The relationship between optic nerve and Onodi cells on CT scan

Lam Huyen Tran, Nguyen Le Vinh Thuan

Department of Otolaryngology, University of Medicine and Pharmacy at Ho Chi Minh City, Ho Chi Minh City, Vietnam

SUMMARY

The Onodi cells, also known as sphenoethmoidal air cells, are a variant of the most posterior ethmoid cells and are closely related to the optic canal. The presence of Onodi cells may increase the risk of optic nerve injury and result in confusion with sphenoid sinuses during endoscopic sinus surgery, leading to the oversight of sphenoid sinus pathology. The aim of the study was to examine the characteristics of Onodi cells and their relationship with the optic nerve on CT scans. A cross-sectional study was conducted, analyzing CT scans of paranasal sinuses in 196 posterior ethmoid air cells from 98 patients (30 males and 68 females) aged 18 or older, without abnormalities in the paranasal sinuses and optic nerve anatomy.

The prevalence of Onodi cells was 38.78%, with 26.32% on the left, 44.74% on the right, and 28.94% bilaterally. Onodi cell pneumatization was observed in the order of Type I > Type II > Type III on both sides. The most common relationship between Onodi cells and the optic nerve was Type A on both sides. The incidence of the optic nerve bulging into Onodi cells was 50%, and the exposure of the optic nerve into Onodi cells was 7.89%. The study investigated the prevalence and relationship between Onodi cells and the optic nerve. CT scans proved to be a crucial diagnostic tool in providing essential information about Onodi cells before surgery.

Key words: Onodi cells – Optic nerve – Posterior ethmoid air cells

INTRODUCTION

Onodi cells, also known as sphenoethmoidal air cells, are the most posterior ethmoidal cells which pneumatized superiorly, laterally, or superolaterally and closely associated with the optic nerve (Stammberger and Kennedy, 1995). The presence of the optic nerve, whether or not there is dehiscence in the Onodi cell, *may* increase the risk of optic nerve injury during endoscopic sinus surgery. Additionally, the potential confusion of Onodi cells with sphenoid sinuses during surgery can lead to incomplete endoscopic sinus procedures (Chmielik and Chmielik, 2017).

It is evident that accurately determining the presence of Onodi cells and their relationship with the optic nerve preoperatively is essential. Therefore, we conducted the study: "The relationship between the Optic Nerve and Onodi Cells on CT Scan."

Corresponding author:
Lam Huyen Tran. 194/46 Vo Van Tan Street, District 3, Ho Chi Minh City, Vietnam
Nguyen Le Vinh Thuan. 91 Tan Vinh Street, District 4, Ho Chi Minh City, Vietnam

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MATERIALS AND METHODS

Study Population

The study sample comprised 96 patients aged 18 and above who underwent paranasal sinus CT scans at Nguyen Tri Phuong Hospital in Ho Chi Minh City, Vietnam, from January 2023 to June 2023. The research obtained approval from both the Institutional Review Ethics Committee and the Ethical Committee of the involved hospital. All participants in the study provided their informed consent to participate by affixing their signatures on the informed consent form.

Exclusion criteria affected patients with a history of facial trauma, malignant facial diseases, or previous surgeries in the paranasal sinus area.

Research Method

A cross-sectional study was performed using a 64-slice multidetector scanner with a slice thickness of 0.625 mm. Subjects under 18 years old, with a history of facial trauma, malignant facial diseases, or previous surgeries in the paranasal sinus area, were excluded from the study (Fig. 1).

All CT scans were conducted in a supine position, and axial slices were parallel to the hard palate bone, ranging from the anterior border of the frontal sinus to the posterior border of the sphenoid sinus. The slice thickness was 0.625 mm, using a bone window (W 2000 L 350), a matrix of 512×512, and technical parameters of 120KV and 330mAs.

The relationship between the Onodi cells and the optic nerve was assessed based on Chmielik's classification (Chmielik and Chmielik, 2017):

- Type A: there was no contact between the wall of the ethmoid cell and optic nerve canal.
- Type B: the wall of the ethmoid cell was adjacent to the optic nerve canal wall on the distance maximum 2 mm (measuring in axial and sagittal planes), not extending laterally or supero- laterally.
- Type C: the wall of the ethmoid cell was adjacent to the optic nerve canal wall within distance >2 mm in the axial and/or sagittal plane extending laterally or supero-laterally without bulging of the optic nerve canal into the ethmoid bone.

Fig. 1.- Onodi cells on the coronal section (red arrow).

Fig. 2.- A: Onodi cell type I. **B:** Onodi cell type II. **C:** Onodi cell type III.

- Type D: the wall of the ethmoid cell was adjacent to the optic nerve canal wall for a distance of more than 5 mm (measuring in axial or sagittal plane) extending supero-laterally with bulging. The bulging was defined as the protrusion of the optic nerve into the ethmoid cell visualised in two planes. The very thin slice thickness guaranteed not missing any bulging of the optic nerve canal.
- Types C and D are defined as a close relationship between the posterior ethmoid cells and the optic nerve.

The Onodi cells are defined according to the Stammberger and Kennedy (1995) standard: they are posterior ethmoid cells pneumatized superiorly, laterally, or superior-laterally to the sphenoid sinus and have a close relationship with the optic nerve (Type C or D). Paranasal sinus CT scans are analyzed in all three planes: coronal, axial, and sagittal, to avoid missing Onodi cells.

The pneumatization pattern of Onodi cells is assessed based on Thimmaiah's classification (Thimmaiah and Anupama, 2017). In the coronal plane, the location of the sphenoid sinus is iden-

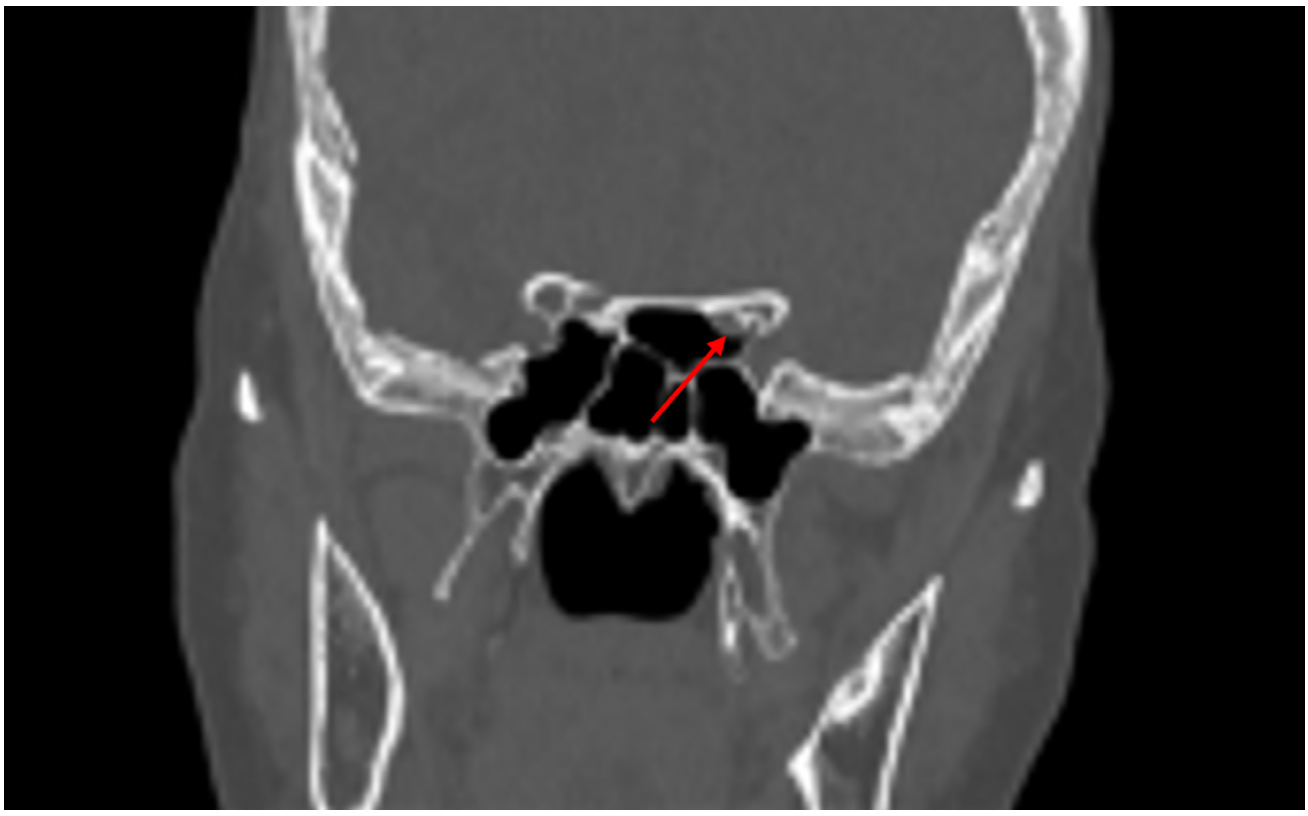

Fig. 3.- Protrusion of the optic nerve into the Onodi cell (red arrow).

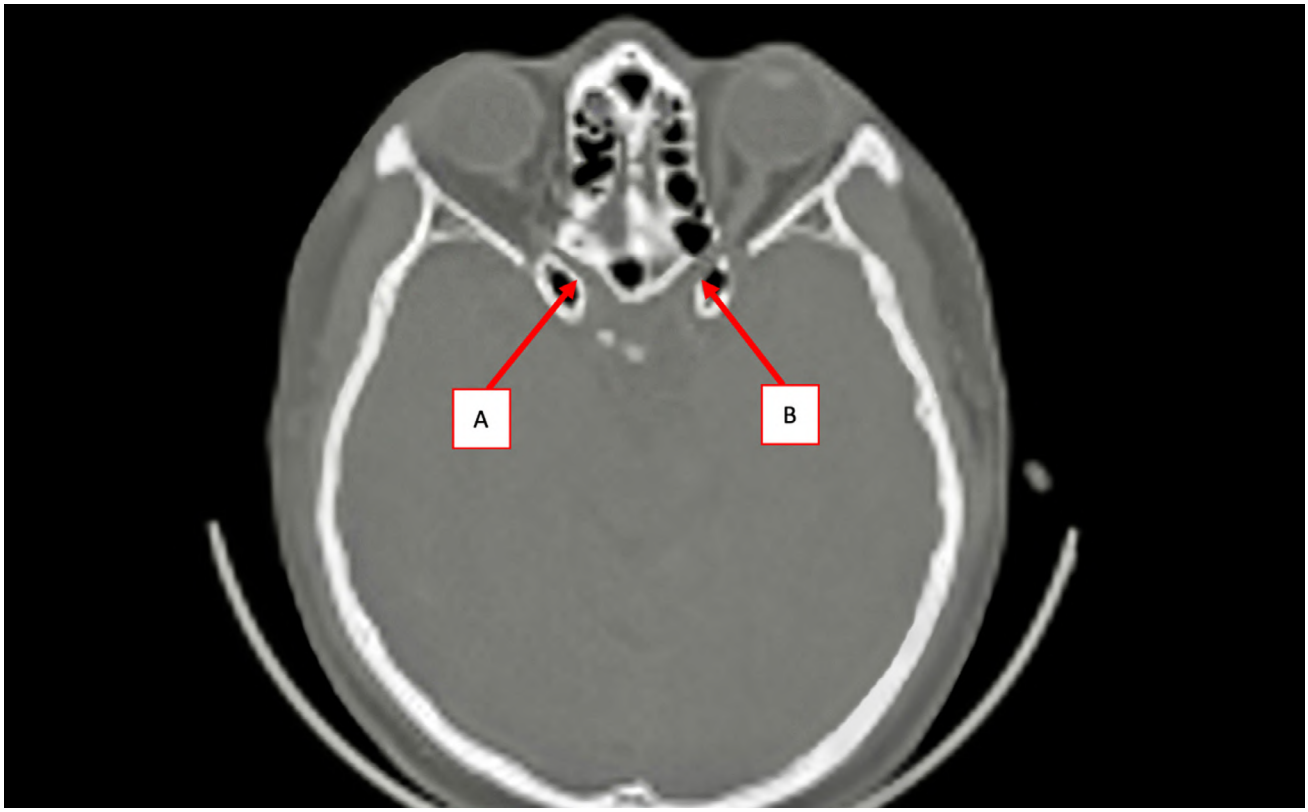

Fig. 4.- Protrusion of the optic nerve into Onodi cells on both sides, with the right optic nerve having bony coverage (A) and the left optic nerve lacking bony coverage - exposed into the Onodi cell (B).

tified, and the section where Onodi cells have the largest cross-sectional area and are related to the sphenoid sinus is determined. A horizontal line is drawn at the highest point of the sphenoid sinus at that section, and the position of Onodi cells is evaluated in relation to the drawn line (Fig. 2):

- Type I: if Onodi cells are observed above or laterally to the sphenoid sinus.
- Type II: if Onodi cells are observed both above and below the drawn line.
- Type III: if Onodi cells are observed below the drawn line.

The protrusion of the optic nerve is assessed according to Chmielik's study (Chmielik and Chmielik, 2017): it refers to the bulging of the optic nerve into the cavity of Onodi cells, evaluated on two sections (Figs. 3, 4). It must be meticulously analysed on each section to ensure that no optic nerve protrusion is overlooked.

Exposure of the optic nerve into the cavity of Onodi cells is noted when there is a protrusion of the optic nerve into the cavity of Onodi cells, and there is no bony wall covering.

RESULTS

The study analysed CT scans of 196 posterior ethmoid air cell systems and optic nerve relationships from 96 patients (30 males and 68 females). The average age was 47.15 ± 15.22 years, ranging from 19 to 88 years, with no history of facial trauma, malignant facial conditions, or prior surgery in the adjacent nasal sinus area.

The study observed the presence of Onodi cells in 38 patients (38.78%). Among these cases, Onodi cells were identified on the right side in 17 out of 38 cases (44.74%), on the left side in 10 out of 38 cases (26.32%), and bilaterally in 11 out of 38 cases (28.94%). In the male group, Onodi cells were noted in 13 out of 30 cases (43.33%): 4 cases on the left (30.77%), 4 cases on the right (30.77%), and 5 cases bilaterally (38.46%). In the female group, Onodi cells were identified in 25 out of 68 cases (36.76%): 6 cases on the left (24%), 13 cases on the right (52%), and 6 cases bilaterally (24%). The correlation between posterior ethmoid cells and the optic nerve is presented in Table 1.

Table 1. The correlation between posterior ethmoid cells and the optic nerve.

Type	Left (%)	Right (%)
A	73.46	66.32
B	5.1	5.1
C	11.22	13.26
D	10.22	15.32
Total	100	100

Regarding the pneumatization types of Onodi cells, on the left side, Type I was observed in 47.61%, Type II in 42.86%, and Type III in 9.53%. On the right side, Type I accounted for 60.71%, Type II for 35.71%, and Type III for 3.58%.

The study also noted that the rate of optic nerve protrusion into the Onodi cells was 50%, and the rate of exposure of the optic nerve into the Onodi cells was 7.89%. Comparison of the prevalence rate of Onodi cells with previous studies is exposed in Table 2.

DISCUSSION

Onodi cells are closely related to vital anatomical structures such as the optic nerve and the internal carotid artery, and they can be confused with the sphenoid sinus during surgery. Therefore, the detection of Onodi cells prior to nasal sinus surgeries is crucial for minimising complications and avoiding missing sphenoid sinus pathology during the procedure.

Previous studies have indicated varying prevalence rates of Onodi cells and their association with the optic nerve. However, most of these studies utilized one or two sectional views for assessment. For instance, Delano's study (Delano et al., 1996) showed that only 3% of posterior ethmoid cells were associated with the optic nerve, but this study only analysed coronal sections. Until now, there has been no consensus on the method of evaluating Onodi cells on CT scans. According to Hoang et al. (2010), the assessment of paranasal sinus on CT scans should involve all three sectional views.

In some studies, the detection rate of Onodi cells was higher when evaluated in multiple sectional views compared to a single sectional view (Weinberger et al., 1996; Driben et al., 1998). Therefore, our study assessed all three sectional views (coronal, axial, and sagittal) to prevent overlooking Onodi cells during CT scan analysis (Hui et al., 2022).

Numerous previous studies have reported a considerable variation in the prevalence of Onodi cells, ranging from 3.4% to 65.3% (Delano et al., 1996; Yanagisawa et al., 1998; Kasemsiri et al., 2011; Tomovic et al., 2012; Pham Thy and Pham Ngoc, 2012; Ozturan et al., 2013; Toan, 2013; Chmielik et al., 2014; Sarita Choudhary et al., 2014; Wada et al., 2015; Seung-Ju et al., 2015; Senturk et al., 2016; Chmielik and Chmielik, 2017; Nguyen et al., 2018). In our study, the observed rate of Onodi cells was 38.78%, distributed by gender as 34.21% in males and 65.72% in females, with no statistically significant difference between the two genders.

Table 2. Comparison of the prevalence rate of Onodi cells with previous studies.

Authors	Location	Year	Sample Size	Prevalence Rate
Thiên	Vietnam	2008	289	21%
Kasemsiri et al.	Thailand	2011	187	49,5%
Seung-Ju et al.	South Korea	2015	129	47,3%
Sarita et al.	India	2014	100	31%
Chmielik and Chmielik	Poland	2017	196	39,8%
Nguyen Thi et al.	Vietnam	2018	120	25,42
Nair and Ibrahim	India	2021	201	42,8%
Özdemir et al.	Germany	2019	508	21,2%
Le Nhat Vinh	Vietnam	2021	400	19,6%
Liuling Hui et al.	China	2022	273	60,4%
Our study	Vietnam	2023	98	38,78%

The prevalence rate of Onodi cells in our study was higher than in some previous studies, such as Sarita Choudhary et al. (2014) (31%), Ozdemir et al. (2019) (21.2%), and Vinh (2021) (19.6%) studies. However, it was quite similar to Chmielik and Chmielik's (2017) study in Poland in 2017, partly due to the use of similar criteria for analysing Onodi cells.

According to Chmielik's study, among the four types of relationships between Onodi cells and the optic nerve, types C and D are considered Onodi cells with a close relationship to the optic nerve. In the context of endoscopic sinus surgery, injuries to the optic nerve are more likely to occur with types C and D, especially when the optic nerve lacks bony covering (Chmielik and Chmielik, 2017). In our study, type A had the highest prevalence, accounting for 73.46% on the left and 66.32% on the right, followed by types C, D, and the lowest was type B, with no statistically significant difference between the left and right sides.

It can be observed that in both studies, type A consistently had the highest prevalence. However, the two dangerous types that often lead to optic nerve injuries during surgery (types C and D) still accounted for a considerable proportion, with 14.8% for type C and 25% for type D in Chmielik's study, and 12.24% for type C and 12.77% for type D in our study.

The pneumatization types of Onodi cells were classified into three types according to Thimmaiah's classification (Thimmaiah and Anupama, 2017), where type I had the highest prevalence, followed by type II, and the least was type III. This is quite similar to Nair and Ibrahim's study (Nair and Ibrahim, 2021), but differs from Thimmaiah's study, which reported type II as the most prevalent, followed by type I and type III. This difference may be attributed to variations in anatomical structures and pneumatization processes of the Onodi cell system among different ethnic groups.

Our study recorded that 50% of cases exhibited the optic nerve protruding into the Onodi cell, which is lower than the findings of Vinh (2021) (59.9%). In both studies, when Onodi cells were present, the prevalence of optic nerve protrusion was relatively high. The study also noted that 7.89% of cases involved the exposure of the optic nerve into the Onodi cell, which is the most dangerous type, leading to optic nerve injury during endoscopic sinus surgery.

Due to its close association with many important anatomical structures, especially the optic nerve, identifying the characteristics of Onodi cells before surgery is crucial. The presence of the optic nerve, whether or not there is dehiscence in the Onodi cell, *may* increase the risk of optic nerve injury, particularly when the surgeon fails to recognize their presence on preoperative CT scans. Evaluating Onodi cells on all three coronal, axial, and sagittal planes can help reduce the likelihood of overlooking these cells and provide a better assessment of their relationship with the optic nerve.

CONCLUSION

In this study, we reported the prevalence, characteristics, and relationship of Onodi cells with the optic nerve. CT scan proved to be a selected imaging diagnostic method that provides crucial information about Onodi cells before surgery.

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