

ORIGINAL STUDY

Variations of sphenoid pneumatization: a CBCT study

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ABSTRACT

BACKGROUND. The pneumatization pattern of the sphenoid sinus seems rather unpredictable, as resulted from previous studies. It is however extremely important for endoscopic approaches to target structures of the middle cranial fossa, such as the pituitary gland.

MATERIAL AND METHODS. We aimed at documenting by Cone Beam Computed Tomography (CBCT) the possibilities of anatomic variation of the sphenoid sinus. 25 randomly selected patients were retrospectively analyzed.

RESULTS. In 56%, the left and right sphenoidal sinuses were bilaterally symmetrical with respect to the sagittal pneumatization type: four patients had sellar types, one had presellar type and in nine cases the sphenoidal sinuses were reaching posteriorly to the sella turcica. Only in 8% of cases were found conchal types of pneumatization, but they were part of anatomical pictures including Onodi air cells. Such an Onodi cell presented a posterior (sphenoidal) recess reaching posteriorly and superiorly to the pterygopalatine fossa. The recesses of the sphenoid sinus were also documented: anterior or septal, ethmoidal, maxillary, clinoidal and lateral. In 32% was found a lateral recess only engaged between the vidian and maxillary nerve canals.

CONCLUSION. It appears that CBCT is a reliable tool for accurate anatomic identification of the sphenoid sinus pneumatization pattern, on a case-by-case basis.

KEYWORDS: sphenoid sinus, recess, Cone Beam Computed Tomography.

INTRODUCTION

The transsphenoidal approach of the skull base has become a usual surgical procedure which targets the sellar, parasellar and suprasellar regions of the middle cranial fossa, as well as Meckel's cave and the clivus¹. Anatomical studies are essential in increasing the anatomical knowledge and improving surgical performance². Although pituitary surgery is traditionally within the realm of neurosurgeons, otolaryngologists became active partners in the surgical management of hypophysis to decrease rates of complications and morbidity³, being known that the posterior ethmoid air cells and the sphenoid sinus are surrounded by more vital structures than any other sinus⁴.

The sphenoid sinus is probably the most variably pneumatized structure of the skull; its recesses are able to facilitate minimally invasive access to different surgical targets, thus it play roles in the selection of surgical procedures¹. From a developmental point of view, the sphenoid sinus will not reach its full extension until adolescence and it may occasionally extend into the vomer, ethmoid, palatine and occipital bones, as well as in different parts of the sphenoid bone, such

as the anterior clinoid process, the lesser wing and the great wing, and the pterygoid process⁵. The pneumatizations of the anterior clinoid process and pterygoid process are surprisingly common⁶.

According to its sagittal extension, as related to the sella turcica, the sphenoid sinus was classified either in three, or in four types. There are authors describing sellar, presellar and conchal types of sinus, which occur in 55%, 17% and, respectively, 28% of cases⁷. This classification in three types was suggested by Congdon in 1920⁸. Other authors also considered the postsellar pneumatization⁹ which can occur in more than 50% of cases¹⁰. There were not found differences in regard to age, gender and ethnicity⁹.

The lateral recess of the sphenoid sinus was evaluated in relation to the pterygopalatine fossa, and was classified in six types: type I, in which such recess is absent in the posterior fossa wall, type II, when the recess reaches above the vidian canal, type III with the recess engaged between the vidian and maxillary nerve canals, type IV, of alar pneumatization, type V, in which the root of the pterygoid process lodges the pneumatic expansion and type VI, of combined alar and pterygoid pneumatizations¹¹.

This article was aimed at studying retrospectively a lot of patients evaluated with Cone Beam Computed Tomography, to determine the prevalence of sagittal patterns of pneumatization of the sphenoid sinuses, as well as the prevalence of the sphenoid sinuses recesses.

MATERIAL AND METHODS

A Cone Beam CT (CBCT) study was performed retrospectively on a randomized lot of 25 subjects who were scanned for various dental procedures, the informed consent for using the scan data having been obtained. The subjects were scanned using a CBCT machine – iCat (Imaging Sciences International), and the CT data were analyzed using the iCatVision software and the application 3DVR v5.0.0.3, for the three-dimensional reconstructions, the specific protocol having been previously described¹¹. Bidimensional

multiplanar reconstructions (MPRs) in the axial, coronal and sagittal planes, as well as three-dimensional volume renderizations (3D VRs) with different filters and with variable bone subtraction, were performed.

The conchal, presellar, sellar and postsellar patterns of sagittal pneumatization were documented, as well as the occurrence of clinoid, anterior (septal), anterolateral (maxillary, or palatine), ethmoidal and lateral recesses of the sphenoid sinuses, these latter being considered in relation to the extent of pneumatization within the greater wing and the pterygoid process.

RESULTS

Fourteen patients (56%) of the general lot (n=25) had bilateral symmetries of the sphenoid sinus pneumatization types: 4 (16%) were of sellar type, 9 (36%) were postsellar and in one case (4%) the sphenoid

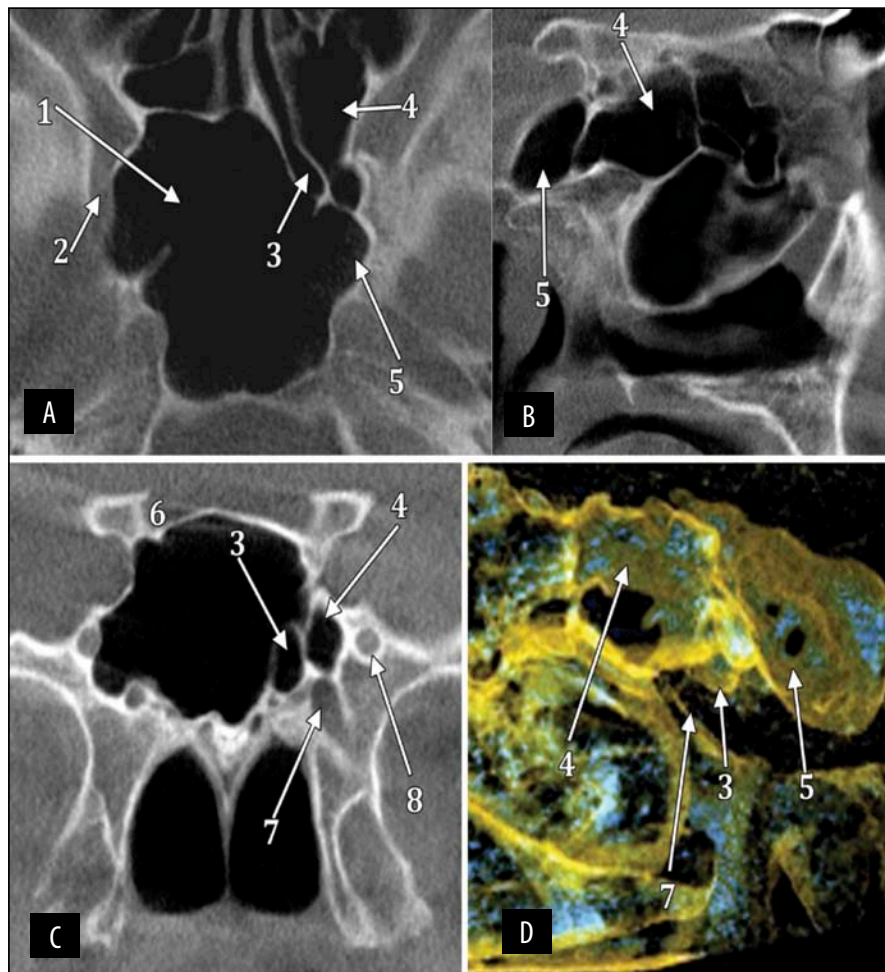


Figure 1 (A) Sphenoid sinus of conchal type, surrounded by a posteriorly extended Onodi cell and by the contralateral extension of the opposite sphenoid sinus. A. axial MPR; (B) sagittal MPR; (C) coronal MPR; (D) three-dimensional volume renderization (filter: transparent skin, bone transparency: 99%, left lateral view). 1. right sphenoid sinus, of postsellar type; 2. right canal of maxillary nerve; 3. left sphenoid sinus, of conchal type; 4. left Onodi cell; 5. left lateral recess of the right sphenoid sinus; 6. right optic canal; 7. left pterygopalatine fossa; 8. left canal of maxillary nerve

sinus had presellar pneumatization. Eleven patients (44%) had bilaterally asymmetrical pneumatization of the sphenoid sinuses, as related to the sella turcica.

From the 50 sphenoid sinuses that were investigated, only in two cases (8%) conchal types of pneumatization of the sphenoid were found. In both cases, the opposite sinus had postsellar pneumatization and complex variations of pneumatization were found around the optic canal and pterygopalatine fossa. In one of these cases (Figure 1), a large Onodi cell was found on the same side (left) with the sphenoid sinus of conchal type and it was sending a posterior (sphenoid) recess placed posteriorly and superiorly to the pterygopalatine fossa; the ipsilateral sphenoid sinus was placed between that posterior expansion of the Onodi cell and a contralateral recess of the opposite sphenoid sinus, of postsellar type. The opposite sphenoid sinus was thus bilaterally expanded within the sphenoid body, reaching bilaterally in direct relation with the optic and vidian canals. In the second case

(Figure 2), there were bilateral Onodi cells and the left sphenoid sinus had conchal pneumatization. There was asymmetrical pneumatization of the anterior clinoid process: while on the left side the optic strut was pneumatized from the right sphenoid sinus, on the right side the anterior clinoid process was pneumatized from the Onodi cell on that side. So, the clinoid pneumatization was beneath the optic canal on the left side but above that canal on the right side.

Presellar pneumatization of the sphenoid sinuses was found in four cases (16%): in one case it was symmetrical and, in the other three cases (12%), only one of the sphenoid sinuses had presellar pneumatization. Sellar types of pneumatization were encountered in ten patients (40%), in six of them being asymmetrical (24%). Postsellar types of pneumatization were documented in 20 patients, in 11 cases (44%) being asymmetrical.

Recesses of the sphenoid sinus were also documented. In 14 patients (64%) the anterior (septal)

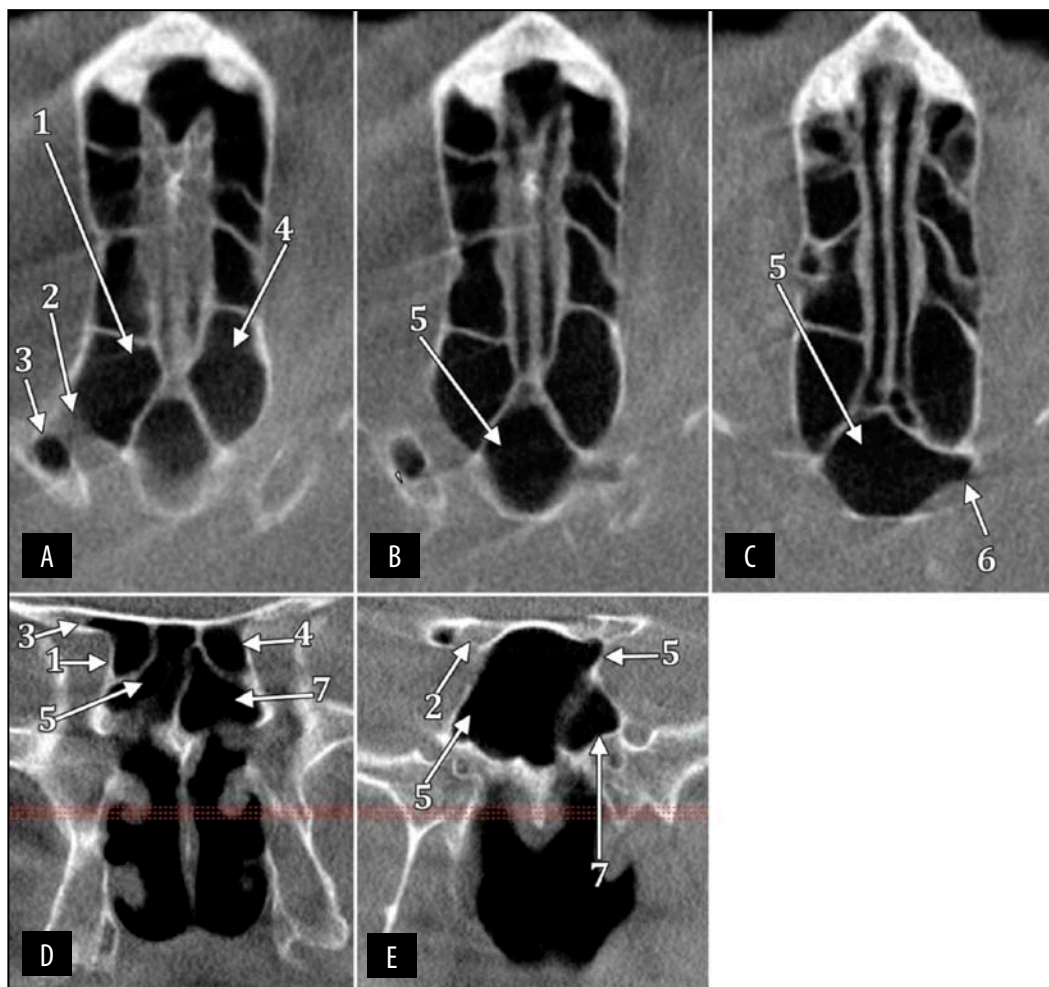


Figure 2 Bilateral anatomic variations around the optic canals: 1. right Onodi cell; 2. right optic canal; 3. clinoid recess of the Onodi cell, passing above the optic canal; 4. left Onodi cell; 5. right sphenoid sinus; 6. left clinoid recess of the right sphenoid sinus; 7. left sphenoid sinus, of conchal type

recess was unilateral (Figure 3) and only in one case (4%) it was bilateral.

Except the variant of the clinoid pneumatization anatomically related to a conchal pneumatization of the sphenoid, the optic strut was pneumatized from the ipsilateral sphenoid sinus in four patients, in two of these (8% of the general lot) the pneumatization being unilateral and in the other two being bilateral (Figure 3).

According to the length of the maxillary recess of the sphenoid sinus, it was evaluated either as short or long, depending upon whether it reached or not the maxillary sinus wall. Long maxillary recesses were encountered bilaterally in four cases (16%). In three cases (12%), bilateral short maxillary recesses were found, while in five cases (20%) such short expansions were unilateral, three on the left side and two on the

right side. In two patients (8%), on one side a long maxillary recess was found, while on the opposite side it was the short subtype (Figure 3). In only three cases we found unilateral small recesses projecting towards the posterior ethmoid air cells (Figure 4).

In evaluating the lateral recesses of the sphenoid sinuses, we took into account the variable relation of that pneumatization with the vidian and maxillary nerve canals (Figure 3, Figure 5). In this regard, we gathered the data summarized in Table 1. On the right side prevailed (11/25) the second type of lateral pneumatization, only reaching above the vidian canal, while on the left side types I-III and VI were uniformly distributed. With reference to all fifty sphenoid sinuses, it appeared that the most usual pneumatization (32%) was the second type.

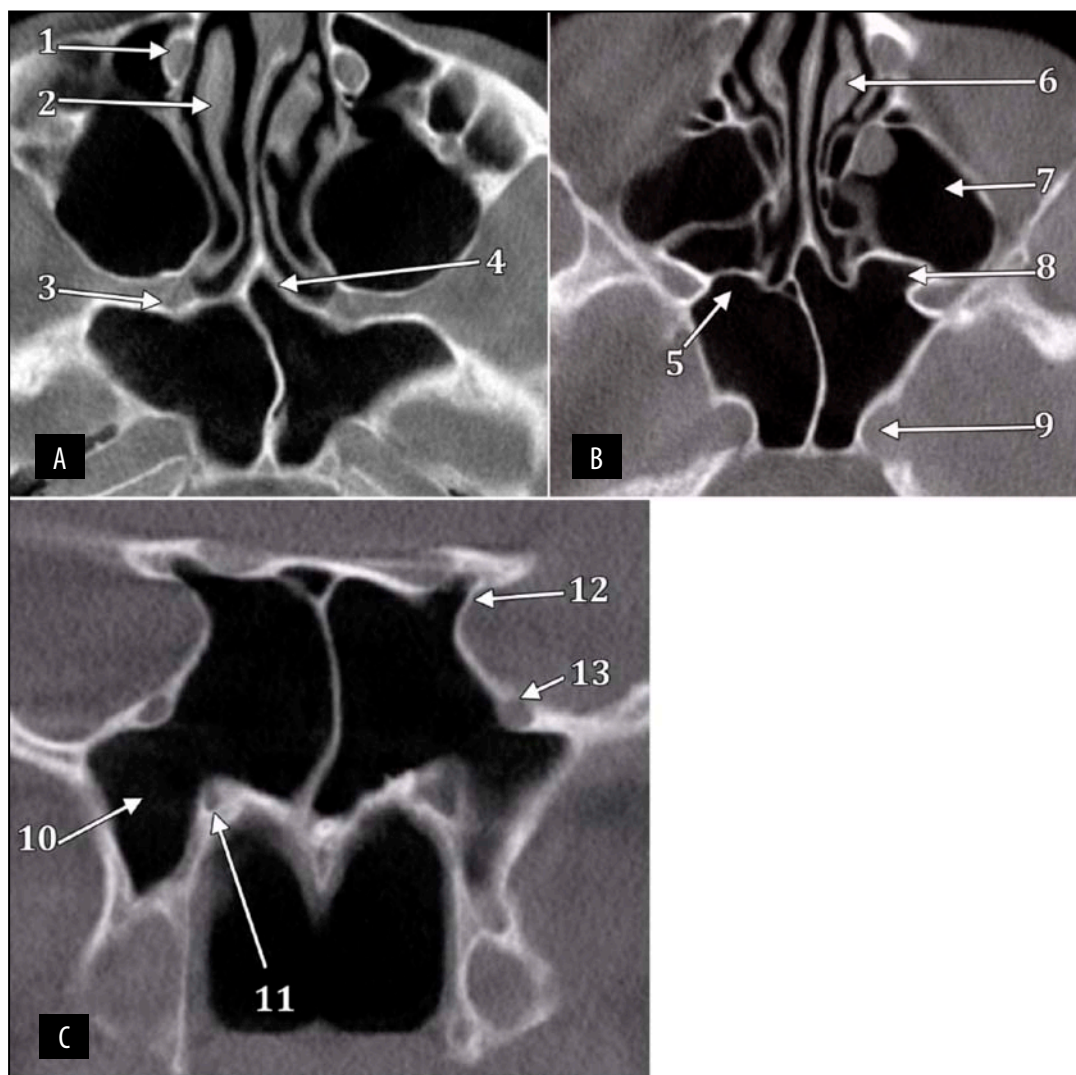


Figure 3 Recesses of sphenoid sinuses are evaluated on axial (A, B) and coronal (C) MPRs. 1. lacrimonasal canal; 2. inferior nasal turbinate; 3. right pterygopalatine fossa; 4. anterior recess of the left sphenoid sinus; 5. short maxillary recess of the right sphenoid sinus; 6. middle nasal turbinate; 7. maxillary sinus; 8. long maxillary recess of the left sphenoid sinus; 9. carotid sulcus; 10. combined pterygoalar pneumatization; 11. vidian canal; 12. clinoid recess; 13. maxillary nerve canal

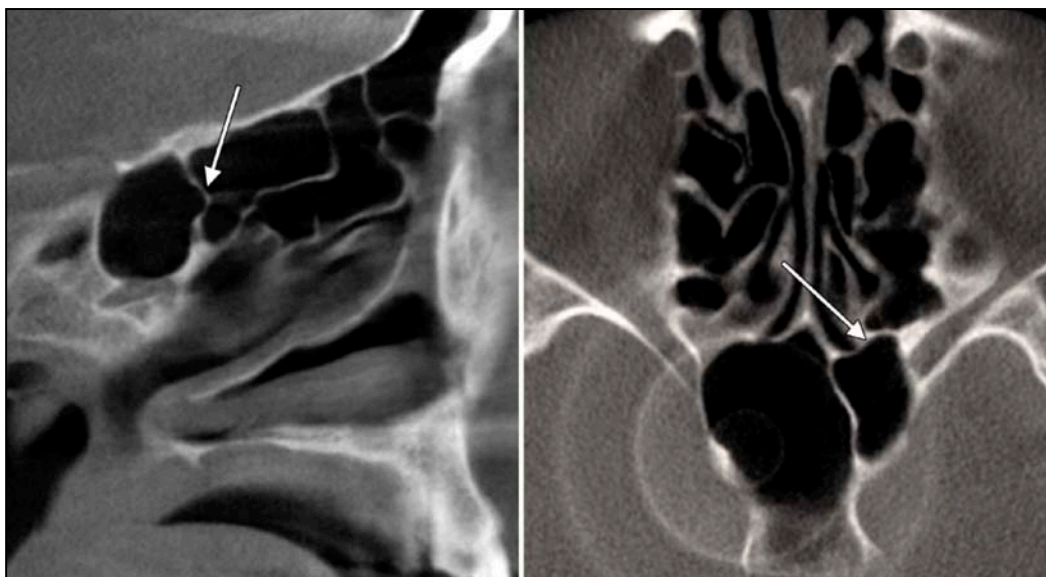


Figure 4 Sagittal and axial MPRs (left and, respectively, right panel) in two different patients. There are identified small ethmoidal recesses (arrows) of the left sphenoidal sinuses, projecting into the posterior ethmoid

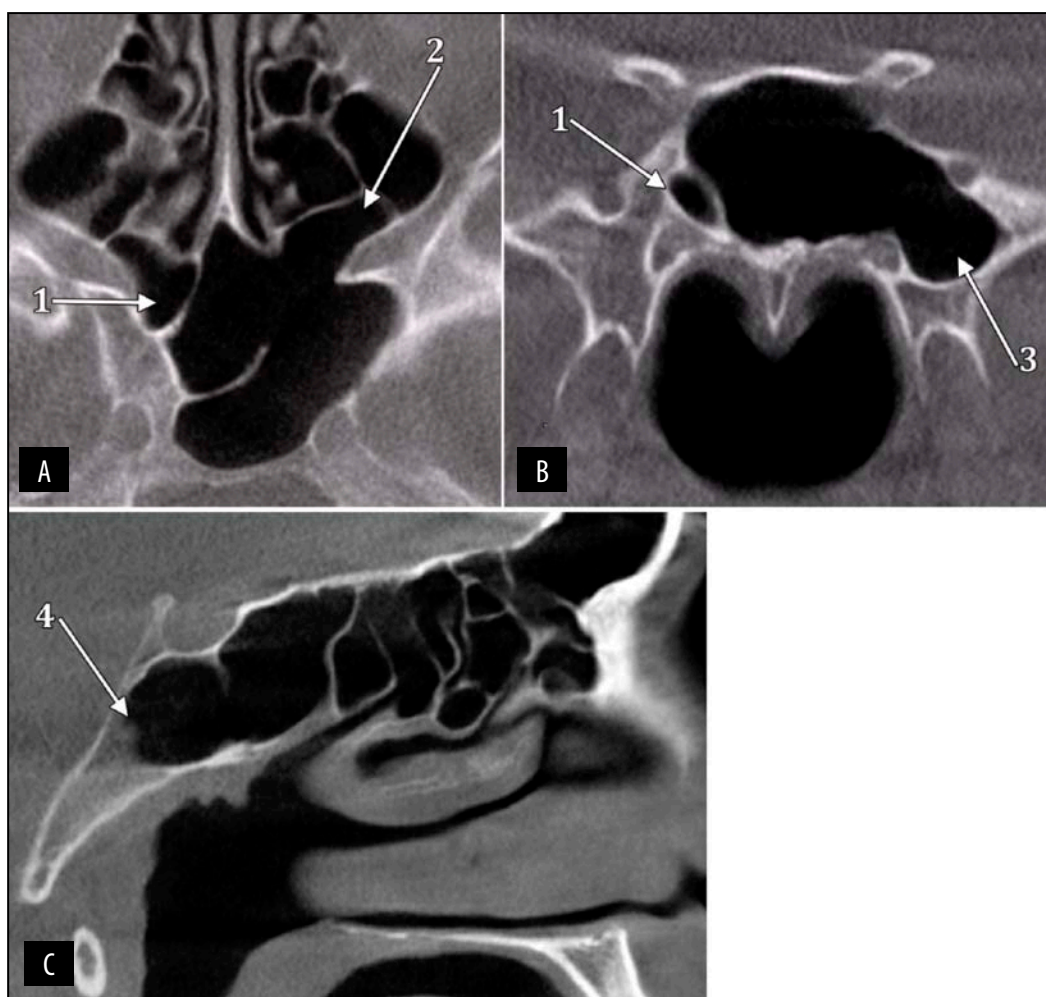


Figure 5 Axial (A), coronal (B) and sagittal (C) MPRs in a case of huge asymmetry of sphenoid sinuses. 1. right sphenoid sinus, of conchal type; 2. long maxillary recess of the left sphenoid sinus; 3. the lateral pneumatization of the left sphenoid sinus goes beyond the maxillary nerve canal but not inferior to the vidian canal opening anteriorly; 4. postsellar pneumatization of the sphenoid body

Table 1
Repartition of types of lateral pneumatization (I-VI) on each side and in the general lot

Type of lateral pneumatization	Right side (n=25)	Left side (n=25)	Total (N=50)
I	3	6	9
II	11	5	16
III	5	5	10
IV	-	1	1
V	1	3	4
VI	5	5	10

DISCUSSIONS

Different studies report a great variety of sphenoid sinus rates of pneumatization, but one similarity noted among these reports is that these rates depend on the ethnicity of the patients¹².

The sellar type of sphenoid sinus, which is the most common⁷, was classified according to the extensions of the pneumatizations in six types defined by the direction of the extension: sphenoid body, lateral, clival, lesser wing, anterior and combined¹. A different classification, also modified from usual standards, defined a type I pneumatization, with completely absent or minimal sphenoid sinus, a type II, corresponding to a presellar type, type III, with the posterior sinus wall beneath the sella turcica; there were two variants of type IV in which the posterior wall of the sinus was behind the sella, with or, respectively, without air in the dorsal sella¹³.

Lang (1989) classified the pneumatized extensions of the sphenoid sinus as follows¹⁴: (a) septal recess or sphenovomerine bulla, projecting between the alae of the vomer; (b) ethmoidal recess, rarely occurring; (c) superior and inferior lateral recesses extended, respectively, above and below the optic canal; (d) palatine recess (which we termed here maxillary recess, as previously done¹⁵), directed towards or reaching the orbital process of the palatine bone; (e) infero-lateral recess extending into the greater wing of the sphenoid bone and (f) the pterygoid recess. These two latter were considered here as subvariants of the lateral recess of the sphenoid sinus. Such an extensive alar pneumatization was reported reaching the oval foramen, the lateral wall of the orbital apex, the inferior limit of the temporal fossa and between the superior and inferior orbital fissures¹⁶, and modifies the usual anatomy of the parapharyngeal space¹⁷. An extensive lateral recess creates an area beneath the temporal

lobe, which seems relatively inaccessible to surgeons, but could be targeted by an endoscopic transpterygopalatine approach¹⁸. The lateral and clinoid recesses of the sphenoid sinus were found in 72.4% and, respectively, 20% of patients⁹. One should however take care of distinguishing between an ethmoid and a sphenoid origin of the anterior clinoid pneumatization: an ethmoid one usually reaches above the optic nerve, while a sphenoid one usually passes within the optic strut.

An Onodi cell may modify the surrounding anatomic structures, but it usually does not determine an alteration of the intrasphenoidal course of the vidian canal, being however significant as related to the anterior clinoid pneumatization¹⁹. When Onodi cells are present, the sphenoid sinus ostium shows tendency to be located inferiorly to a level observed in the absence of Onodi cells²⁰. We found however a case in which an Onodi cell was reaching the pterygopalatine fossa and the anterior opening of the vidian canal by a posterior, or sphenoidal, recess, which was, in our opinion, undescribed previously.

It was suggested the nose tip-ear apex line could represent a practical tool for orienting the sphenoid sinus, sellar floor and surgical trajectory of the endonasal transsphenoidal approach and it was discussed that preoperative 3D-CT increases the surgeon's confidence in such surgical approaches²¹.

As we have demonstrated, here and in other studies^{13,22,23}, CBCT is also a reliable tool for accurate anatomic identification of the sphenoid sinus, on a case-by-case basis.

CONCLUSIONS

As the anatomic possibilities of sphenoidal sinus variation are numerous, it is mandatory to evaluate the

patients prior to surgical or endoscopic procedures targeting the sphenoidal sinus on a case-by-case basis.

Conflict of interest. None.

Acknowledgements. None.

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