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Delano's Classification of Optic Nerve Canal to Posterior Paranasal Sinuses: A Retrospective Study in Eastern District, KSA

MONA G. ALKAPHOURY, M.D. and EMAN F. DOLA, M.D.

The Department of Radiology, Faculty of Medicine, Ain Shams University

Abstract

Background: The Delano classification categorizes the relationship between the sphenoid sinus and optic nerve into four types. This classification helps understand the location of the optic nerve and posterior paranasal sinuses, especially for endoscopic sinus surgical procedures in which the proximity of the optic nerve to the sphenoid sinus can pose risks.

Aim of Study: This study aimed to determine the relationship between the optic nerve canal (ONC) and posterior paranasal sinuses and their types, incidence, and prevalence among a study population in the eastern district of the Kingdom of Saudi Arabia (KSA). Key Points paranasal sinuses CT; Delano's classification; optic nerve canal; optic nerve dehiscence; pneumatization of anterior clinoid process.

Patients and Methods: This retrospective study included 300 patients who were referred to our CT unit for paranasal sinus for the planning of functional endoscopic sinus surgery.

Results: This study found that the most common type was type 1, whereas the second most common was type 2. Types 3 and 4 were least common. Delano type 3 was more common on the right side, and type 4 was more common on the left, whereas types 1 and 2 occurred most frequently bilaterally. This illustrates the significance of Delano's classification according to side, with a *p*-value of <0.001. We found a significantly higher frequency of dehiscence and positive pneumatization of anterior clinoid process (PACP) in Delano type 3 on both sides.

Conclusion: Optic nerve dehiscence and PACP were associated more frequently with Delano type 3; therefore, patients with type 3 are more predisposed to optic nerve injury during sinus surgery. Hence, we conclude that anatomical variations of the paranasal sinuses using the Delano classification of the optic nerve are very important for preoperative identification.

Key Words: *Delano's Classification – Optic Nerve Canal – Posterior Paranasal Sinuses.*

Correspondence to: Dr. Mona G. Alkaphoury,
The Department of Radiology, Faculty of Medicine,
Ain Shams University

Introduction

CT and MRI can be used to assess the relationship between the sphenoid sinus and optic nerve ***[1]***. They provide precise data regarding the location and shape of the optic nerve and sphenoid sinus.

There are different anatomical relationships between the optic nerve and the sphenoid sinus. Different studies on paranasal sinus CT have used the Delano classification to categorize the relationship between the optic nerve and the sphenoid sinuses ***[2]***.

Researchers have found that:

90% of the sphenoid sinuses contacted the ipsilateral optic nerve and 10% contacted both nerves. These studies also observed pneumatization of the anterior clinoid process (PACP) and bony dehiscence of the optic nerve **[3,4]**.

According to the Delano classification, the relationship between the sphenoid sinus and the optic nerve is categorized into four types: Type 1, the optic nerve is immediately adjacent to the lateral or superior wall of the sphenoid sinus without impression of the sinus wall; type 2, the optic nerve causes an impression of the lateral sphenoidal sinus wall; type 3, the optic nerve courses through the sphenoid sinus; and type 4, the optic nerve courses immediately lateral to the posterior ethmoid and sphenoid sinuses ***[5-7]***.

Abbreviations:

FESS : Functional endoscopic sinus surgery.
KSA : Kingdom of Saudi Arabia.
ONC : Optic nerve canal.
PACP : Pneumatization of anterior clinoid process.
PNS : Paranasal sinus.

This classification is useful for understanding the location of the optic nerve and the posterior paranasal sinuses (PNSs), especially in surgical procedures in which the proximity of the optic nerve to the sphenoid sinus can pose risks during endoscopic sinus surgery [8].

The modified Delano classification is different only in type 3: The optic nerve courses through the sphenoid sinus without contacting the posterior ethmoid cells [5].

Delano's classification, together with its modified version, shows some limitations, including variability in the definition of types, which is based on visual assessment of CT scans. These assessments can be subjective and prone to interobserver variability [9].

Delano's classification does not cover all possible variations in the positions of the optic nerve in relation to the sphenoid sinus and lack of correlation with clinical outcomes [6].

The position of the optic nerve in the sphenoid sinus has significant implications in surgical procedures, particularly transnasal endoscopic surgery. The proximity of the optic nerve to the sphenoid sinus and the degree of its protrusion into the sinus can increase the vulnerability of the nerve during surgery and may lead to serious consequences or complications. This is particularly relevant in transnasal endoscopic surgery, in which the orbit, posterior PNSs, optic canal, and skull base are involved. Patients with extensive disease, those undergoing revision surgery, and those with anatomical variations due to previous disease or surgery are at an increased risk of complications. The close proximity of key landmarks, including the optic canal, carotid protuberance, and skull base, renders surgical procedures involving the sphenoid sinus potentially risky. Therefore, understanding the position of the optic nerve in the sphenoid sinus is essential for surgical planning and endoscopic transnasal surgery to minimize the risk of complications and ensure patient safety [10].

Further research is needed to establish a more direct link between the optic nerve position and clinical outcomes.

This study aimed to determine the relationship between the optic nerve canal (ONC) and posterior paranasal sinuses and their types, incidence, and prevalence among a study population in the eastern district of the Kingdom of Saudi Arabia (KSA).

Patients and Methods

This study was conducted retrospectively on 300 patients who were referred to our CT unit for PNS CT for functional endoscopic sinus surgery (FESS) planning between March 2021 and June 2023. All data were retrieved from the picture archiving and communication system of the Tele Radiology Departments of Mowasat Hospitals in the eastern district of KSA. Approval was obtained from the ethics committee of Mouwasat Hospital, Dammam.

Inclusion criteria: Patients referred for pre-FESS assessment with PNS CT.

Exclusion criteria: Patients with a previous sinus surgical procedure.

Imaging protocol:

All participants underwent CT scans of the PNS acquired on 64 rows MDCT in helical mode, 0.65 mm slice thickness, 120 kV, and auto mAs. Multiplanar coronal reconstructions were analyzed using a dedicated workstation.

No contrast media was used.

Image analysis:

Images were evaluated by two radiologists with 7 and 15 years of experience in diagnostic head and neck imaging.

Statistical analysis:

Data were analyzed using the Statistical Package for Social Sciences (SPSS version 27).

Descriptive analyses were performed to obtain the means and deviations of the quantitative data. Qualitative data is expressed as numbers and frequencies. Bar graphs illustrate the different types of ONCs.

Bivariate analyses were performed using the chi-squared test and goodness-of-fit chi-square tests for categorical variables. Statistical significance was set at $p<0.05$.

Results

We enrolled 300 patients with ages ranging from 7.0–81.0 years (mean age: 35.1 years). When examining the participants' characteristics, 102 were female (34.0%) and 198 were male (66.0%) (Table 1).

Our results described the frequency of the ONC according to the Delano classification and found that the most common type was type 1 (Fig. 1), with 60.7% on the right side and 61.35% on the left side. The second most common was type 2, with 17.7% on the right side and 18.7% on the left side. Types 3 and 4 were the least common. Bony dehiscence was seen bilaterally in about 87.0% (Fig. 2).

Delano type 3 was more common on the right side, and Delano type 4 was more common on the left side, whereas types 1 and 2 occurred at the same frequency bilaterally. This illustrates the significance of Delano's classification according to side ($p<0.001$) (Table 2).

Table (1): Descrip ve (Pneuma za on of Anterior Clinoid Process (PACP).

	N	%
Age:		
Mean ± SD	35.1±12.4	
Min-Max	(7-81)	
Gender:		
Female	102	34.0%
Male	198	66.0%
RT side:		
Type I	182	60.7%
Type II	53	17.7%
Type III	29	9.7%
Type IV	36	12.0%
LT side:		
Type I	184	61.3%
Type II	56	18.7%
Type III	31	10.3%
Type IV	29	9.7%
RT bony dehiscence:		
Negative	261	87.0%
Positive	39	13.0%
LT bony dehiscence:		
Negative	259	86.3%
Positive	41	13.7%
RT side PACP:		
Negative	275	91.7%
Positive	25	8.3%
LT side PACP:		
Negative	261	87.0%
Positive	39	13.0%

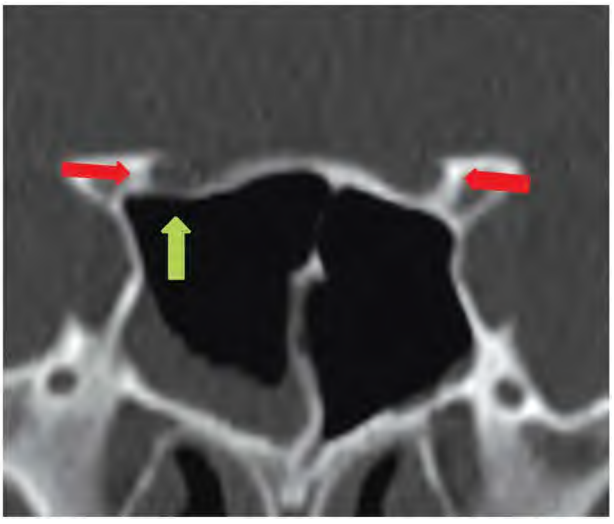

Fig. (1): Coronal CT images showing bilateral type 1 op c nerve canals (red arrows). The canal is seen at the superior wall of the sphenoid sinuses with no canal indenta on on the sinus cavity. Right side shows canal floor dehiscence (green arrow).

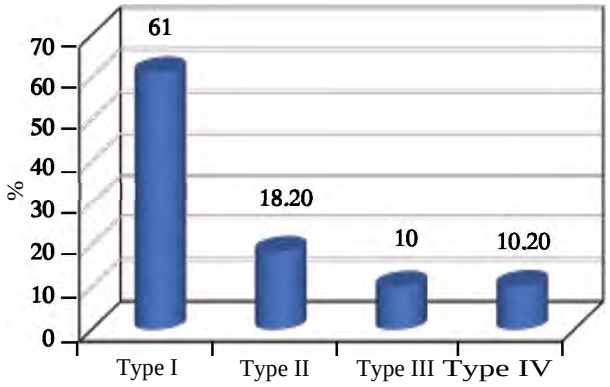

Fig. (2): Frequency of the optic nerve canal according to Delano's classification.

Table (2): Frequency of the optic nerve canal according to Delano's classification according to the side (N=300).

	Right side N (%)	Left side N (%)
Type I	184 (61.3)	180 (60.7)
Type II	56 (18.7)	53 (17.7)
Type III	31(10.3)	29 (9.7)
Type IV	29(9.7)	36 (12)
p-value	<0.001*	<0.001*

The relationship between sex and Delano's type of ONC showed that there were no differences between males and females regarding the frequency of the different types (Table 3).

Regarding optic canal dehiscence and Delano classification, there was a statistically significant high frequency of dehiscence and positive PACP in Delano type 3 on both sides (Tables 4,5).

Table (3): Relationship between gender and Delano's types of optic nerve canal (N=300).

	Gender		*p*-value
	Female N (%)	Male N (%)	
RT side:			
Type I	70 (68.6)	112 (56.6)	0.153
Type II	14 (13.7)	39 (19.7)	
Type III	6 (5.9)	23 (11.6)	
Type IV	12 (11.8)	24 (12.1)	
LT side:			
Type I	71 (69.6)	113 (57.1)	0.168
Type II	14 (13.7)	42 (21.2)	
Type III	10 (9.8)	21 (10.6)	
Type IV	7 (6.9)	22 (11.1)	

Test of sig: Chi-square test.

Comment : On both sides there were no differences between males and females regarding the frequency of different types.

Table (4): Relation between Delano's optic nerve canal types and the presence of canal bony dehiscence at the right side (n=300)

	RT side				*p*-value
	Type I N (%)	Type II N (%)	Type III N (%)	Type IV N (%)	
RT bony dehiscence:					
–ve	164 (90.1)	47 (88.7)	15 (51.7)	35 (97.2)	0.153
+ve	18 (9.9)	6 (11.3)	14 (48.3)	1 (2.8)	
RT side PACP:					
–ve	180 (98.9)	47 (88.7)	13 (44.8)	35 (97.2)	0.168
+ve	2 (1.1)	6 (11.3)	16 (55.2)	1 (2.8)	

Test of significant chi-square test. * Sig *p*-value.

Comment: Regarding the right side, there was a statistically significant high frequency of dehiscence and positive PACP in Delano's types III.

Table (5): Relation between Delano's optic nerve canal types and the presence of canal bony dehiscence at the left side (n=300).

	LT side				*p*-value
	Type I N (%)	Type II N (%)	Type III N (%)	Type IV N (%)	
LT bony dehiscence:					
Negative	168 (91.3)	47 (83.9)	19 (61.3)	25 (86.2)	0.153
Positive	16 (8.7)	9 (16.1)	12 (38.7)	4 (13.8)	
LT side PACP:					
Negative	182 (98.9)	45 (80.4)	9 (29)	25 (86.2)	0.168
Positive	2 (1.1)	11 (19.6)	22 (71)	4 (13.8)	

Test of significant chi-square test. * Sig *p*-value.

Comment: Regarding the right side, there was a statistically significant high frequency of dehiscence and positive PACP in Delano's types III.

Discussion

Understanding the relationship between the optic nerve and sphenoid sinus is an important dilemma before FESS. This can be attributed to the clear proximity of the optic nerve canal to the sphenoid sinus and posterior ethmoid air cells. In addition, bony dehiscence can occur when the sphenoid and posterior ethmoid sinuses are extensively pneumatized. CT is the modality of choice to assess the ONC and PNSs because of its ability to display bone, air, and soft tissue of different densities at high resolution. The inconsistent pneumatization pattern of the sphenoid sinus is attributed to the variable relationship between the optic nerve and the PNSs [11]. Delano's classification was one of the first in its field to describe the relationship between ONC and the sphenoid sinus [8]. Delano et al. [2] found that 85% of optic nerves associated with PACP were of the type 3 configuration, which is comparable to our study that showed that PACP was significantly associated with type 3, followed in frequency by type 2.

In our study, we found that type 1 was the most frequent type, followed by type 2, whereas types 3 and 4 changed their frequency according to the side compared to Itagi et al. [5], who reported nearly the same frequency in an Indian population. In their study, type 1 seen in 60% of the studied group, followed by type 2 (15%), type 3 (14%), and type 4 (11%). In our study, optic nerve dehiscence was seen in about 13% bilaterally and was significantly associated with Delano type 3 (Fig. 3). Itagi et al. [5] also found that dehiscence in 17.5% of the study group, and it was mostly associated with type 3 canals.

Our study proved that PACP was seen in 8% on the right side and 13% on the left side and was significantly associated with Delano type 3 (Figs. 4-6). Ravindra and Devika [6] showed comparable results to our study; PACP cells were observed in 8.9% on the right side and 5.6% on left side of the patients. Itagi et al. [5] showed that 10.5% PACP were on the right side, and 6.5% were on the left side.

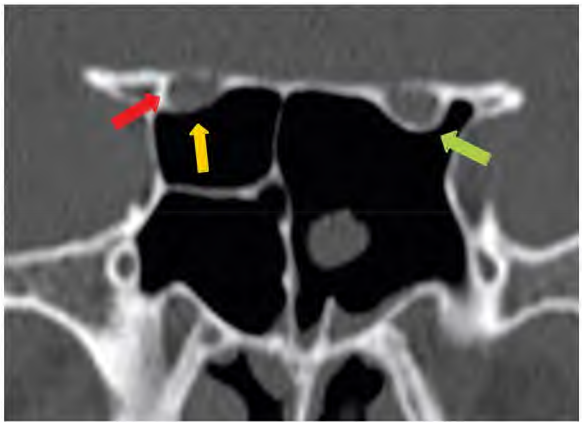

Fig. (3): Coronal CT images showing type 2 op c nerve canal at the right (red arrow) with less than half of its canal circumference protruding into the sinus cavity. On the le , type 3 op c nerve canal with more than half of its canal circumference protruding into the sinus cavity (green arrow). Right canal bony dehiscence (orange arrow).

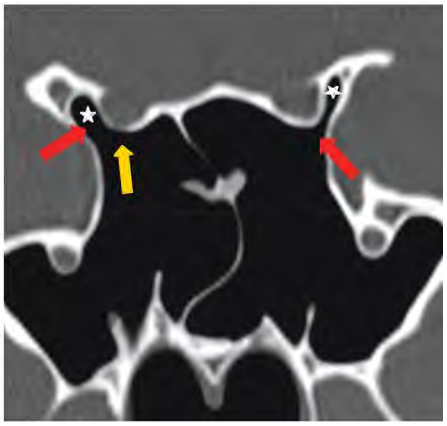

Fig. (4): Coronal CT images showing bilateral type 3 op c nerve canal with more than half of both canal circumferences protruding into the sinus cavity (red arrows). Right canal bony dehiscence (orange arrow). Bilateral aerated anterior clinoid processes (white asterisks).

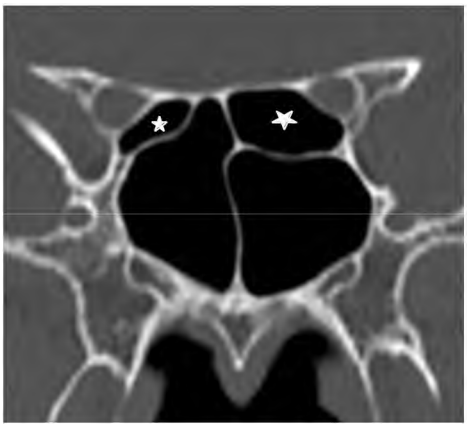

Fig. (5): Coronal CT images showing type 4 op c nerve canal with both canals adjacent to sphenoid and posterior ethmoid sinuses with the presence of Onodi cell (white asterisk).

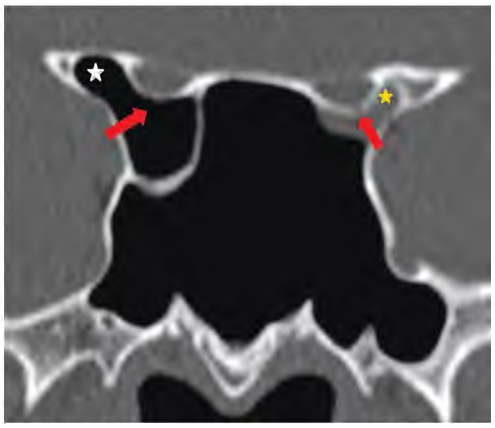

Fig. (6): Coronal CT images showing right type 3, le type 2 canals. Bilateral bony canal dehiscence (red arrows). Bilateral pneuma zed anterior clinoid processes, aerated at the right (white asterisk), opacified at the le (orange asterisks).

Fadda et al. *[12]* described sphenoid sinus pneumatization with 1.5% of dehiscence of the ONC. They found a correlation between the degree of ONC dehiscence, the internal carotid artery, and the severity of sphenoid sinus pneumatization. They concluded that CT should be considered before endoscopic sinus surgery to identify the extent of ONC dehiscence and sphenoid sinus pneumatization.

Another study by Dias et al. *[7]* described that the majority of the patients (78.96%) had Delano type 1. Type 2 was observed in 16.83% of the patients, Type 3 in 3.47%, and Type 4 in 0.74%. ONC dehiscence was observed in 21.29% of the studied population. The pneumatization of the anterior clinoidal process was observed in 10.64% of the cases. They also concluded that ONC dehiscence was related to the degree of pneumatization of the anterior clinoid and Delano types 2, 3, and 4.

On the other hand, Thakur et al. *[9]* analyzed 400 CT scans and found that the most common configuration of the ONC was Delano type 2 (34.75%).

Kanotra et al. *[1]* described the type 1 position of optic nerve in 69.3%, type 2 in 20.9%, type 3 in 3%, and type 4 in 6.8% of sinuses. PACP was observed in 10.5%, and bony dehiscence of optic nerve was noted in 6.5% sinuses. Bony dehiscence of optic canal was associated PACP in 64.1% sinuses.

Heskova et al. *[10]* found that the most frequent position of optic nerve was Delano type 1 (55.9%),

followed by Delano type 2 (14.7%) and type 3 (23.5%). Delano type 4 represented 5.9%. Optic nerve protrusion, dehiscence of the bony wall, and PACP was observed in 35.3%, 11.8%, and 26.5% patients, respectively.

In our study, 300 patients were evaluated using Delano's classification. Type 1 is the most common type. There was a statistically significant difference in Delano's classification frequency between the right and left sides. Optic nerve dehiscence and PACP were associated more frequently with Delano type 3; therefore, patients with type 3 are more predisposed to optic nerve injury during sinus surgery. Hence, we concluded that the anatomical variations of the PNSs are very important to identify preoperatively, since the sphenoid sinus and optic nerve are known for their anatomical variation. Before endoscopic sinus surgery, one needs to know this anatomy using CT of the PNSs and assigning the Delano classification of the optic nerve.

References

1- SETHI K.S., CHOUDHARY S., GANESAN P.K., et al.: Sphenoid sinus anatomical variants and pathologies: Pictorial essay. Neuroradiology, 65: 1187–1203, 2023. DOI:10.1007/s00234-02303163-4.

2- DELANO M.C., FUN F.Y. and ZINREICH S.J.: Relationship of the optic nerve to the posterior paranasal sinuses: A CT anatomic study. AJNR Am. J. Neuroradiol., 17: 669–675, 1996.

3- KANOTRA S., BASHIR S., SHARMA P., et al.: Anatomical variations of the optic nerve in the sphenoid sinus: Do ethnic variations matter? Indian J Otolaryngol Head Neck Surg., 75: 1943–1949, 2023. DOI:10.1007/s12070-023-03798-y.

4- BANSBERG S.F., HARNER S.G. and FORBES G.: Relationship of the optic nerve to the paranasal sinuses as shown by computed tomography. Otolaryngol. Head Neck Surg., 96: 331–335, 1987. DOI:10.1177/019459988709600405

5- ITAGI R.M., ADIGA C.P., KALENAHALLI K., GOOLAHALLY L. and GYANCHANDANI M.: Optic nerve canal relation to posterior paranasal sinuses in Indian ethnics: review and objective classification. J. Clin. Diagn. Res., 11: TC01–TC03, 2017. DOI:10.7860/JCDR/2017/23447.9510.

6- RAVINDRA B.N. and DEVIKA C.: Evaluation of optic nerve variations in relation to posterior paranasal sinuses among study population of Mandya District of Karnataka State. Int. J. Radiol. Diagn Imaging, 3: 16–20, 2020. DOI: 10.33545/26644436.2020.v3.i3a.110.

7- DIAS P.C.J., ALBERNAZ P.L.M. and YAMASHIDA H.K.: Anatomic relationship of the optic nerve channel with sphenoidal sinus: A computed tomography study. [Spanish] Rev. Bras Otorrinolaringol., 70: 651–657, 2004. DOI:10.1590/S0034-72992004000500012.

8- CHEN Y.L., LEE L.A. and LIM K.E.: Surgical consideration to optic nerve protrusion according to sinus computed tomography. Otolaryngol Head Neck Surg., 134: 499–505, 2006. DOI:10.1016/j.otohns.2005.10.036

9- THAKUR B., POTLURI P., KUMAR A., et al.: Sphenoid sinus and related neurovascular structures-anatomical relations and variations on radiology-a retrospective study. Indian J. Otolaryngol. Head Neck Surg., 73: 431–436, 2020. DOI:10.1007/s12070-020-01966-y.

10- HESKOVA G, MELLOVA Y., HOLOMANOVA A., et al.: Assessment of the relation of the optic nerve to the posterior ethmoid and sphenoid sinuses by computed tomography. Biomed Pap Med Fac Univ Palacky Olomouc Czech Repub, 153: 149–152, 2009. DOI:10.5507/bp.2009.025.

11- BRAGGS A. and S. KK C.T.: Study of relationship of optic nerve to posterior paranasal sinuses. Int. J. Contemp Med. Surg. Rad 3: D71–D73, 2018. DOI:10.21276/ijcmsr.2018.3.4.16.

12- FADDA G.L., PETRELLI A., URBANELLI A., et al.: Risky anatomical variations of sphenoid sinus and surrounding structures in endoscopic sinus surgery. Head Face Med., 18: 29, 2022. DOI: 10.1186/s13005-022-00336-z.

تصنيف ديلانو لقناة العصب البصرى إلى الجيوب الأنفية الخلفية: دراسة استرجاعية فى المنطقة الشرقية بالمملكة العربية السعودية

\الهدف: يصنف تصنيف ديلانو العلاقة بين الجيب الوتدى والعصب البصرى إلى أربعة أنواع. يساعد هذا التصنيف على فهم موقع العصب البصرى والجيوب الأنفية الخلفية، خاصة بالنسبة لإجراءات جراحة الجيوب الأنفية بالمنظار والتى يمكن أن يشكل فيها قرب العصب البصرى من الجيب الوتدى مخاطر. هدفنا إلى تحديد العلاقة بين قناة العصب البصرى والجيوب الأنفية الخلفية وأنواعها ومعدل حدوثها وانتشارها بين مجتمع الدراسة فى المنطقة الشرقية من المملكة العربية السعودية.

\الطرق: شملت هذه الدراسة بأثر رجعى ٣٠٠ مريض تمت إحالتهم إلى وحدة التصوير المقطعى للجيوب الأنفية للتخطيط لجراحة الجيوب الأنفية الوظيفية بالمنظار.

\النتائج: وجدنا أن النوع الأكثر شيوعاً هو النوع ١، فى حين أن النوع الثانى الأكثر شيوعا هو النوع ٢. وكان النوعان ٣ و ٤ الأقل شيوعا. كان نوع ديلانو ٣ أكثر شيوعًا على الجانب الأيمن، وكان النوع ٤ أكثر شيوعًا على الجانب الأيسر، فى حين أن لقد $p < ٠,٠٠١$ النوعين ١ و٢ ظهرا بشكل ثنائى فى أغلب الأحيان. وهذا يوضح أهمية تصنيف ديلانو حسب الجانب، بقيمة. وجدنا ترددًا أعلى بكثير من التفزر والتهوئة الإيجابية لعملية الإكلينويد الأمامية فى نوع ديلانو ٣ على كلا الجانبين.

\الاستنتاج: ارتبط تفزر العصب البصرى وانتفاخ الناتئ السريرى الأمامى بشكل متكرر أكثر مع نوع ديلانو ٣؛ ولذلك، فإن المرضى الذين يعانون من النوع ٣ هم أكثر عرضة لإصابة العصب البصرى أثناء جراحة الجيوب الأنفية. ومن ثم، نستنتج أن. الاختلافات التشريحية للجيوب الأنفية باستخدام تصنيف ديلانو للعصب البصرى مهمة جدًا لتحديد الهوية قبل الجراحة.

هدفت هذه الدراسة إلى تحديد العلاقة بين قناة العصب البصرى والجيوب الأنفية الخلفية وأنواعها ومعدل حدوثها وانتشارها بين مجتمع الدراسة فى المنطقة الشرقية من المملكة العربية السعودية.