ORIGINAL ARTICLE Head and Neck

Anatomization And Prevalence Of Onodi Cells Using Cone Beam Computed Tomography

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ABSTRACT

Purpose

The Onodi cell is the most posterior ethmoid cell that pneumatized superiorly and laterally to the sphenoid sinus. Nearby are the internal carotid artery and the optic nerve canal. Understanding the intricate architecture of the skull base can help you perform endoscopic transsphenoidal and skull base procedures with less chance of damaging nearby structures. Therefore, it is absolutely essential to establish the prevalence and position of Onodi cells.

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Method

164 CBCT images of subjects aged 18 to 70 years with optimal diagnostic quality and area coverage satisfying the selection criteria without a history of maxillofacial fractures, pathologies, or anomalies involving the middle one-third of the face were analyzed.

Results

Onodi cells were observed in 71 (43%) of the 164 patients assessed. Onodi cells were identified in 42 (44.2%) males and 29 (42%) females. Out of 42 males with Onodi cell presentations, 19 exhibited pneumatization in the age group of 18-30 yrs, 13 in the age group of 31-50 yrs, and 10 in the age group of 51-70 yrs. In the case of females, 11 subjects exhibited Onodi cells in the age group of 10-30 yrs, 9 in the age group of 31-50 yrs, and 9 in the age group of 51-70 yrs.

Conclusion

Both male and female individuals in the current study had an elevated incidence of posterior ethmoidal air cells. Furthermore, this study shows a stronger identification of Onodi cells using CBCT as compared to CT and cadaveric dissection analyses. There is significant debate over the anatomy and location of the posterior ethmoidal pneumatization. As a result, the fields of otolaryngology and maxillofacial radiography encourage CBCT investigations of Onodi cells.

KEY WORDS Ethmoidal sinus, CBCT, Prevalence, Pneumatization, Sinus surgery

Introduction

Variations in normal anatomy can occasionally result in disease progression and treatment complications. As a result, it is crucial to comprehend normal anatomy and its variations, confirm them, and update them with the help of more advanced imaging techniques. The anterior base of the skull is among the most difficult structures to evaluate due to its complexity. In addition to individuality, the structures of the skull are susceptible to undergoing changes over time.

The ethmoid bone is the indispensable proportion of the anterior base of the skull, located between the orbital bones of the eyes, superior to the anterior cranial fossa, and positioned behind the sphenoid bone and nasal bone. It is a cube-shaped, porous, light bone that has distinct channels and grooves. It is composed of a collection of air chambers called ethmoid air cells. The ethmoid air cell is the most riveting attribute of the anatomy of the ethmoid bone. Both labyrinths contain numerous air cells, collectively identified as ethmoid sinuses [1,2].

These air cells are present at birth, and they develop rapidly from 0 to 4 years of age. They further mature from 8 to 12 years of age through puberty.

Over time, ethmoidal air cells significantly increase in number due to the phenomenon known as pneumatization. An ongoing increase in the paranasal sinuses' volume is referred to as "sinus pneumatization." The first paranasal sinus to begin pneumatization is the ethmoid sinus [3,4].

Onodi cells, the posterior-most ethmoid cells that extend superolateral to the sphenoid sinus, were initially identified by Dr. Adolfo Onodi in 1903 [5].

Cells derived from the ethmoid lying within the sphenoid bone were referred to by Lang as Onodi cells (named after the Hungarian surgeon) [6].

Kainz & Stammberger, who classified the Onodi cell as a posterior ethmoidal cell presenting with an optic canal bulge, selected a different description than the former [7].

Onodi cells can have important anatomical variances and connections to crucial nearby structures, including the internal carotid artery, sphenoid sinus, and optic canal; it is critical to identify them for performing ethmoidectomy, endoscopic transsphenoidal sinus, endonasal sellar, and para sellar surgeries.

With advances in popular endoscopic sinus and endonasal sellar surgery, the definition of these cells and their variations has recently garnered more and more attention. During sinus surgeries, unidentified Onodi cells can gravely injure the optic nerve. Therefore, it is essential to thoroughly understand the surrounding

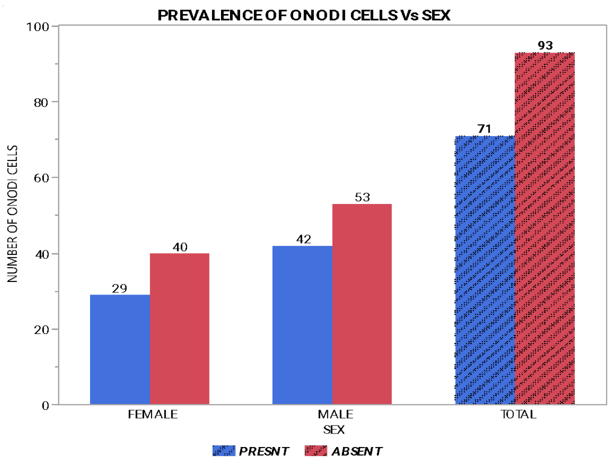

***Figure 1** – Graph presenting prevalence of onodi cells in males and females*

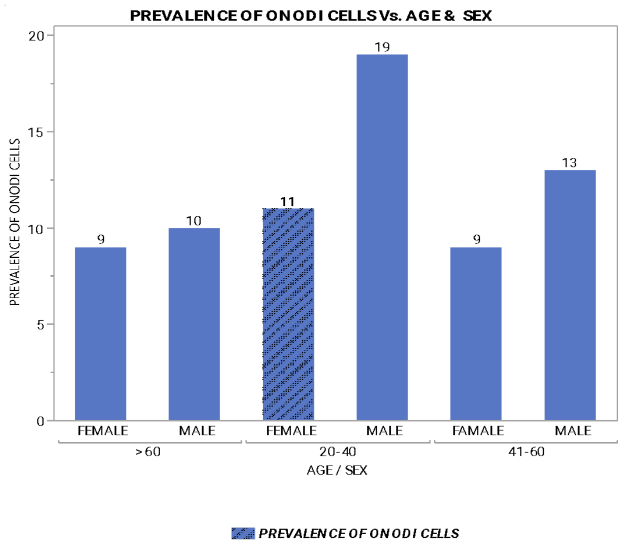

***Figure 2** – Graph representing age wise distribution of onodi cells*

anatomy in order to ensure a precise and reliable dissection with maximum exposure and minimal damage to the adjacent structures. This is often accomplished by Cadaveric dissections; High-Resolution Computed Tomography (HRCT), Computed Tomography (CT), and Endoscopy are imaging techniques used by maxillofacial radiologists and otolaryngologists for the visualization of sphenoethmoidal pneumatization in the past [8,9].

CBCT is the latest multiplanar imaging technology for the craniofacial region that has revolutionized 3D imaging and offers significant advantages over CT in clinical diagnostic imaging. It is relatively inexpensive and provides greater isotropic spatial resolution at a lower radiation dosage than CT.

For evaluating the morphological characteristics of complex structures in the anterior base of the skull, paranasal sinuses, maxillofacial surgical outcomes, and surveillance of intraoperative and perioperative osseous structures, CBCT is deemed reasonable [9].

One structure of the skull that is lacking an update in terms of the latest imaging technique, Cone Beam Computed Tomography (CBCT), is the "Onodi Cell," which has been investigated exclusively only once, as found in the scientific literature on a Google search. Therefore, to better understand the position, size, distribution, development, and surgical consequences of Onodi cells, it is imperative sine qua non to analyze them using CBCT, which may disclose more detailed features and morphology compared to previously employed modalities.

Based on their position in relation to the sphenoid sinus, Onodi cells in this study are divided into superior, superolateral, and lateral groups [9].

This study using CBCT to examine the prevalence and placement of Onodi cells in relation to the sphenoid sinus is of great value in terms of understanding and provides invaluable, comprehensive knowledge.

Materials and methods.

This observational study was conducted in the Department of Oral Medicine and Radiology, during the period of September 2022 to February 2023, and subsequent ethical clearance was obtained from the Institutional Ethical Board.

The total sample size, including males and females, was 164.

To determine the sample size

Where, Z =is the 95% confidence level and P =is the expected prevalence, taken as 0.4

Q == 0.6; D =is the allowable error, which is 0.075. The sample size was calculated to be 164.

Statistical methods: A cross-tabulation of gender with the presence and position of Onodi cells was evaluated

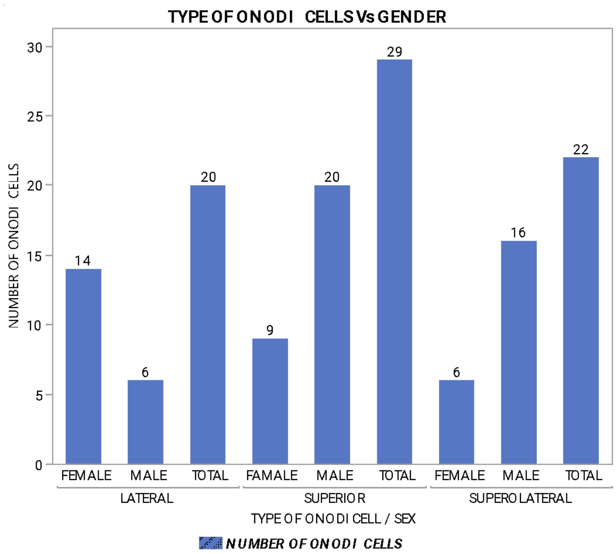

***Figure 3** - Graph representing distribution of types of onodi cells in males and females*

using the Chi-squared (χ2) test.

For continuous data, a mean and standard deviation were used, and for categorical data, a percentage proportion was used. At a 95% confidence interval, the Chi-square test for categorical data was used for statistical /evaluation. P values less than 0.05 were regarded as significant. For data computation, SPSS version 22 was used. Both prospective and retrospective information were obtained from the source.

The Department of Oral Medicine and Radiology provided the antiquated CBCT images that fulfilled the retrospective component requirements.

CBCT (in-house PLANMECA PROMAX 3D MID) images of the patients visiting the OPD for dental procedures that meet the inclusion criteria were collected prospectively at the Department of Oral Medicine and Radiology.

All the images were analysed using the Viewer software. The images on display had voxel sizes of 75 micrometres for better resolution.

Patients were grouped into three categories according to their age, i.e., 10–30 years as Group A (44 males and 15 females), 31–50 years as Group B (28 males and 15 females), and 51–70 years as Group C (13 males and 15 females), to assess the prevalence of Onodi cells in different strata of age groups. Selected CBCT images were examined in sagittal, coronal, and axial views to ascertain the Onodi cell prevalence and position.

To prevent intra-examiner variability, a highly trained oral and maxillofacial radiologist analysed the visibility and position of Onodi cells twice at two-week intervals.

Inclusion criteria:

CBCT images of superior diagnostic quality of the entire maxilla, from the alveolar bone to the orbit (full face scan and 90mm maxilla scan). CBCT images obtained without a clinical history of maxillary trauma or evident defects, for orthodontic procedures, dental implants, and other maxillofacial purposes.

Exclusion criteria:

CBCT images of subjects younger than 18 years, whose sinuses have not completely developed, are excluded. Subjects with midfacial aberrations, past ethmoid and sphenoid sinus injuries, and midface interventions.

CBCT images of patients with pathologies of the sphenoid and ethmoid bones, developmental abnormalities, sinonasal pathologies, sphenoidal and ethmoidal sinus syndromes, and mothers who are expecting or nursing.

Radiographic images that weren't of diagnostic quality, had artifacts or didn't clearly demonstrate the area of concern were discarded.

Results

The data from 164 patients was included according to the eligibility criteria. Of these, 95 were male and 69 were female.

The ages of the patients ranged from 19 years to 70 years.

The chi-square test was used to analyse the level of significance between males and females for the presence and absence of Onodi cells, as well as the position of Onodi cells.

Onodi cells were observed in 71 (43%) of the 164 patients assessed. Onodi cells were identified in 42 (44.2%) males and 29 (42%) females. (Table and Figure 1) Out of 42 males with Onodi cell presentations, 19 exhibited pneumatization in group A, 13 in group B, and 10 in group C. In the case of females, 11 subjects exhibited Onodi cells in group A, 9 in group B, and 9 in group C. (Table and Figure 2)

The predominance of Onodi cells was determined using the Chi-square test, and it transpired that there was

TABLE 1 (PREVALENCE OF ONODI CELLS IN MALES AND FEMALES)
ASSOCIATION OF GENDER AND THE PRESENCE OF ONODI CELLS

GENDER	ONODI CELLS		TOTAL
	PRESENT	ABSENT	n (%)
MALE	42 (44.2%)	53 (55.8%)	95 (100)
FEMALE	29 (42%)	40(58%)	69 (100)
TOTAL	71(43%)	93(57%)	164 (100)

TABLE 2 (PREVALENCE O F ONODI CELLS IN MALES AND FEMALES OF DIFFERENT AGE GROUPS)
AGE WISE DISTRIBUTION OF ONODI CELLS

GENDER	AGE (in years)		
	20-40 (A)	41-60 (B)	Above 60 (C)
MALE (95)	19 (44) 42.2%	13(28) 86.7%	10(13) 77%
FEMALE (69)	11(15) 73%	9(15) 60%	9(15) 60%

TABLE 3 (DISTRIBUTION OF TYPES OF ONODI CELLS IN MALES AND FEMALES)
ASSOCIATION OF GENDER AND THE POSITION OF ONODI CELLS

GENDER	ONODI CELLS			TOTAL n (%)
	SUPEROLATERAL n (%)	SUPERIOR n (%)	LATERAL n (%)	
MALE	16 (38%)	20 (47.8%)	6(14.2%)	42 (100)
FEMALE	6 (20%)	9(32%)	14(48%)	29(100)
TOTAL	22 (31%)	29(41%)	20(28%)	71(100)

no statistically significant difference between the genders... (p = 0.214)

Among males, Onodi cells were more widespread in the mid-age group (41–60 years) and less frequent in younger males (20–40 years).In the case of females, the younger age group (20–40 years) seems to have the highest proportion, trailed by the middle-aged (41–60 years) and older individuals (>60 years).

Aside from prevalence, the phenomenon of pneumatization was reviewed. Superior, (Figure 4), Superolateral (Figure 5), and lateral (Figure 6–7) features were associated with the orientation of Onodi cells with allusion to the sphenoid sinus. Of the 42 males possessing Onodi cells, 16 (38%) were classified as superolateral, 20 (47.8%) as superior, and 6 (14.2%) as lateral. (Table and Figure 3) Females displayed six (20%) Onodi cells superolaterally, nine (32% superiorly), and fourteen (48% laterally) in proximity to the sphenoid sinus.Hence, Males featured superior Onodi cell placement, but females had lateral posterior ethmoidal air cell positioning.

Upon juxtaposing the types of Onodi cells, it was determined, employing the Chi-square test, that there was a statistically significant difference between the genders ($p > 0.05$).

Discussion

The ethmoidal labyrinth of the ethmoid bone contains

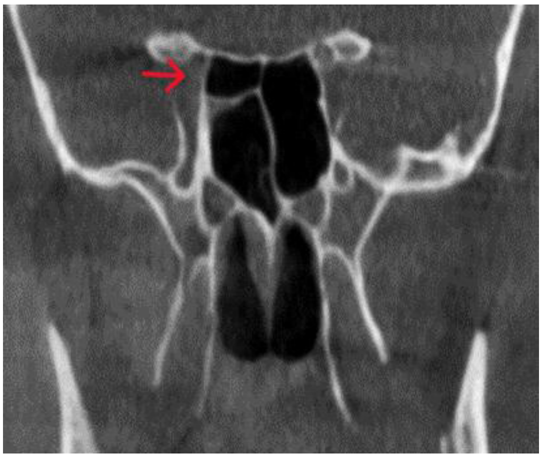

Figure 4 *– shows the superior type of Onodi cell.*

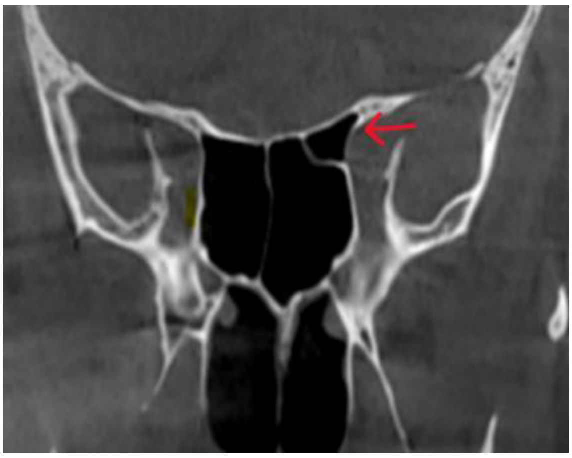

Figure 5 *– shows the superolateral type of Onodi cell.*

a number of thin-walled cavities known as ethmoidal air cells, or cellulae ethmoidales in Latin. The frontal, sphenoidal, and maxillary sinuses, in conjunction with the ethmoidal air cells, are bunched together as paranasal sinuses.

Reviewing the anatomy of the ethmoid bone with the sphenoethmoidal air cells. The superior part of the nasal cavity and the orbit encompass where the ethmoidal air cells are located. The ethmoidal air cells are alienated from the orbit by the ethmoid's orbital plate [1].~~[1]~~

The anterior and posterior groups of the ethmoid sinuses are differentiated by the ground lamella of the middle turbinate. According to Stammberger H. et al., the posterior group, the subject of the current investigation, is made up of one to seven cells and clefts that access the superior meatus and, occasionally, the supreme meatus posteriorly over the ground lamella [10]. Their number is affected by the number of septations as well as whether or not the ground lamellae of the superior and supreme turbinates reach the lamina papyracea. Occasionally, one or more cells can easily penetrate the sphenoid sinus.

Modern endoscopic surgeons now commonly refer to the lateral or superolateral pattern of pneumatization of the posterior ethmoid, where a bulge of the optic canal into the posterior ethmoid is noticeable, as an "Onodi cell" in honor of Onodi's work [11].

It is interesting that Onodi's original work did not describe a "cell," but rather~~,~~ 38 variations in posterior ethmoid anatomy that he characterized into 12 main groups. In our study, we have considered three variants based on the position of Onodi cells with respect to the sphenoid sinus as described by Ibrahim et al. [12].

While rhinologists and maxillofacial radiologists have long been aware of variations in pneumatization, their significance has escalated with the expanding popularity of functional endoscopic sinus surgery.

Many studies have shown that patients undergoing endoscopic trans-sphenoidal surgery have less associated pain and discomfort after surgery, decreased use of postoperative nasal packing, shorter hospital stays, and lower complication rates. Additionally, there has been evidence to show superior tumour removal using the endoscope to visualize suprasellar tumours in comparison with the conventional approach.

The findings from our research serve to draw attention to the anatomical differences that raise the dangers to the optic nerve, and internal carotid artery during procedures on the posterior ethmoid [13].

These dangers are divided into two categories: the inconstant relationship of the optic nerve to the posterior ethmoid sinus, as determined by the diversity of air cell pneumatization, and the varying thickness of the ethmoid lateral wall.

There are three elements that make Onodi cells crucial for medical applications. Well, first of all, because of the direct proximity between the Onodi cell and the optic nerve, Onodi cell sinusitis may result in visual abnormalities. Second, the Onodi cell can easily be confused with the sphenoid sinus during endoscopy. Lastly, the Onodi cell increases the potential for harm to the ICA and optic nerve. Surgery on the sphenoid may not be complete

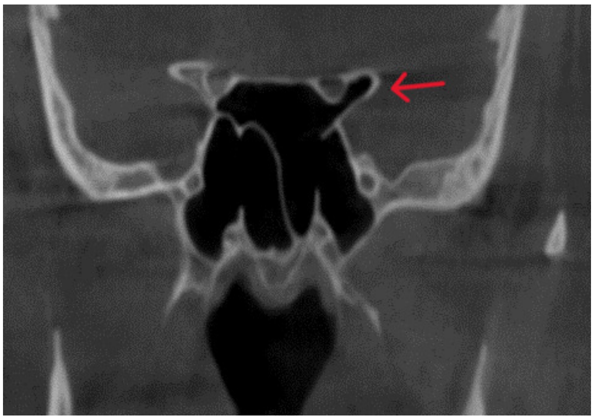

Figure 6 *– shows the lateral type of Onodi cell.*

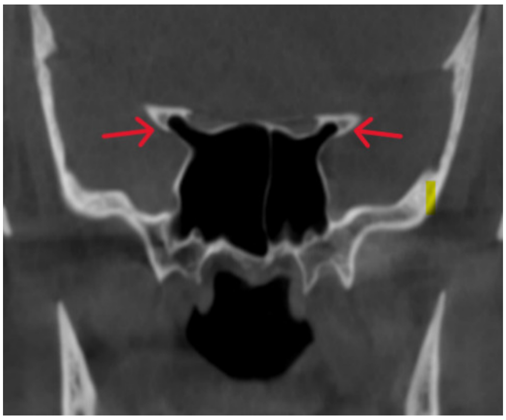

Figure 7*– shows the bilateral bilateral presentation of lateral type of Onodi cell.*

because the Onodi cell occasionally confounds surgeons [14].

According to previous researchers, establishing the presence or absence of the Onodi cell, as well as its shape, based solely on axial or coronal images is difficult. Surgeons must be cognizant of the Onodi cell's location in relation to the optic nerve, internal carotid artery, and pituitary gland. As a result, a three-dimensional representation is necessitated for more precise identification, as supported by the current study.

On the contrary, a large Onodi cell is frequently confused with the sphenoid sinus, making sphenoid sinus surgery challenging. The anterior wall of the sphenoid sinus is the most posterior wall of the ethmoid sinus or Onodi cell. The risk of optic nerve damage and insufficient sphenoethmoidectomy could be reduced by improving preoperative and intraoperative detection of the Onodi cell [15,16].

Computerized tomography (CT) and cone beam computerized tomography (CBCT) of the paranasal sinuses are being employed to identify pivotal anatomic locations, such as the ethmoid roof and lamina papyracea, where anatomic deviations pose recognized risks during sinus surgery [9,14].

As a corollary, it is feasible for surgeons to adopt intraoperative surgical techniques that confine instrumentation in the region where an optic nerve protrudes into the posterior ethmoid sinuses, thereby minimizing the possibility of optic nerve damage.

Ibrahim K. Ali et al. published in 2020 that utilizing CBCT yielded a greater incidence of Onodi cell detection (40–45%) compared to using CT, which only revealed 25–40% of them. Thus, we postulated that CBCT examination was the most efficient strategy for the current investigation [9].

As previous research has highlighted, both CT and CBCT have been employed for the identification of Onodi cells. The parameters of our study contrasted with the parameters of Onodi cells studied using CT due to the paucity of CBCT studies pertaining to Onodi cells.

In the current study, males had a higher prevalence of Onodi cells (44.2%) than females (42.2%). In contrast, Ibrahim et al.'s 2020 study using CBCT reported that the prevalence in males was 41.5% and 42.2% in females [9].

In a study conducted by Senja Tomovic et al. (2012), Three-dimensional maxillofacial and paranasal sinus High-Resolution CT scans of 170 patients treated by the senior author were reviewed by two independent observers (an otolaryngologist and a radiologist). The study found an incidence of 111 patients (65.3%) with Onodi cells; 62.2% in males, and 63.5% in females. This study shows a high prevalence of Onodi cells compared to the aforementioned studies using CT [17].

Differences in the prevalence of Onodi cells in the investigations could be attributed to ethnic, racial, or genetic variations among the Caucasian and Asian populations or to inaccuracies in the identification of Onodi cells.

In a study by–Kang et al., among 877 patients (429 males and 448 females), CT identified Onodi cells in

449 patients (51.2%), emphasizing a slightly higher incidence as opposed to our study. The absence of an Onodi cell was more common in the young (< 30 years) age group. Furthermore, the prevalence of Onodi cells was noticeably high in the older patient group (above 50 years). However, in our study, we found a higher frequency among those between the ages of 41 and 60 [18].

Fifty-four (33.3%) individuals exhibited Onodi cells in their paranasal sinus CT, according to Shin et al.'s research of 162 patients (90 men, 72 women). It included 24 (45%) women and 30 (55%) males. The current study's findings revealed a substantially greater proportion of Onodi cells (44.2%), as technically sensitive CBCT investigations employ multiplanar imaging for identifying posterior ethmoidal pneumatization. Consequently, it demonstrates strengthened Onodi cell prevalence whilst compared to CT scans. In addition to the aforementioned research, the tendency demonstrates that males have more posterior ethmoidal air cells than females [13].

Five hundred and eight patients (265 males and 243 females) underwent paranasal sinus CT as a component of a retrospective study by Ödemir et al. The findings revealed Onodi cells in 108 of the patients (21.2%). Onodi cells were found in 65 (24.5%) males and in 43 (17.6%) females. In contrast, our experiment illustrated an incidence of 44.2% (males) and 42% (females). Males had a slightly higher Onodi cell presentation than females, which was commensurate with the previous research. The aforementioned findings argue that CBCT, thanks to its volumetric rendering illustrations, is a better modality to evaluate the prevalence of Onodi cells [19].

In 2012, Orhan Ozturan et al. in Germany studied 999 individuals' paranasal sinus CT scans in three planes (coronal, axial, and sagittal), in 537 men and 462 women ranging in age from 13 to 91 years. He arrived at the verdict that 16.6% of the 160 patients exhibited Onodi cells, comprising 93 men and 67 women [20]. Onodi cell incidence is substantially higher in our study (43%), and the study cited above also demonstrates an increased incidence in males and females.

Therefore, there is a significant disparity in the prevalence of Onodi cells in the aforementioned CT studies (ranging from 65% to 16%). Additionally, contrary to the findings of the study conducted by Senja Tomovic et al., males had a higher prevalence of Onodi cells than females. A handful of radiological studies in the literature indicate the precise location of the posterior ethmoid pneumatization; most of the research focuses primarily on the incidence and competence of the optic nerve.

This study attempted to examine the position of Onodi cells with the Sphenoid sinus as established by Ali, Ibrahim K., et al. [9,12].

When the various characteristics of the Onodi cells were examined, the superior type was more prevalent in men (47.8%), followed by superolateral (38%) and lateral (14.2%). This is consistent with the findings of Ibrahim et al., who revealed that superior type was more prevalent in males (48.8%). In females, however, lateral placement (48%) was more prevalent, followed by superior (32%), and superolateral (20%) positions. Unlike Ibrahim et al. superior type for prominence, which was followed by superolateral and lateral positioning of Onodi cells [12].

In the current study, males between the ages of 41 and 60 had a high incidence of Onodi cells, whereas females between the ages of 20 and 40 had an increased prevalence. We were unable to draw parallels or contrast our findings with existing literature since the age-wise distribution of posterior ethmoidal air cells is extremely uncommon to be identified in the literature at this juncture.

Yeoh's research concluded that in 65% of the patients, the posterior ethmoid cells showed a direct link with the optic nerve. In 51% of subjects, the optic nerve canal protruded into a sphenoethmoidal cell. These outcomes came from anatomical dissection studies, which, in comparison with the present work, demonstrated direct contact with the Onodi cells in 42 to 44% of the patients [21].

Our definition of an Onodi cell simply refers to a posterior ethmoid cell that is positioned above the sphenoid sinus and does not require optic nerve protrusion or dehiscence; hence, we attribute the variance of the aforementioned study instances to this [22].

Conclusion

The current investigation found a high predominance of posterior ethmoidal air cells in both male and female participants. In males, the superior position was the most common, followed by the superolateral and lateral positions, and in females, the lateral position was followed by the superior position. males between the ages of 41 and 60 had a high incidence of Onodi cells, whereas females between the ages of 20 and 40 had an increased prevalence. The surgical importance of the presence of the Onodi cell makes its identification paramount.

Additionally, CT studies reveal more pronounced disparities in the prevalence of Onodi cells when compared to CBCT analysis. The difference in prevalence percentage is attributed to ethnic, racial, or genetic variations of the populations and limitations in the identification of Onodi cells in the diagnostic images.

It has only been referenced in a small assortment of paperwork since the CBCT. A great deal of considerable discussion is being held over the anatomy and location of the posterior ethmoid pneumatization. Additionally, a straightforward plan for the methodical appraisal of Onodi cells needs to be implemented. As a result, CBCT research on Onodi cells is encouraged in the fields of maxillofacial radiography and otolaryngology. **R**

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