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# STUDY ON THE OPTIC NERVE VARIATIONS IN RELATION TO POSTERIOR PARANASAL SINUSES USING CT IN TERTIARY CARE CENTRE

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**Abstract:**

**Background and objectives:** Optic nerve has a close relationship with the posterior paranasal sinuses. Depending on the degrees of pneumatization of these sinuses, the optic nerve may indent the sinus wall or protrude into them, predisposing the nerve to injury during sinus surgeries. Aim was to analyse the optic nerve variations in relation to the posterior paranasal sinuses and to categorize the subjects as per DeLano's classification.

**Methods:** Cross-sectional study was conducted on 336 patients above 16 years of age who underwent computed tomographic evaluation of head and brain. From volume data, multiplanar reconstructions were made in axial, coronal and sagittal planes and analysed in both bone and soft-tissue windows. Relationship of optic nerve with posterior paranasal sinuses were categorised into 4 types according to DeLano's classification. Bony dehiscence of optic canal and pneumatization of anterior clinoid process were also assessed.

**Results:** 672 optic nerves were assessed, the most common optic nerve type identified was type 1 (62.6%), followed by type 2 (18.6%). Types 3 and 4 were seen equally in number (9.6% each). Dehiscence of optic nerve canal and pneumatization of anterior clinoid process (ACP) was seen respectively on 66 (9.8%) and 75 (11.2%) sides. Compared to type 1 and 4 optic nerves, dehiscence of bony optic canal was statistically more significant in type 2 and 3 nerves. 45.5% individuals with anterior clinoid process pneumatization had associated optic canal dehiscence, which was found to be statistically significant.

**Conclusion:** Optic nerve variations were identified and classified according to DeLano's classification. The range was within international limits and type 1 was the most common occurrence. When compared to other similar studies among Indian population, disparity observed in the frequency of optic nerve types and bony optic canal dehiscence in our study, were probably due to differences in ethnicity and size of study group. Association of bony optic canal dehiscence with type 2 & 3 optic nerves and ACP pneumatization with type 3 optic nerve was found to be statistically significant, making them more vulnerable to injury during surgery. Knowledge of optic nerve relation with posterior paranasal sinuses, and its identification in preoperative computed tomography (CT) scan are important to avoid injury to optic nerve.

**Keywords:** Optic nerve, sphenoid sinus, posterior ethmoid cell, Onodi cell, anterior clinoid process pneumatization, optic canal dehiscence.

## Introduction:

Optic nerve is the second cranial nerve, carrying sensory nerve impulses from the retina towards the visual centres in the brain. Emerging from the posterior aspect of orbit, optic nerve courses posteromedially towards the optic chiasma. While coursing towards chiasma, the nerve has a close relationship with the posterior paranasal sinuses, where it seen superolateral to these sinuses. The position of optic nerve may be changed due to various degrees of pneumatization of the sinuses and it may protrude into them which is hardly visible or clear. Occasionally optic nerve is covered by a thin layer of bone or mucosa in the sphenoid sinus.[1–5]

DeLano et al. classified the relations of optic nerve with sphenoid and posterior ethmoid sinuses into four types. In Type 1, course of the nerve was adjacent to sphenoid sinus without indenting its wall. In Type 2, the nerve courses adjacent to sphenoidal sinus, indenting its wall. In Type 3, course of the nerve was through the sphenoid sinus. And in Type 4, the nerve passes immediately adjacent to the sphenoid sinus and the posterior ethmoidal air cell.[6]

Damage to one or both optic nerves during sinus surgery has been reported in various literatures.[7–9] Most of the complications resulting from endoscopic sinus surgery (ESS) are temporary and reversible. But, major and serious complications may result in permanent vision loss.[10–13] Detailed knowledge of

paranasal sinuses, adjacent anatomical structures and their variations are essential for clinicians performing sinus surgery, transseptal and transsphenoidal pituitary surgeries.[14] Preoperative CT scan of paranasal sinus will provide an excellent anatomical view as well as extent of the disease which can minimise the injury to vital structures. Classification of optic nerve course and its relations are mentioned in various literatures but not many literatures are available pertaining to Kerala population.

**Aim & Objectives**

- Analyse the optic nerve variations in relation to the posterior paranasal sinuses.
- To categorize the subjects as per DeLano's classification.

**Methodology**

**Study Design:** Cross Sectional study.

**Study Period:** 18 months. (January 2019 to June 2020)

**Study Setting:** Department of Radiodiagnosis, Jubilee Mission Medical College & Research Institute, Thrissur, Kerala.

**Sample Size:** Based on the proportion of optic nerve variation in an earlier publication[15], with 95% confidence level and 10% relative allowable error minimum sample size comes to 310.

$$\text{sample size (n)} = \frac{z_{(1-\alpha/2)}^{2}\, pq}{d^2}$$

$z_{(1-\alpha/2)}^{2}$ =confidence interval, p = estimated proportion, d = desired precision

**Inclusion Criteria:** Males and females above 16 years of age, who are referred by various clinicians, for undergoing computed tomographic evaluation of head and brain.

**Exclusion Criteria:** Individuals with sinonasal tumors, prior sinus surgery, facial fracture and congenital craniofacial anomaly.

**Materials and Methods:**

CT Head and Brain was performed on GE 660 OPTIMA 128 multislice CT SCANNER. The axial examination was performed in routine protocol with the patient supine, the hard palate perpendicular to the table top, and the scanning plane parallel to the orbitomeatal line. The cranial and caudal limits of the average scan (vertex and hard palate, respectively) localized from the lateral scout view. The technical parameters adopted for acquisition of tomographic images included a 120 kV tube voltage and auto mAs (160mAs), 0.8 second rotation time, section thickness of 5 mm, a field of view (FOV) of 25cm. Images were then transferred into the computer workstation for interpretation. Sequential axial images were obtained and processed to form volume data. From volume data, multiplanar reconstructions were made in axial, coronal and sagittal planes (0.625 mm) and analysed in a dedicated workstation. All images were evaluated in both coronal and axial planes in both bone (window width 2,000 Hounsfield units [HU]; window level 300 HU) and soft-tissue window (window width 350 HU; window level 40 HU). Right and left sides were considered separately. Optic nerve, sphenoid sinus, posterior ethmoid cell, dehiscence of optic nerve canal, pneumatization of the anterior clinoid process and position of the inter and accessory sphenoid septum were evaluated from the obtained images. The CT scan images were first assessed by the principal investigator and thereafter, independently by co-authors. Variations in the course of optic nerve in relation to posterior paranasal sinuses were studied from the obtained images and categorised into 4 types according to DeLano system of classification. Bone dehiscence was defined as the absence of visible bone density separating the sinus from the course of the optic nerve. Anterior clinoid process pneumatization was also noted.

**Sampling Procedure:** Consecutive CT Head and Brain of 310 subjects, of those who met the criteria were analysed. These included both males and females above 16 years the age.

**Plan of Analysis**

Statistical tests, percentage analysis, chi-square test.

**Statistical Methods:** Numerical variables were expressed as mean and standard deviation. Categorical variables were expressed as frequency and percentages. Chi square test / Continuity correction test was used to find the association between categorical variables. Data was entered in excel sheet and analyzed by using IBM Statistical Package for Social Sciences (SPSS) version 25. The p value <0.05 was considered as statistically significant.

**Results & Analysis**

A total of 336 cases (672 sides) were analysed of which 191 (56.85%) were males and 145 (43.2%)

were females. Age of individuals ranges between 16 to 95. Average age was 52.38 ± 18.78.

**Optic Nerve - Types**

Optic nerves were categorized according to DeLano classification[6]. The most common optic nerve type was type 1, followed by type 2. Types 1 to 4 were respectively seen on 421 (62.6%), 125 (18.6%), 63 (9.6%) and 63 (9.6%) sides. Type 1 optic nerve was the most frequently seen type on both sides, followed by type 2. On right side, the least common type was type 3. While on the left, it was type 4. Type 1 optic nerve morphology was observed in 209 (62.2%) right and 212 (63.1%) left optic nerves. Type 2 morphology was present in 63 (18.8%) right and 62 (18.5%) left optic nerves. Type 3 morphology noted in 29 (8.6%) right and 34 (10.1%) left optic nerves. Type 4 morphology noted in 35 (10.4%) right and 28 (8.3%) left optic nerves. In 310 (92.3%) cases, sphenoid sinus contacts the ipsilateral optic nerve and in 26 (7.7%) cases it contacts both optic nerves, 6 (1.8%) on right and 20 (5.9%) on left side. (Figure 1-4)

**Figure 1:** Coronal CT scan showing type 1 optic nerve on right side, type 3 on left and pneumatization of left ACP.

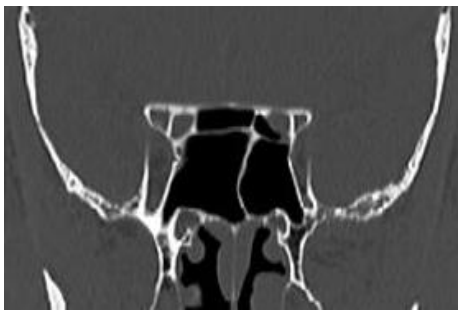


**Figure 2:** Coronal CT scan showing Onodi cell and type 4 optic nerve on both sides. Left optic canal is showing dehiscence and protrusion into Onodi cell.

**Figure 3:** Oblique coronal CT scan showing Onodi cell and type 4 optic nerve on right side. Right ACP is showing pneumatization from Onodi cell. Type 2 optic nerve is seen on left side.

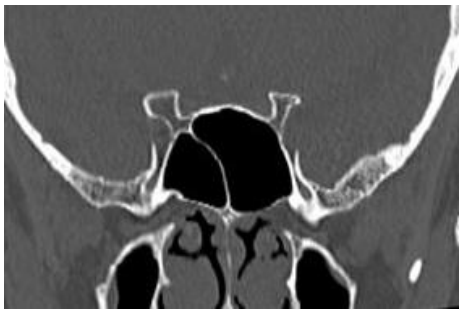


**Figure 4:** Coronal CT scan showing left sphenoid sinus in contact with both optic nerves.

Optic nerve canal dehiscence was noted on 66 (9.8%) sides. Accessory septa were observed in 116 (17.3%) sphenoid sinuses, of which it's attachment to optic nerve was observed on 9 (1.3%) sides. Anterior clinoid process pneumatization was noted on 75 (11.2%) sides. Onodi cells were noted on 61 (9.1%) sides.

**Dehiscence of Bony Optic Nerve Canal**

Dehiscence of optic nerve canal was present in 52 (15.5%) individuals. Out of this, 18 (34.6%) cases were noted on right side, 20 (38.5%) on left side and 14 (26.9%) bilaterally. 17.8% (34 cases) of males and 12.4% (18 cases) of females had dehiscence of bony optic nerve canal, which was not statistically significant. Out of 66 sides of bony optic canal dehiscence, 45.5% were noted in type 2 optic nerve. 1.2% (5 sides) of type 1, 24.0% (30 sides) of type 2, 33.3% (21 sides) of type 3 and 9.8% (10 sides) of type 4 optic nerve canals had dehiscence. Compared to type 1 and 4 optic nerves, dehiscence of bony optic canal was statistically more significant in type 2 and 3 nerves. (Table No.1) (Figure 2).

**Table 1: Frequency distribution of bony optic canal dehiscence and optic nerve type.**

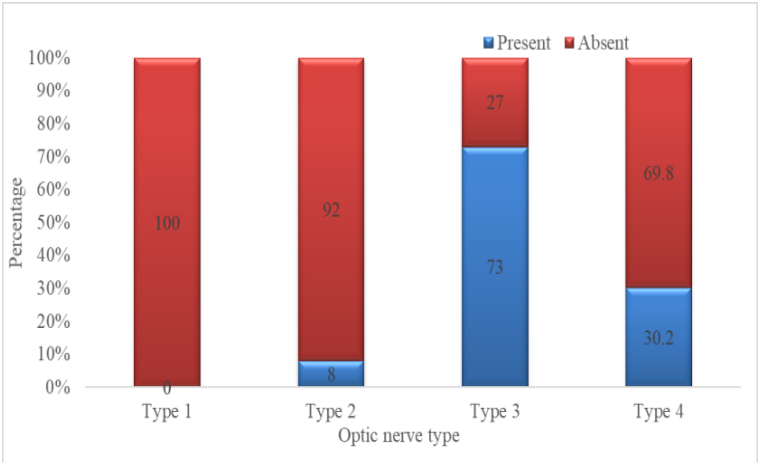
| Dehiscence of bony optic canal | Optic nerve type | | | | Total | p Value |
|---|---|---|---|---|---|---|
| | Type 1 n (%) | Type 2 n (%) | Type 3 n (%) | Type 4 n (%) | | |
| Absent | 416 (98.8%) | 95 (76.0%) | 42 (66.7%) | 53 (84.1%) | 606 (90.2%) | <0.001 |
| Present | 5 (1.2%) | 30 (24.0%) | 21 (33.3%) | 10 (15.9%) | 66 (9.8%) | |
| Total | 421 | 125 | 63 | 63 | 672 | |

**ANTERIOR CLINOID PROCESS PNEUMATIZATION**

ACP pneumatization was present in 55 (16.4%) individuals. Out of this, 22 (40.0%) were noted on right side, 13 (23.6%) on left side and 20 (36.4%) bilaterally. 18.3% (35 cases) of males and 13.8% (20 cases) of females had ACP pneumatization, which was not statistically significant. Out of 75 sides of ACP pneumatization, 61.3% were noted to be associated with type 3 optic nerve. None of them were seen with type 1 optic nerve. 8.0% (10 sides) of type 2, 73.0% (46 sides) of type 3 and 30.2% (19 sides) of type 4 optic nerves were associated with ACP pneumatization. Statistically significant association was noted between type 3 optic nerve and ACP pneumatization. (Table No.2) (Graph No.1)

**Table 2: Frequency distribution of Anterior clinoid process pneumatization and Optic nerve type**

| ACP Pneumatization | Optic nerve type | | | | Total | p Value |
|---|---|---|---|---|---|---|
| | Type 1 n (%) | Type 2 n (%) | Type 3 n (%) | Type 4 n (%) | | |
| Absent | 421 (100%) | 115 (92.0%) | 17 (27.0%) | 44 (69.8%) | 597 (88.8%) | <0.001 |
| Present | 0 (0.0%) | 10 (8.0%) | 46 (73.0%) | 19 (30.2%) | 75 (11.2%) | |
| Total | 421 | 125 | 63 | 63 | 672 | |




**Graph 1: Distribution of Anterior clinoid process pneumatization and Optic nerve type**

45.5% individuals with ACP pneumatization had associated bony optic canal dehiscence, which was found to be statistically significant. (Table No.3).

**Table 3: Frequency distribution of ACP pneumatization and Dehiscence of optic canal**

| ACP pneumatization | Dehiscence of bony optic canal | | Total | p Value |
|---|---|---|---|---|
| | Absent n (%) | Present n (%) | | |
| Present | 25 (45.5) | 30 (54.5) | 55 | <0.001 |
| Absent | 27 (9.6) | 254 (90.4) | 281 | |
| Total | 52 (15.5) | 284 (84.5) | 336 | |

**Inter sphenoid sinus septa and its termination to optic nerve canal**

Inter sphenoid sinus septa was observed in all cases, out of which 77 (22.9%) were attached to optic nerve canal - 40 to right and 37 to left optic nerve canal. (Figure 5)

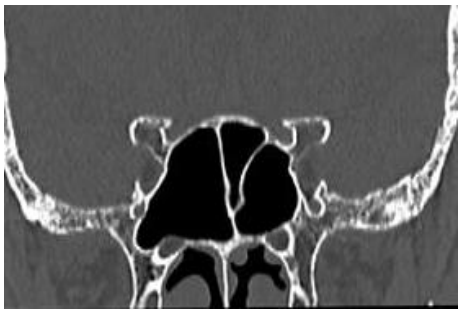


**Figure 5:** Coronal CT scan showing the accessory septa in left sphenoid sinus attaching to ipsilateral optic canal.

**Accessory sphenoid septa attaching to optic nerve canal**

Accessory sphenoid septa was present in 87 (25.9%) individuals. Out of this, 27 (31.0%) were noted on right side, 31 (35.6%) on left side and 29 (33.3%) bilaterally. 116 (34.6%) sinuses had accessory septa, 56 were on right and 60 on left side. 9 (7.8%) accessory sphenoid sinus septae were seen attaching to optic nerve canal, of which 03 were in right sinus and 06 in left sinus. (Figure 6)

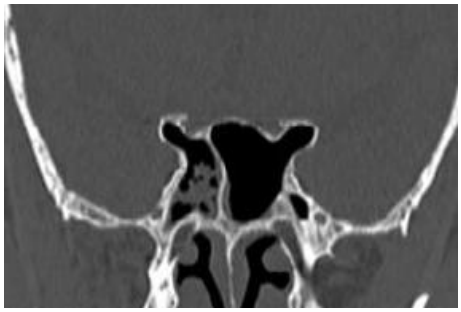


**Figure 6:** Coronal CT scan showing type 3 optic nerve on both sides with intersphenoid septa attaching to right optic canal.

Out of 336 individuals, 87 were having septa attaching to optic nerve canal either from inter sphenoid sinus, inter Onodi, accessory sphenoid sinus septa or that with in the Onodi cell.

**ONODI CELL**

Onodi cells were present in 51 (15.2%) individuals. Out of this, 24 (47.1%) were noted on right side, 17 (33.3%) on left side and 10 (19.6%) bilaterally. In two patients, single Onodi cell was seen crossing midline. Optic nerves on both sides had close contact with this Onodi cell. (Figure 7) Onodi cell septa was noted in one patient, which was seen attaching to optic canal also. (Figure 8) In one patient with bilateral Onodi cell, inter Onodi septa was seen attaching to right optic nerve canal. (Figure 9) ACP pneumatization from Onodi cells was seen on 10 sides. (Figure 9)

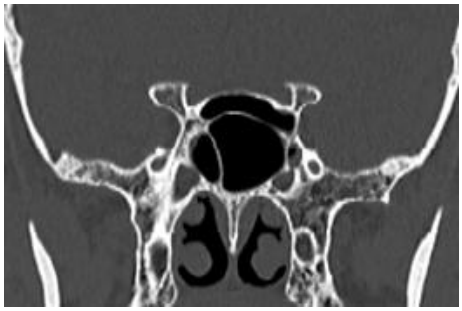


**Figure 7:** Coronal CT scan showing Onodi cell crossing the midline, and showing contact with both optic nerves.

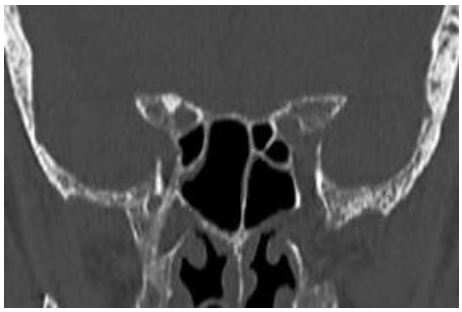


**Figure 8:** Coronal CT scan showing Onodi cell on both sides. Septa in left Onodi cell is attaching to optic canal.

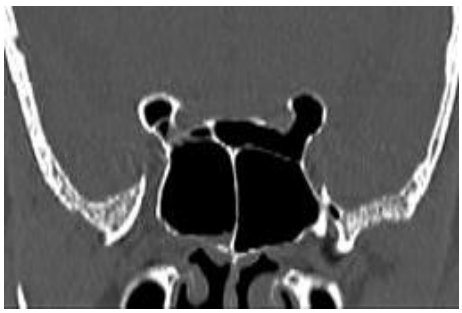


**Figure 9:** Coronal CT scan showing Onodi cell and type 4 optic nerve on both sides. Inter onodi septa is attaching to right optic canal. ACP is showing pneumatization from Onodi cells on both sides.

**Discussion**

Damage of the optic nerve during intranasal sinus surgery can result in serious complications and

blindness. Knowledge of optic nerve course and its relation with posterior paranasal sinus is important to avoid iatrogenic injury. CT of paranasal sinus is the best technique to assess the morphological relationship of optic nerve canal with posterior ethmoid and sphenoid sinuses. In various researches, overall, the most commonly reported morphology of optic nerve was type 1 followed by type 2.[2,3,5,6,15–20] But in the study conducted by Batra et al[5], type 2 (39.8%) optic nerve was the most common and type 1 (25.8%) was second most common. They used a modified DeLano classification for analysis. Type 3 (23.5 %) optic nerve morphology was reported as the second common type in the study by Heskova et al[2]. In most of the studies, type 4 was the least commonly reported optic nerve. Santhana Lakshmi et al[16] and Braggs[20] et al reported type 3 (1.8% and 7.6% respectively) as the least common optic nerve in their studies. Sapçı et al[3] observed equal number of optic nerves in type 3 and 4 (7% each), in a pattern similar to our study. Lakhani et al[15] and Braggs et al[20] compared the frequency of different optic nerve types on right and left side and reported that there was not much difference in number of the various optic nerve types on right and left side. In our study, frequency of type 1 optic nerve was close to the Indian range (60%-65.8%). Frequency of type 2 optic nerve was also seen close to the range of Braggs et al[20] (17.8%) and Rishikesh et al[19] (15%), but was much less than that of Santhana Lakshmi et al[16] (29.8%). Type 3 optic nerve was seen less frequently than that of Rishikesh et al[19] (14%). Both type 3 and 4 optic nerves were seen in higher frequencies than that of Santhana Lakshmi et al[16] (1.8% ad 2.6%). In our study, approximately 92.3% of sphenoid sinuses were in contact with ipsilateral optic nerve, and in 7.7% they contact both optic nerves. Similar findings were reported previously by Bansberg et al[14] in Ronchester. To the best of our knowledge, no Indian studies have reported it so far. Disparity in frequency of optic nerve types in various studies can be explained as a result of ethnicity. Apart from ethnicity, selection of study group and age groups also influences the frequency.

Dehiscence of optic canal was within the international range (0.6% to 30.6%).[2–6,16–19,21–23] Compared to other Indian studies, optic canal dehiscence found in our study was in higher frequencies than that of Santhana Lakshmi et al[16] (2.1%) and lower frequencies than that of Rishikesh et al[19] (17.5%). Anusha et al[22] observed 60.9% of optic canal dehiscence in males, while in a study by Davoodi et al[24], it was more frequently seen in females (46% of females). In our study, optic canal dehiscence was more frequently seen in males, but it was not statistically significant. Dehiscence of optic canal was seen significantly with type 2 and 3 optic nerves in various studies. DeLano et al[6] observed optic canal dehiscence in all type 3 optic nerves. Rishikesh et al[19] noted optic canal dehiscence in 64.3% of type 3 optic nerves. In our study, optic canal dehiscence with type 2 and 3 optic nerves were seen within the international range, but was less frequent when compared to that of other Indian studies. Total absence of bony wall is taken as dehiscence in our study. While in some other studies, thinning of bone less than 0.5mm is also included.[1] Ethnicity, type of scan and study group also attribute to a wide range in dehiscence.

ACP pneumatization was seen within the international range (4% to 54%).[2–4,6,16–19,21,23,25] Significant association between ACP pneumatization and type 3 optic nerve was reported in most of the studies; it was 93% in the study by Rishikesh et al in Karnataka population.[19] While in the study by Santhana Lakshmi et al[16] in South Indian ethnicity, optic nerve types and its association with anterior clinoid process pneumatization were found to be insignificant. Significant association between ACP pneumatization and optic canal dehiscence was reported in studies by DeLano et al[6] (77%) and Sapçı et al[3] (23%). 45.5% individuals with ACP pneumatization had associated optic canal dehiscence in our study, which was found to be statistically significant. Pneumatization of ACP from onodi cell was previously reported by Yuefeng Li et al.[25]

Inter- sinus septa termination on optic canal was observed by Manisha et al[26] in 10% and Batra et al[5] in 30.5%. Multiple sphenoid sinus septations were reported in various (5 - 80%) studies.[3,22,27] Manisha et al[26] in their study on North Karnataka population, observed accessory septa / crests in 43% cadavers and termination into optic nerve canal in 6%. Onodi cell was reported upto 50.8 % in various studies.[14,28,29] Central Onodi cell has been previously reported by Deepa et al.[30] In our study, two patients had similar Onodi cell. Optic nerves on both sides had close contact with this Onodi cell. Onodi cell septa, ACP pneumatization from onodi and central onodi cell are uncommon, knowledge of these rare findings and optic nerve relation to them are important.

**Limitations**

Sample included only a small population of central Kerala which does not represent the whole population.

Movement of the patient produced CT artifacts which hindered our evaluation.

## Conclusion

In our study, optic nerve variations were identified and classified according to DeLano's classification. The range was within international limits and type 1 was the most common occurrence. When compared to other similar studies among Indian population, disparity observed in the frequency of optic nerve types and bony optic canal dehiscence in our study, were probably due to differences in ethnicity and size of study group. Association of optic canal dehiscence with type 2 & 3 optic nerves and ACP pneumatization with type 3 optic nerve was found to be statistically significant, making them more vulnerable to injury during surgery. Knowledge of optic nerve relation with posterior paranasal sinuses, and its identification in preoperative CT scan are important to avoid injury to optic nerve.

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