

Lateral frontoethmoidal cell obstructing frontal sinus drainage pathway – report of six cases

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Abstract

The European Anatomical Position Paper on the Anatomical Terminology of the Internal Nose and Paranasal Sinuses distinguishes anterior, posterior, medial and lateral frontoethmoidal cells. The lateral cells have not been characterized yet. Other classifications (Lee and Kuhn, International Frontal Sinus Anatomy Classification) neglect them. The aim of this study is to describe lateral frontoethmoidal cells in rhinosinusitis patients. Method: Analysis of medical records and computed tomography (CT) examinations using multiplanar reconstruction with adjustable planes. The lateral cell extending between the frontal beak and the skull base pushing the frontal sinus drainage pathway medially/anteromedially was identified in 6 patients. These cells could not be classified as anterior, posterior or medial according to existing classifications. Four patients were operated on previously due to sinonasal symptoms. The lateral frontoethmoidal cell is an underestimated anatomical variation that may contribute to the persistence of inflammatory disease and can be easily overlooked preoperatively.

Key words: radiology, endoscopy, frontal sinus, sinus anatomy, frontoethmoidal cell, sinus surgery.

Introduction

Frontoethmoidal cells are anterior ethmoid air spaces that alter the frontal sinus drainage pathway (FSDP) and may encroach into the frontal ostium and sinus [1–3]. The presence of these cells increases the difficulty of frontal sinus surgery [1–6]. Potentially, they may contribute to the development of recurrent acute rhinosinusitis or the persistence of inflammatory changes in paranasal sinuses despite proper conservative treatment. However, among different anatomical variations that may predispose to acute rhinosinusitis, the EPOS (European Position on Rhinosinusitis and Nasal Polyps 2012) does not list frontoethmoidal cells, nor are they discussed in this document [7]. Residual anterior ethmoidal cells were found to be responsible for the recurrence of chronic rhinosinus-

itis (CRS) after endoscopic sinus surgery [4, 5]. In CRS, it is not the presence of frontoethmoidal cells that results in the development of frontal sinusitis, but their opacification [8, 9].

Van Aleya presented the first detailed description of these cells [10]. He used the term frontal cells for “certain types of minor cells in the neighbourhood of the frontal sinus”. He characterized most of the cells currently referred to as frontoethmoidal cells. Their definitions and classifications have been evolving. Bent *et al.* defined frontal cells as those pneumatizing above the agger nasi, and divided them into four types [11]:

- type I – single frontal recess cell above agger nasi cell,
- type II – tier of cells in frontal recess above agger nasi cells,

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- type III – single massive cell pneumatizing cephalad into frontal sinus,
- type IV – single isolated cell within the frontal sinus.

This classification was further extended in 1996 [12] by adding:

- agger nasi cell (ANC),
- frontal bullar cells (FBC),
- suprabullar cells (SBC),
- supraorbital cells (SOEC),
- interfrontal sinus septal cells.

The exact definitions of these cells were not established until Lee *et al.* published a revised version of their classification (2004) [1]. The main paradigm of this classification was the division of the frontoethmoidal cells into three groups – anterior, posterior and medial – depending on their position within the frontal recess. This concept was sustained

by Wormald *et al.*, who clarified and simplified the nomenclature used by Kuhn *et al.*, although they suggested describing the position of the cells with respect to the FSDP [3].

The European Position Paper on the Anatomical Terminology of the Internal Nose and Paranasal Sinuses (2014) suggested classifying frontoethmoidal cells as anterior, posterior, medial or lateral with respect to the frontal recess/inner walls of the frontal sinus [2]. However, lateral cells were not characterized.

The aim of this study is to describe cases of rhinosinusitis patients with lateral frontoethmoidal cells that may contribute to disease persistence.

Case reports

Surgical cases of the patients operated on during a three-month period by the first author were eval-

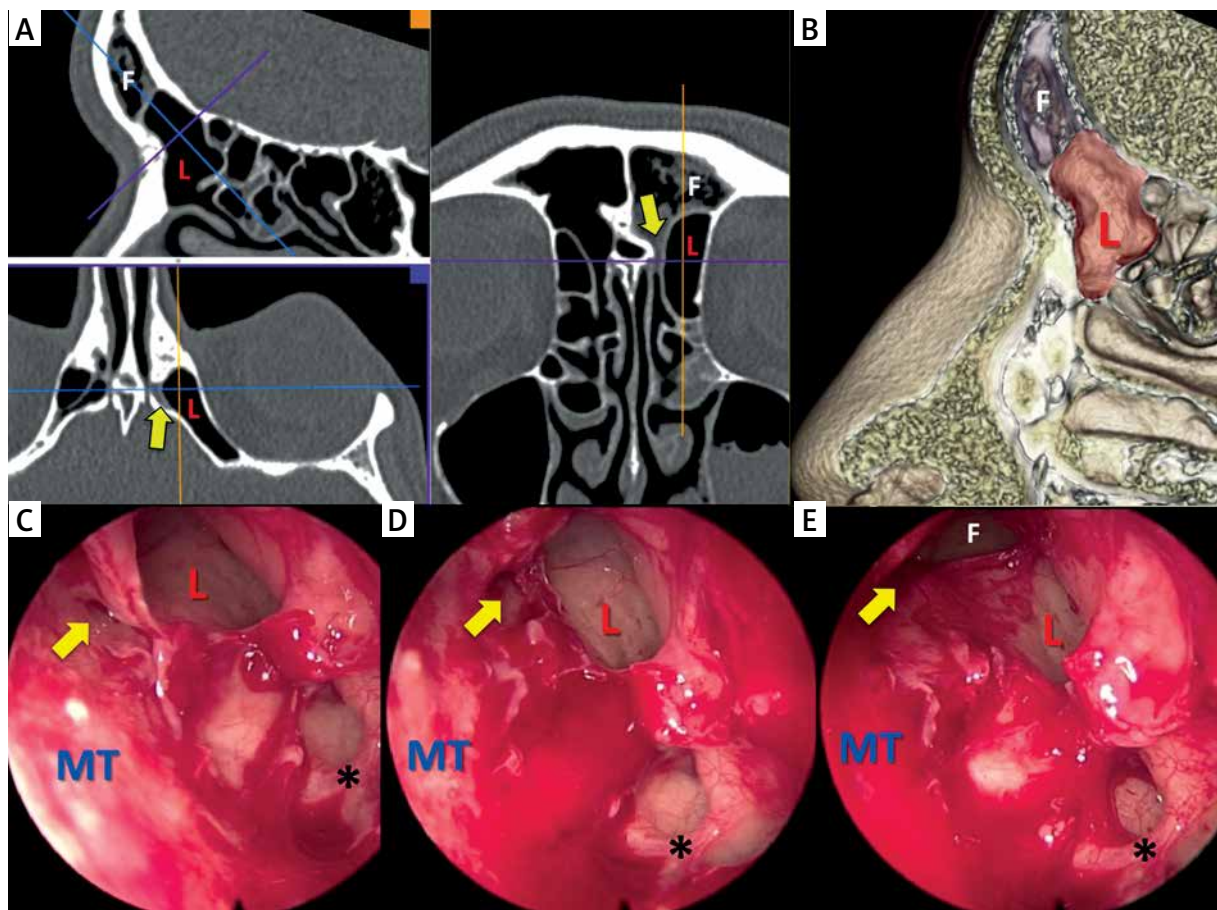


Photo 1. Lateral frontoethmoidal cell on the left side: **A** – multiplanar reconstruction (MPR) of CT, **B** – 3D reconstruction, **C–E** – consecutive steps of widening of the left FSDP (30° scope), **E** – the superior wall of the lateral cell is removed and the inside of the frontal sinus is visible

L – lateral cell, *F* – frontal sinus, yellow arrow – FSDP, *MT* – middle turbinate, asterisk – anterior ethmoidal artery.

uated. Computed tomography (CT) examinations were viewed with Horos (free DICOM medical image viewer) using multiplanar reconstruction (MPR) with adjustable planes. The university ethics committee approved the study.

Five patients with lateral cells that were operated on were identified. Additionally, we included one patient scheduled for surgery.

Case 1

A 45-year-old woman was admitted due to persistent left-sided nasal blockage, frontal headache and nasal discharge exacerbated by upper respiratory tract infections. The patient had undergone septoplasty 2 years earlier, but it did not improve her

symptoms. Thin slice (0.5 mm) paranasal sinus CT showed partial opacification in the left maxillary and frontal sinuses and total opacification of the FSDP, which was narrowed and pushed medially by a large frontoethmoidal cell pneumatizing above the frontal ostium (Photo 1). This cell extending from the frontal beak anteriorly to the fovea ethmoidalis could not be classified as anterior (supra agger frontal cell) or posterior (suprabulla frontal cell). Anterior frontoethmoidectomy and reoperation of the septum under endoscopic control was performed; the FSDP, which was pushed medially and anteriorly, was identified, the inferior wall of the lateral frontoethmoidal cell was opened (Photo 1 C), the FSDP was widened (Photo 1 D), and the upper wall of the lateral cell was removed (Photo 1 E). The postoperative period

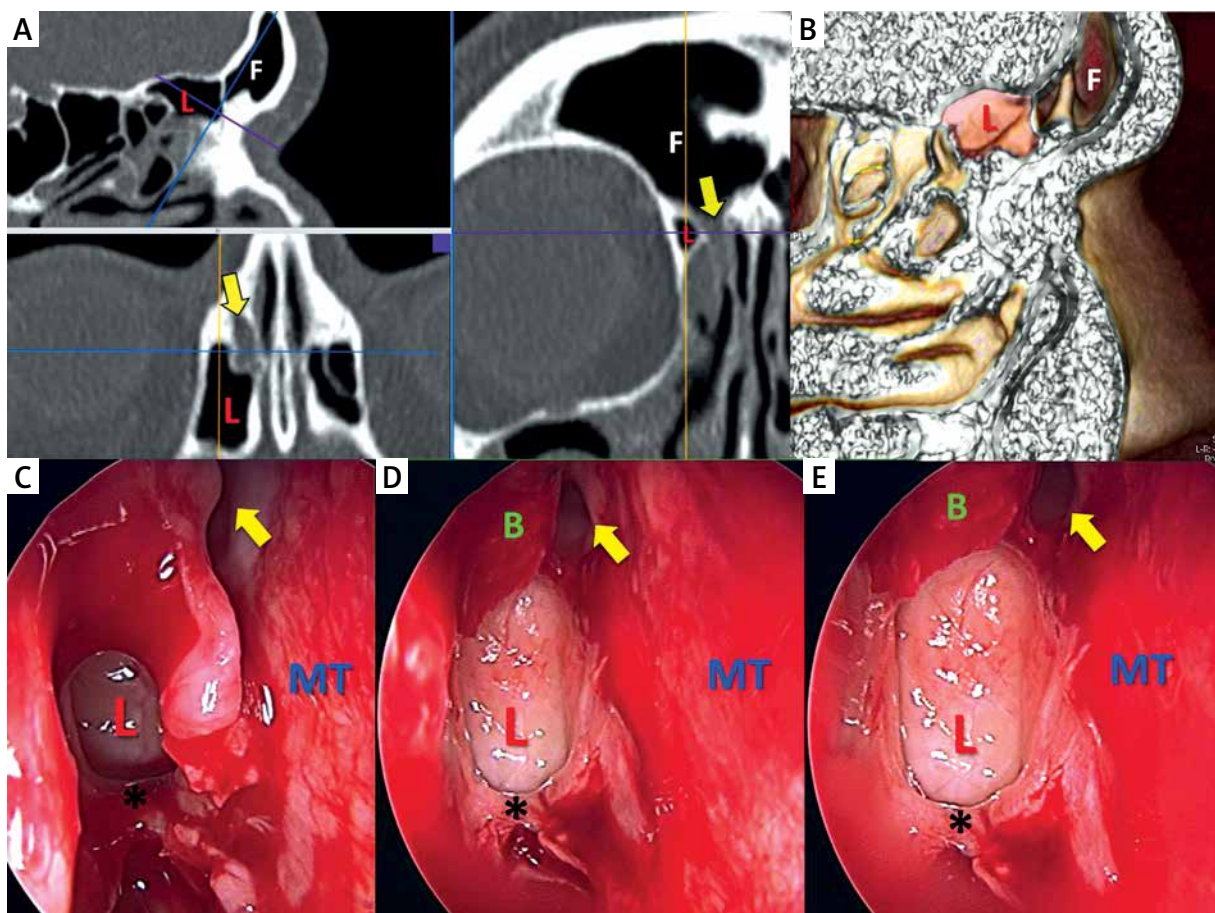


Photo 2. Lateral frontoethmoidal cell on the right side: **A** – multiplanar reconstruction (MPR) of CT, **B** – 3D reconstruction, **C–E** – consecutive steps of widening of the left FSDP (30° scope), **C** – lateral cell is opened, **D, E** – frontal ostium is visible anteriorly and medially to the lateral cell

L – lateral cell, *F* – frontal sinus, yellow arrow – FSDP, green *B* – frontal beak, *MT* – middle turbinate, asterisk – anterior ethmoidal artery.

was uneventful. The patient reported improvement in symptoms.

Case 2

A 44-year-old woman was admitted due to right-sided nasal blockage and frontal headaches exacerbated by upper respiratory tract infections. Paranasal sinus CT showed partial opacification of the ethmoids and the right FSDP, which was narrowed and pushed anteriorly and medially by a frontoethmoidal cell pneumatizing to the level of the frontal ostium (Photo 2 A). Frontoethmoidectomy

was performed; the FSDP was identified, the inferior wall of the lateral frontoethmoidal cell was opened (Photo 2 C), and the FSDP was widened (Photos 2 D, E). The postoperative period was uneventful. The patient reported relief of symptoms.

Case 3

A 35-year-old man with a history of chronic rhinosinusitis presented with frontal headaches. During the previous 10 years he had undergone two endoscopic procedures including one with adjunct extended trephination of the right frontal sinus and an

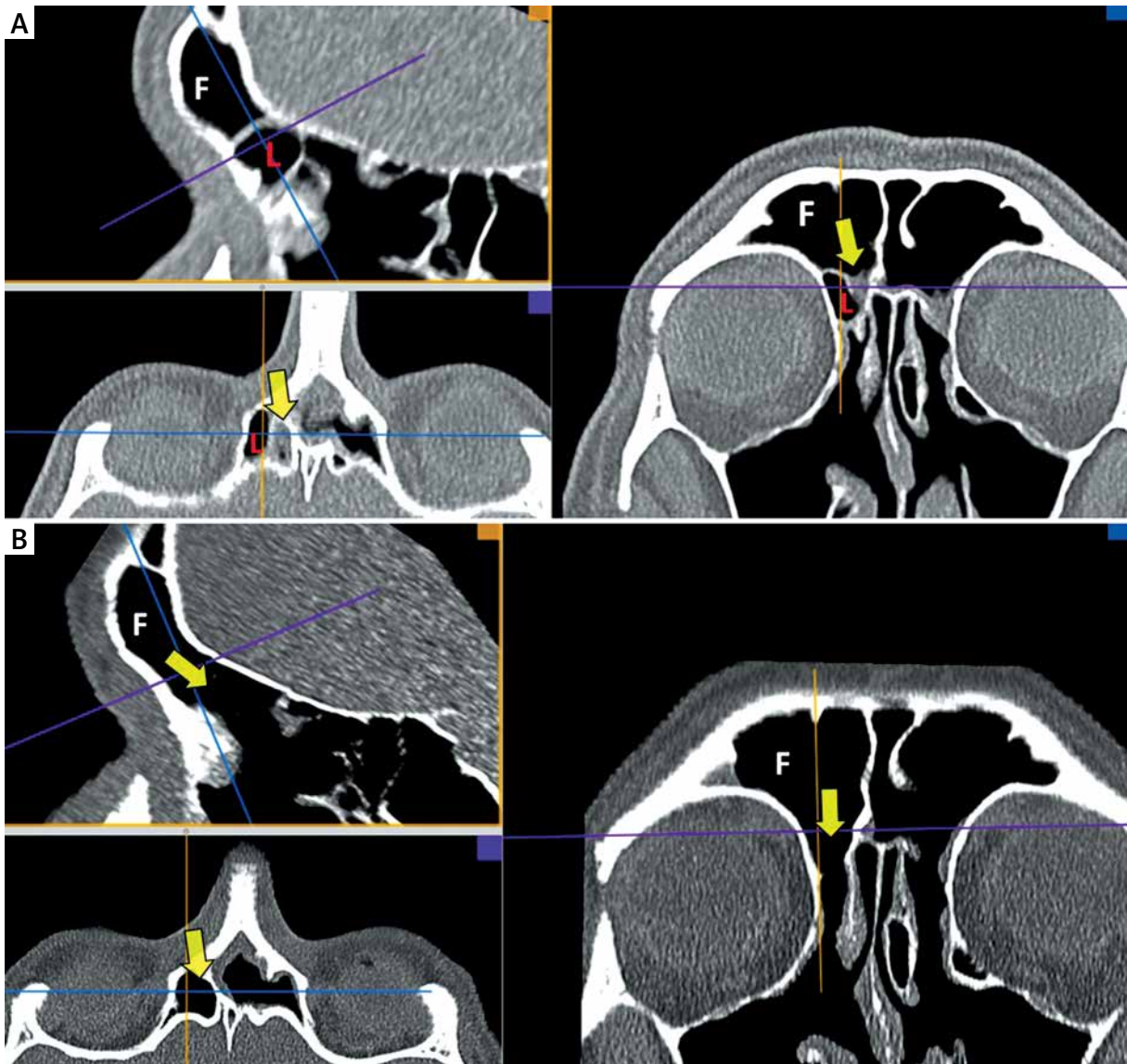


Photo 3. Lateral frontoethmoidal cell on the right side: **A** – preoperative, **B** – postoperative CT MPR
L – lateral cell, *F* – frontal sinus, yellow arrow – FSDP.

unsuccessful balloon sinuplasty. Paranasal sinus CT revealed total opacification of the right FSDP, which was pushed medially by the frontoethmoidal cell extending between the frontal beak and the skull base, pneumatizing to the level of the frontal ostium (Photo 3 A). During surgery the cell walls were removed. Although it could not be clearly seen on preoperative 1 mm scans (Photo 3 A), intraoperatively the posterior wall of the cell was found to be the skull base. The symptoms disappeared in the postoperative period. Control CT showed widely opened ostia of both frontal sinuses (Photo 3 B).

Case 4

A 35-year-old man with chronic rhinosinusitis and a history of multiple previous endoscopic sinus operations presented with a bilateral frontal headache. Paranasal sinus CT revealed total opacification of the

left frontal sinus and the FSDP, and partial opacification of the right frontal sinus and the FSDP. On both sides the FSDP was pushed medially by the lateral frontoethmoidal cell extending between the frontal beak and the skull base (Photo 4 A). The lateral cell on the left side was partly opened from below during one of the previous procedures (Photo 4 A). These cells (not opened at that time) were also visible on one of his previous CT examinations (Photo 4 B, C). They did not pneumatise to the anterior ethmoidal artery. During surgery the walls of the right lateral frontoethmoidal cell were easily removed, but on the left side the bony partition was much thicker and resistant to attempts of breaking. This led to partial removal of the mucosa in the vicinity of the frontal ostium. Endoscopic examination in the postoperative period confirmed patency of both ostia. The symptoms improved.

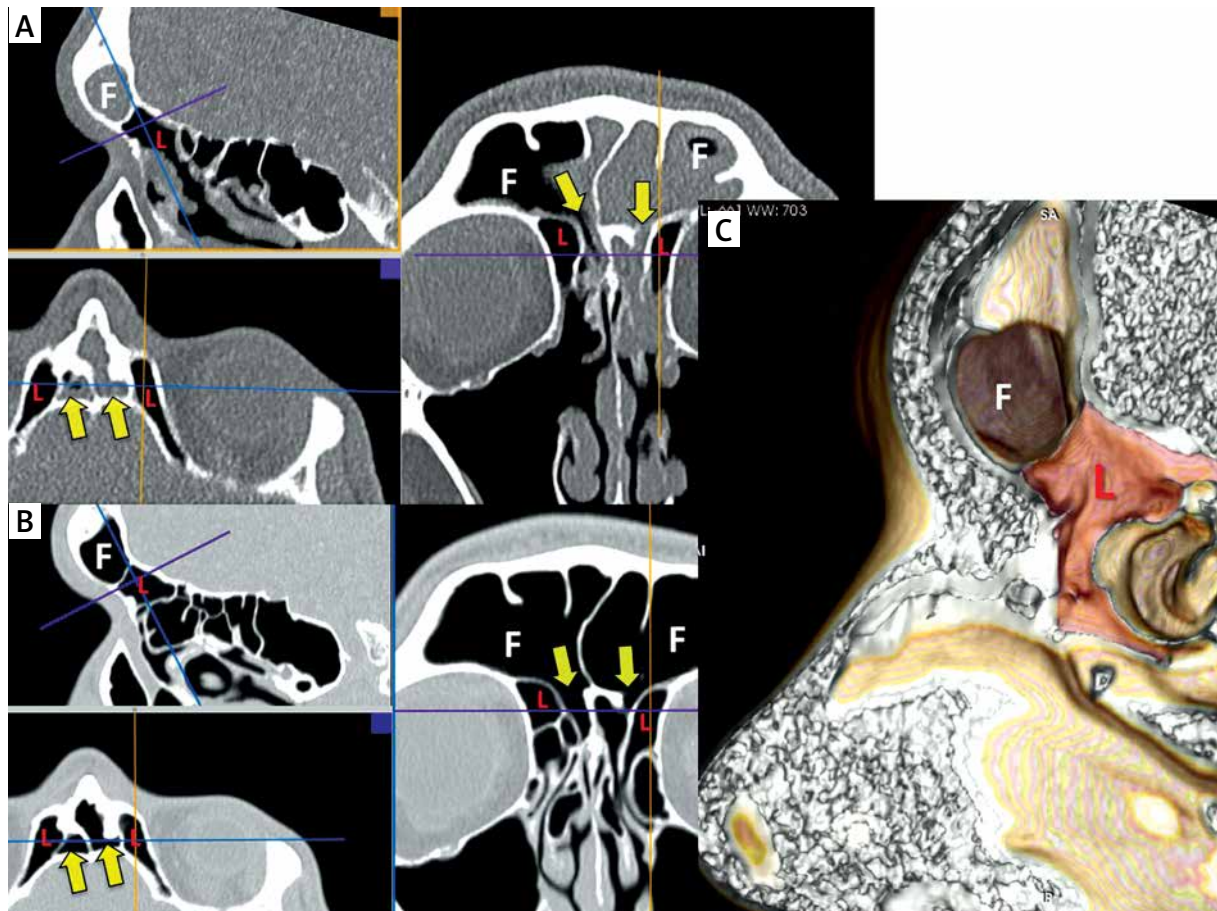


Photo 4. Lateral frontoethmoidal cell on both sides: **A** – MPR of preoperative CT, **B** – MPR of CT performed before previous procedures, **C** – 3D reconstruction

L – lateral cell on the left side (shaded in red), *F* – frontal sinus, yellow arrow – FSDP.

Case 5

A 70-year-old woman was admitted due to a persistent feeling of forehead pressure, left-sided dull cheek pain and purulent nasal discharge. A thin slice paranasal sinus CT revealed mucosal thickening and near-total opacification of the left maxillary sinus with calcifications. The left FSDP was pushed anteriorly and medially by a large frontoethmoidal cell pneumatizing into the frontal sinus (Photo 5). The cell extended between the frontal beak and the skull base, pneumatized around the anterior ethmoidal artery and created a common air space with bulla ethmoidalis. The patient underwent bilateral frontoethmoidectomy. An aspergilloma of the left maxillary sinus was removed via extended middle antrostomy. The left FSDP was widened by removal of the medial wall of the lateral frontoethmoidal cell.

The postoperative course was uneventful. The symptoms have subsided.

Case 6

A 49-year-old patient presented with a complaint of recurrent prolonged episodes of acute rhinosinusitis in autumn and winter with a right-sided frontal headache and purulent discharge. He had undergone endoscopic sinus surgery 9 years before, which improved his symptoms for 1 year. A thin slice (0.625 mm) paranasal sinus CT performed after intranasal steroid treatment in the asymptomatic period revealed a frontoethmoidal cell pushing the FSDP anteriorly and medially (Photo 6 A) and mucosal thickening within the FSDP. The cell was not removed during the first surgery and seemed the most likely cause of the persisting symptoms. A coronal

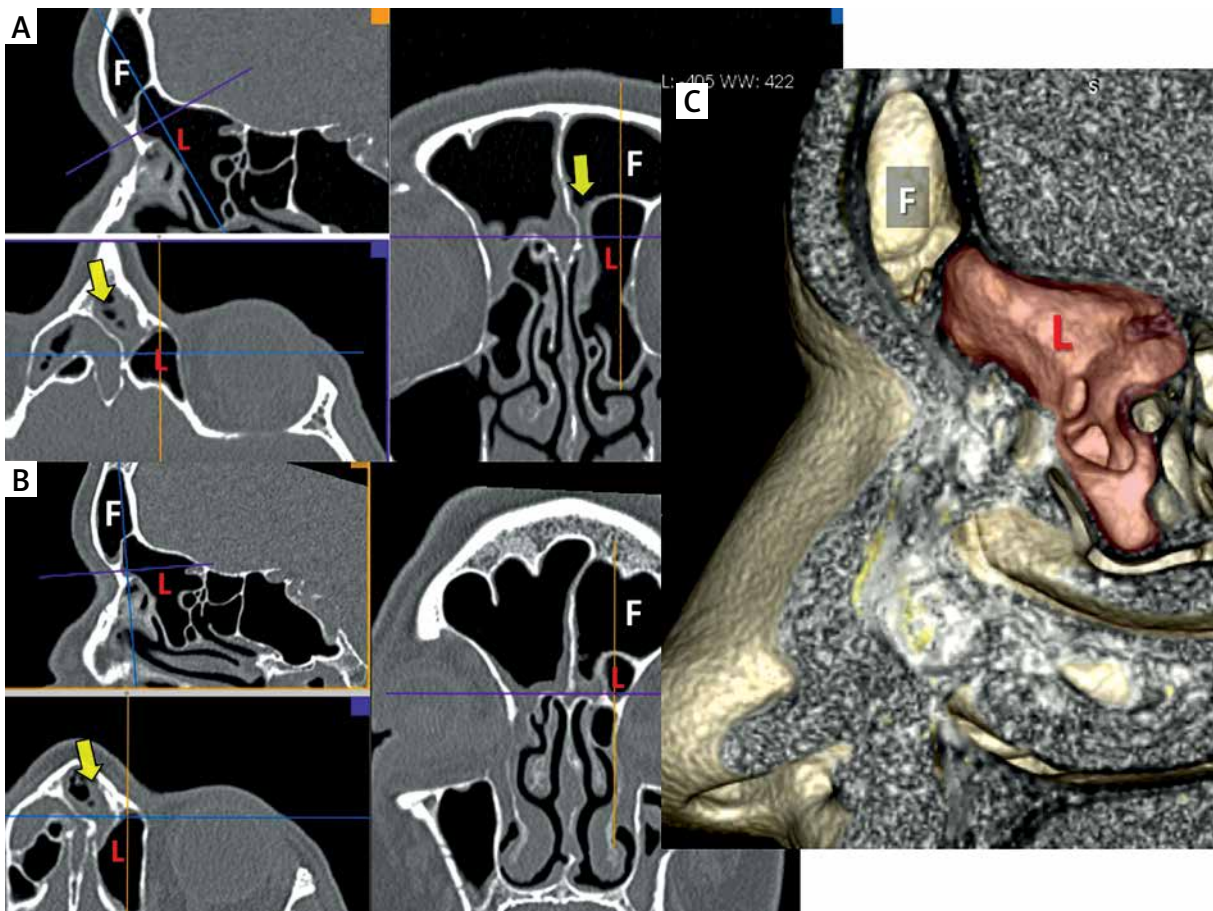


Photo 5. Left-sided lateral frontoethmoidal cell: **A, B** – MPR of preoperative CT: the cell appears as supra agger frontal cell when viewed in the coronal plane at the level of the vertical part of the middle turbinate (**B**), **C** – 3D reconstruction

L – lateral cell (shaded in red), *F* – frontal sinus, yellow arrow – FSDP.

CT performed before the first surgery was re-evaluated. The described frontoethmoidal cell could not be appropriately visualized because of a 2.4 mm slice interval (Photo 6 C). The patient is scheduled for revision endoscopic surgery.

Discussion

Currently available software enables us to view thin slice CT images in coronal sagittal and axial planes, which are linked together in such a way that the same point can be observed simultaneously in three planes. However, only some DICOM viewers are also able to adjust the planes. This function makes it possible to identify and align symmetry axis and to establish a symmetric image. It also en-

ables adjustment of the desired angle at which anatomical structures, such as the FSDP, can be best exposed. The use of software that does not provide this function (or ignoring this function) may result in an over-simplistic understanding of sinus anatomy (see example in Photo 6). Other important features of modern software that help to create a map in the surgeon's mind are virtual endoscopy [13] and the virtual cutting of a 3D image at different planes, which can also be adjusted (Photos 1, 2, 4, 5).

The authors of the European Anatomical Position Paper on the Anatomical Terminology of the Internal Nose and Paranasal Sinuses (2014) did not characterize lateral cells [2]. To the best of our knowledge our article is the first description of these cells.

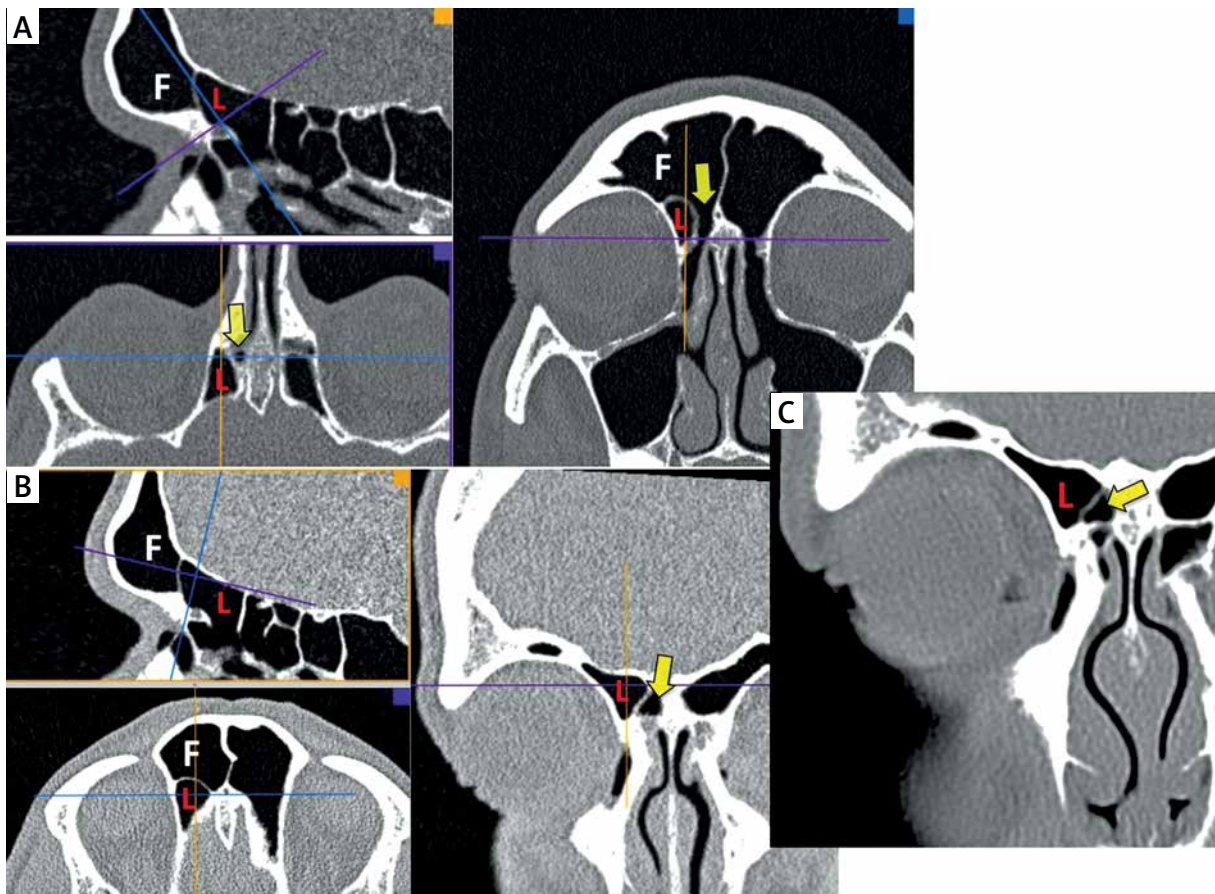


Photo 6. Right-sided lateral frontoethmoidal cell: **A, B** – CT MPR, **A** – the cell appears as a supra agger cell when viewed in the coronal plane. Its extent between the frontal beak and posterior table can be appreciated in axial and sagittal planes, **B** – change in the angulation of planes creates an impression that the cell is a posterior frontoethmoidal cell when viewed in the axial plane. In the coronal plane the septation rather than a cell is observed, **C** – coronal CT performed before the operation in a 2.4 mm slice interval, in which the cell could not be recognized

L – lateral cell, *F* – frontal sinus, yellow arrow – FSDP.

The common features of frontoethmoidal cells presented in our study are:

1. Extension between the anterior face of the frontal recess/sinus and the skull base
2. Relation to the FSDP, which is pushed medially/ anteromedially

These cells cannot be classified as anterior or posterior using the classification of Lee *et al.* [1]. According to these authors, “The anterior group consists of the ANC and FC; for these cells, the posterior boundary is a free partition in the frontal recess”. In contrast, the “Posterior group includes FBC, SBC, and SOEC; for these 3 cell types, the skull base forms the superior/posterior boundary of the cell, whereas their anterior/inferior boundary is a free partition within the frontal recess” [1]. These definitions exclude the possibility that the anterior or posterior cell extends between the anterior wall of the frontal recess/sinus and the skull base.

The International Frontal Sinus Anatomy Classification (IFAC) classification (2016) does not define the posterior boundary of the anterior cells and the anterior boundary of the posterior cells [3]. Lateral cells meet some IFAC criteria of the anterior and some of the posterior cells at the same time. When visualized in the coronal plane at the level of anterior or vertical part of the middle turbinate, they resemble agger nasi cells or supra agger cells (Photo 5), but when viewed more posteriorly they also pneumatise along the skull base like posterior cells (Photo 6). Another reason why they cannot be classified using the IFAC is that they may push the FSDP anteromedially (best examples: cases 2, 5 and 6), which cannot be attributed to anterior, posterior or medial cells (although they can resemble anterior cells, which may push the FSDP medially, but not anteriorly).

Lee *et al.* developed a frontoethmoidal cell classification after evaluating 50 examinations performed with 1-mm contiguous axial slices using “rigid” three planar reconstruction [1]. The examinations performed with a symmetry-axis tilt could not be corrected. Under these conditions, a lateral cell with limited contact to the anterior or posterior wall of the frontal recess/ostium could apparently look like an anterior or posterior frontoethmoidal cell if not viewed at proper angles (Photo 6). Using 1 mm slice thickness it could be difficult to differentiate between a single and a double layer of bone (between the wall of the cell adjacent to thick bone and thick bone alone; Photo 3). Thus Lee *et al.* might not have

recognized some cases of lateral cells. Another reason why the lateral cells were neglected was that the Lee and Kuhn classification (2004) [1] was a logical continuation of the concept that emerged in the 1990s when single plane CT was available [11].

The authors of the IFAC admit that their concept was built on Kuhn’s work [12]. They simplified and clarified existing terminology rather than developing a new classification system. This is the most reasonable explanation why lateral cells are not included in the IFAC. However, the prevalence of lateral cells is unknown. Further radioanatomical studies are needed to compare their prevalence in relation to other frontoethmoidal cells. If they are more frequent than any other known cell type they should be included in existing classifications. Based on our experience we suppose they are present in 10% of sides.

Conclusions

The lateral frontoethmoidal cell is an anatomical variation that may contribute to the persistence of the inflammatory disease and can be easily overlooked preoperatively.

Conflict of interest

The authors declare no conflict of interest.

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