries.[1]

During ESS, as the surgeon proceeds anteroposteriorly, approaching the posterior sinuses (posterior ethmoid and sphenoid sinuses), risk of complications increases as the surgeon comes closer to the complex anatomy in this region. Despite the improvements achieved in the past years, complications still occur during ESS. A safe posterior sinus approach is only achieved with a deep knowledge of the sinus anatomy, its relationship with adjacent structures, and anatomical variations.

One of the possible difficulties during transmeatal sphenoidectomy is the anatomical differentiation between the posterior ethmoid and the sphenoid sinuses, because the anterior wall of the sphenoid sinus is the border of the posterior portion of the posterior ethmoid cells. Thus, during dissection of this region, sometimes it is difficult to identify the exact transition between the two sinuses. This occurs especially when the sphenoid sinus is very small, or when there are large posterior ethmoidal cells.[2]

Ethmoidal cells are derived from the ethmoid bone (part of the medial orbit), whereas the sphenoid sinus results from the pneumatization of the sphenoid bone. Thus, it seems obvious that during their development these sinuses respect the boundaries of the bones they derived from. That is, since the inferior border of the orbit is closer to the skull than the inferior border of the sphenoid bone, the differences between the floors of their respective sinuses should follow the same pattern.

Some authors have suggested this height difference between the sinuses as a landmark for differentiation between the sinuses using the medial orbital floor (MOF, which corresponds to the roof of the maxillary sinus) as reference.[3,4] However, these studies were based on personal observation, or small samples. There is no study designed specifically to measure this difference in tomographic images. Moreover, there is no research assessing the impact of the type of sphenoid pneumatization on this difference. That is, can we use the difference between the floors of the sinus as a reference point regardless of the type of sphenoid sinus pneumatization?

The objective of the present study was to compare the height of the floors between the posterior ethmoid and sphenoid sinuses using the MOF as a reference point and to relate this height difference to the type of pneumatization of the sphenoid sinus.

Materials and Methods

Setting and Participants

This cross-sectional study was conducted at the Department of Radiology of the Hospital de Clínicas de Porto Alegre (HCPA), a tertiary university hospital in southern Brazil. We retrospectively analyzed computed tomography (CT) sinus scans from the imaging database of the HCPA in patients older than 18 years, between January 2012 and December 2012.

CT sinus scans from patients who had undergone previous sinus surgery, had orbital malformations, neoplasias, or other abnormalities affecting the anatomy or hindering the visualization of the regions studied were excluded from the study.

Procedures

CT scans were performed using multidetector scanner (Philips, Brilliance 16 Power model, software version 2.3.0, Netherlands; GE Healthcare, Brightspeed S8, software release 10 BW 27.7, Pennsylvania, United States). The images were viewed using the Impax software, version 6.3 (Agfa-Gevaert N.V., Mortsel, Belgium), and postprocessed on a computer using the Volume Viewing software, version 3.1 (GE Healthcare), at 0.5 mm slice thickness.

All measurements were performed by an ear-nose-throat (ENT) specialist and were repeated in 40 sides by a radiologist to assess agreement. Each examiner was blinded to the measurements performed by the other.

To avoid measurement errors, those images showing inappropriate head positioning were adjusted using specific tools of the software based on a line parallel to the hard palate as a reference point.

Measurement parameters were established by two ENT specialists trained in sinus surgery and one radiologist.

The MOF was used as the reference point. To ensure standardized measurements, the most prominent point of the junction between the lamina papyracea and the maxillary sinus roof in the MOF was used. This region was marked on coronal sections, and the position was confirmed on axial and sagittal sections using multiple plane reconstruction (►**Fig. 1**).

In the sagittal plane, the floors of the posterior ethmoid sinus and ipsilateral sphenoid sinus were identified. The vertical measure (height) was taken from these points to the projection of the reference structure, which was previously marked on the coronal plane (►**Figs. 2** and **3**). If the sinus floor was located above the MOF, a negative value was assigned.

With regard to the sphenoid sinus, the pneumatized portion of the clivus was not considered to be floors (when the posterior wall of the sphenoid sinus extends posteriorly beyond the vertical coronal plane traced in the posterior wall of the sella turcica). When there was mucosal thickening, the bony area of the floor was included in the measurement, and the mucosal region was disregarded.

The sphenoid sinuses were divided based on their pneumatization degree according to Hamberger and Hammer classification[5]: Conchal type (rudimentary or absent), presellar (pneumatization reaches the anterior face of the sella turcica), and sellar (pneumatization reaches the posterior face of the sella turcica) (►**Fig. 4**).

The evaluation of CT slices was done regarding both sides of the sinuses as separate cavities.

Statistical Methods

The statistical analysis was performed using the Statistical Package for the Social Sciences version 19.0. Continuous

Fig. 1 Multiple plane reconstruction of CT scan on coronal, axial, and sagittal sections, representing the MOF. CT, computed tomography; MOF, medial orbital floor.

variables were expressed as mean ± standard deviation (SD) (if normal distribution) and median and interquartile interval (if not normal distribution). Categorical variables were described as percentages. Averages were compared using the Student *t*-test for independent samples (if normally distributed) or Mann–Whitney test (if not normally distributed). A p value less than 0.05 indicated statistically significant difference.

Intraclass correlation coefficient was calculated to assess interobserver agreement.

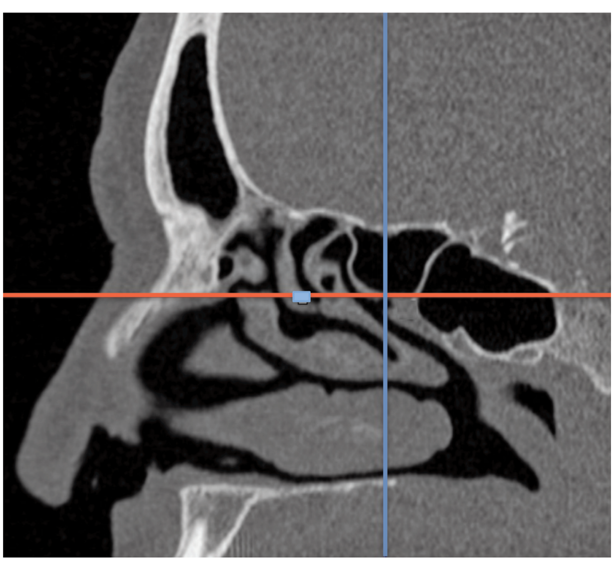

Fig. 2 Vertical measure from the medial orbital floor (blue square) to the floor of the right posterior ethmoid sinus. The red line shows the border of the lower portion of the posterior ethmoid sinus, which is at the same height as the medial orbital floor, thus assigning a zero value.

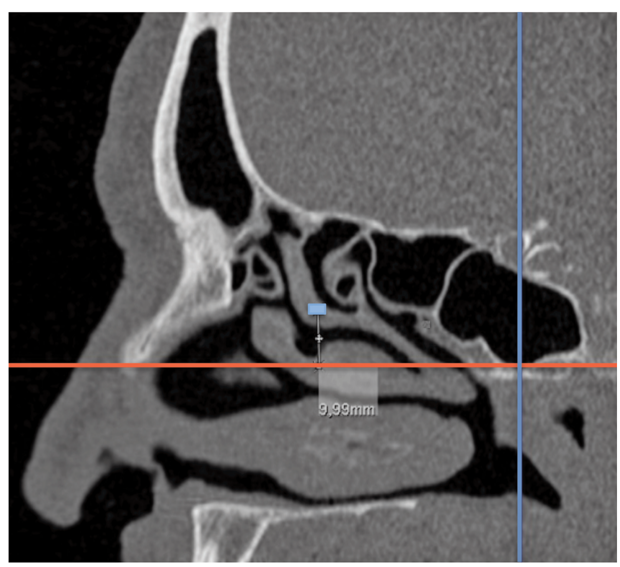

Fig. 3 Vertical measure from the medial orbital floor (blue square) to the floor of the right sphenoid sinus. The red line shows the border of the lower portion of the sphenoid floor. There is a difference of 9.9 mm in height in this case.

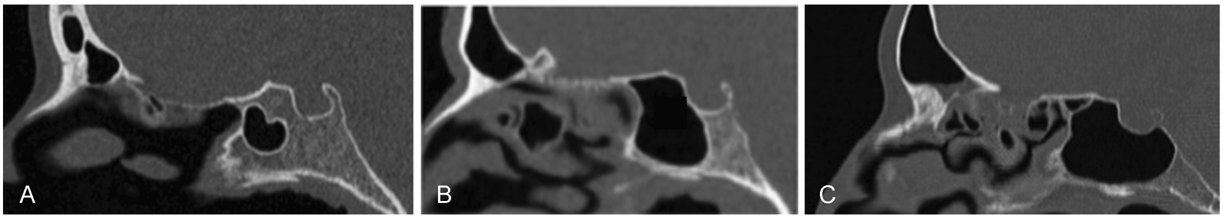

Fig. 4 Types of pneumatization of the sphenoid sinus. (A) conchal; (B) presellar; (C) sellar.

The study was approved by the Research Ethics Committee of the HCPA, and a liability form regarding the use of data was signed by the authors.

Results

A total of 100 patients (200 sides) were included in the study; 45 men and 55 women. The patients' ages ranged from 19 to 88 years (mean = 48.2 years).

The vertical measure (height) from the MOF to the floors of the posterior ethmoid and sphenoid sinuses are shown in ►**Table 1**.

There was no statistically significant difference between the heights of the floors relative to MOF as compared with sex and side (►**Table 2**).

The mean difference between the ethmoid floor and the sphenoid floor was 8.76 ± 3.18 mm (minimum = 1 mm, maximum = 16.8 mm). In addition, the sphenoid floor was below the posterior ethmoid floor in 100% of the cases.

The pneumatization of the sphenoid sinus was conchal type in 1.5% ($n = 3$), presellar in 13.5% ($n = 27$), and sellar in 85% ($n = 170$), with differences among types, obtained by the method of one-way analysis of variance and Tukey posthoc test medium at 5% probability ($p < 0.05$).

The mean vertical distance (height) from the MOF to the floor of the sphenoid sinus according to the type of pneumatization is shown in ►**Table 3**. We found a significant difference between the groups using Student t test ($p < 0.0001$) after grouping the conchal and presellar types and comparing them with the sellar type.

No sphenoid sinus floor was located above the MOF, regardless of the type of pneumatization.

Intraclass correlation coefficient between the observers was 0.92 for the sphenoid floor, and 0.87 for the posterior ethmoid floor.

Table 1 Vertical distances between the MOF and the floor of posterior paranasal sinuses

Height (mm)	MOF and SS floor	MOF and PE floor
Mean ± SD	9.48 ± 3.81	0.72 ± 1.85
Median (q1;q3)	9.22 (6.75–11.9)	0 (0–2)
Range	0.9–19.4	−5.6 to 5.1

Abbreviations: MOF, medial orbital floor; PE, posterior ethmoid; (q1;q3), interquartile interval; SD, standard deviation; SS, sphenoid sinus.

Discussion

Because of the increasing popularity of ESS and the growing risks posed by increasingly advanced approaches to the

Table 3 Mean and SD of height between MOF and sphenoid sinus floor according to degree of pneumatization

Type of pneumatization	Mean ± SD (mm) of height between MOF and sphenoid sinus floor
Conchal	2.04 ± 0.81[a]
Presellar	5.71 ± 2.49[b]
Sellar	10.21 ± 3.52[c]

Abbreviations: SD, standard deviation; MOF, medial orbital floor.
[a-c]One-way analysis of variance and Tukey posthoc test medium at 5% probability ($p < 0.05$).

Table 2 Distances between MOF and sphenoid and posterior ethmoid floors compared in relation to sex and side

	Sex		Side	
	Male	Female	Right	Left
MOF and sphenoid floor				
Mean ± SD	9.95 ± 3.87	9.13 ± 3.75	9.38 ± 3.93	9.59 ± 3.71
p Value	0.13[a]		0.48[b]	
MOF and posterior ethmoid floor				
Mean ± SD	0.92 ± 1.74	0.57 ± 1.92	0.60 ± 1.97	0.84 ± 1.72
p Value	0.16[a]		0.2[b]	

Abbreviations: SD, standard deviation; MOF, medial orbital floor.
[a]Student t-test for independent samples.
[b]Paired Student t-test.

sinuses and their adjacent regions, many endoscopic and radiological studies have been conducted with the purpose of better understanding the anatomy and the potential reference points that can help guide surgeons during endoscopic procedures.[2,4,6–9]

Approaches to the posterior ethmoid and sphenoid sinuses are common procedures that offer significant risks during ESS. The major concern when entering these areas is the inadvertent breach of the skull base. In these cases, prevention is the best management. Prevention is based on the surgeon's familiarity with the region that will be approached and detailed knowledge of its anatomy.

The anatomy of the sphenoid sinus has been extensively studied through measurements of the sphenoid structures or even adjacent structures, such as the upper turbinate, which can assist surgeons with their localization and dissection.[10–12] However, few studies have contributed to the surgical differentiation between the posterior ethmoid and sphenoid sinuses during transethmoidal approaches. The concepts provided by May (1994) and Casiano (2001) were the first ones to demonstrate that the MOF could serve as an anatomical landmark during ESS.[3,4] Other prior radiologic studies have already showed that MOF is an important guide for entering the posterior ethmoid and sphenoid sinus. Lee et al demonstrated that at the MOF height, the posterior ethmoid skull base and sphenoid skull base were always superior to this line.[9]

The study conducted by Casiano in 2001, which was a pioneering study in the determination of the endoscopic measurements of the MOF in relation to the floor of the posterior PNS, has the limitation of a small number of human cadaver heads (11 cadavers, 18 sides).[4] In this study, the height from the MOF to the sphenoid sinus floor was similar to that of our study. However, the measure between the MOF and the floor of the posterior ethmoid sinus was different in our study. Casiano found a mean value of 4.89 mm in the direct measurement and 5.42 mm in the endoscopic measurement, whereas we found a mean value of 0.72 mm. This can be explained by the fact that different points of the MOF were used by Casiano to take the measures in his study. Furthermore, the small number of cadaver heads may also contribute to explain such difference. Therefore, the importance of this current study is that the floor of the PE and sphenoid sinuses were at different distances relative to the MOF and thus can be used as a distinguishing characteristic between the PE and sphenoid sinus, also serving as a landmark.

In line with our study, Orlandi et al radiologically simulated the angle of view with a zero degree nasal endoscope during ESS. They found that the floor of the posterior ethmoid sinus can be seen with a zero degree nasal endoscope with this angle of view. Conversely, the sphenoid sinus floor cannot be seen, suggesting that the inability to see this floor indicates the presence of the sphenoid sinus.[2] Although these authors did not quantitatively compare the height of the floor of the posterior ethmoid sinus with that of the sphenoid sinus, their study also considered the difference in height of the floor of the posterior sinuses, confirming and complementing our findings.

Previous studies about the pneumatization of the sphenoid sinus have shown similar results, with the sellar sinus being the most common type (approximately 85%).[5] The higher the degree of pneumatization, the greater the distance from the sphenoid floor to the MOF. This is explained by well-established knowledge about the pneumatization process of the sphenoid, which also happens in the inferior and lateral directions.[13] The preoperative radiological evaluation of the pneumatization of the sphenoid sinus is extremely important for surgical planning, both regarding sphenoid sinus surgeries and transsphenoidal approaches to the skull base.

Our findings are in agreement with the notion that the ethmoidal cells are derived from the pneumatization of the ethmoid bone, which is one of the components of the medial orbit and, therefore, the ethmoid floor is located very close to that level. Conversely, the sphenoid sinus is derived from the pneumatization of the sphenoid bone, and its floor is located in a lower region.

Image-guided ESS has gained ground in recent years because it provides guidance to the surgeon. However, this tool has some important limitations, such as its high cost, which prevents routine use in many hospitals. Navigators are used to confirm the localization, thus increasing the safety of the procedure. Therefore, the use of navigators should be seen as an aid, but it should never replace deep understanding of the anatomical region being approached.[14,15] Consequently, further studies that can help better understand anatomy are warranted, even when such advanced technological tools, are available. From an academic standpoint, this type of tool can be used to conduct studies confirming the usefulness of reference points, such as the ones discussed in the present study.

CT scan was the imaging method chosen to perform the measurements in our study because it is widely used and offers better image resolution than magnetic resonance imaging for analysis of the bone structures of the PNS. The preoperative evaluation using CT scan is very useful in ESS planning because it makes it possible to measure the extent of sinus diseases. CT scans also help to identify anatomical variations and landmarks that may be useful during dissection.[16,17]

We included in this study only patients over 18 years, with the aim of avoiding analysis of patients who presented incomplete pneumatization of PNS. Thus, our results have validity only for the adult population.

We decided on the use of the MOF as the reference point because it is easily identifiable during wide maxillary antrostomy and is always exposed and visible during the approach to the posterior ethmoid and sphenoid sinuses. This region is not often affected by previous extensive inflammatory diseases or surgeries, which makes it a consistent reference point.[3,6,9] It is noteworthy that patients with inflammatory disorders, such as chronic rhinosinusitis with or without polyposis, were not excluded from the study because we believe that such disorders do not change the reference point. Thus, we conclude that the MOF can be used as a reference point during ESS. It is especially useful when the anatomy has been affected by extensive inflammatory processes, or when there is deeper dissection and during revision surgeries.

Because the ethmoid sinus floor is usually very close to the orbital floor, the sphenoid sinus floor is, on average, 9.48 mm below this reference point, and no sphenoid floor was found above the MOF or the ethmoid floor in the present study, we believe that the vertical measure from the MOF to the floor of the posterior ethmoid and sphenoid sinuses is an additional anatomical information that can be useful to differentiate this structures. Therefore, when a posterior cell is found and there is doubt about it being the posterior ethmoid sinus or the sphenoid sinus, a possible solution is to compare the floor of the cell and the MOF, thus achieving a reference point for this localization. Such information is especially relevant when there are sphenoethmoidal cells (Onodi cells), which are posterior ethmoidal cells that pneumatize more laterally and posteriorly to the sphenoid sinus, because these cells may be a point of confusion between the sinuses.

In conclusion, the present study shows that, in adults, the floor of the sphenoid is always below the floor of the posterior ethmoid and the MOF, confirming, through imaging studies, previous studies performed with cadavers. We have shown for the first time the relationship between the type of pneumatization of the sphenoid sinus and the difference in height of the floors of the posterior ethmoid and sphenoid, demonstrating that it is more evident when the sphenoid sinus is well pneumatized. These data suggest that this landmark may be considered during endoscopic surgery to guide adequate localization, but the surgeon should be aware of the type of pneumatization of the sphenoid sinus to use this landmark.

References

1 Messerklinger W. [Endoscopy of the nose]. Monatsschr Ohrenheilkd Laryngorhinol 1970;104(10):451–456

2 Orlandi RR, Smith B, Shah L, Wiggins RH III. Endoscopic verification of the sphenoid sinus. Int Forum Allergy Rhinol 2012;2(1):16–19

3 May M, Schaitkin B, Kay SL. Revision endoscopic sinus surgery: six friendly surgical landmarks. Laryngoscope 1994;104(6 Pt 1):766–767

4 Casiano RR. A stepwise surgical technique using the medial orbital floor as the key landmark in performing endoscopic sinus surgery. Laryngoscope 2001;111(6):964–974

5 Hamberger CA, Hammer G, Norlen G, Sjogren B. Transantrosphenoidal hypophysectomy. Arch Otolaryngol 1961;74:2–8

6 Harvey RJ, Shelton W, Timperley D, et al. Using fixed anatomical landmarks in endoscopic skull base surgery. Am J Rhinol Allergy 2010;24(4):301–305

7 Perondi GE, Isolan GR, de Aguiar PH, Stefani MA, Falcetta EF. Endoscopic anatomy of sellar region. Pituitary 2013;16(2):251–259

8 Isolan GR, de Aguiar PHP, Laws ER, Strapasson ACP, Piltcher O. The implications of microsurgical anatomy for surgical approaches to the sellar region. Pituitary 2009;12(4):360–367

9 Lee JM, Woods T, Grewal A. Preoperative evaluation of the maxillary sinus roof as a guide for posterior ethmoid and sphenoid sinus surgery. J Otolaryngol Head Neck Surg 2012;41(5):361–369

10 Orlandi RR, Lanza DC, Bolger WE, Clerico DM, Kennedy DW. The forgotten turbinate: the role of the superior turbinate in endoscopic sinus surgery. Am J Rhinol 1999;13(4):251–259

11 Millar DA, Orlandi RR. The sphenoid sinus natural ostium is consistently medial to the superior turbinate. Am J Rhinol 2006;20(2):180–181

12 Bolger WE, Keyes AS, Lanza DC. Use of the superior meatus and superior turbinate in the endoscopic approach to the sphenoid sinus. Otolaryngol Head Neck Surg 1999;120(3):308–313

13 Wolf G, Anderhuber W, Kuhn F. Development of the paranasal sinuses in children: implications for paranasal sinus surgery. Ann Otol Rhinol Laryngol 1993;102(9):705–711

14 Orlandi RR, Petersen E. Image guidance: A survey of attitudes and use. Am J Rhinol 2006;20(4):406–411

15 Smith TL, Stewart MG, Orlandi RR, Setzen M, Lanza DC. Indications for image-guided sinus surgery: the current evidence. Am J Rhinol 2007;21(1):80–83

16 Batra PS. Radiologic imaging in rhinosinusitis. Cleve Clin J Med 2004;71(11):886–888

17 Beale TJ, Madani G, Morley SJ. Imaging of the paranasal sinuses and nasal cavity: normal anatomy and clinically relevant anatomical variants. Semin Ultrasound CT MR 2009;30(1):2–16