ORIGINAL ARTICLE

Variation of Optic Nerve Types in Different Age Quartiles on Two Sides Based on Delano's Classification of Optic Nerve using Computerized Tomography: A Single Center Cross-Sectional Study in Karachi

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ABSTRACT

Objective: To understand the anatomy of the sphenoid sinus and its associated structures, especially the variations of the optic nerve, to avoid any surgical trauma.

Study Design: Cross-sectional study.

Place and Duration of Study: The study was conducted at the Radiology Department, Ziauddin University, Karachi, Pakistan from January 2017 to May 2017.

Methods: During the study, 270 participants were assessed after ruling out any sphenoid sinus (SS) abnormality or any abnormality involving adjacent structures. The scans were performed using a Toshiba Alexion 16-slice CT scanner. Delano's classification was used to classify the optic nerve into different types according to the relationship between the optic nerve and the posterior paranasal sinuses. Data was analyzed on SPSS version 26. Frequencies and percentages were recorded for categorical variables. Mean and standard deviation were reported for the continuous variables.

Result: According to the age quartiles, no significant difference was found in the distribution of classes of different types of optic nerve according to Delano's classification on both the right and the left sides—also, Type I optic nerve was the most frequent type bilaterally. However, there was a considerable difference in the frequency of optic nerve occurrence on the left and right sides.

Conclusion: The preoperative analysis of optic nerve classification is necessary, and knowledge of anatomical variations is imperative so that endoscopic sinus surgery may be planned accordingly to avoid any iatrogenic injuries during functional endoscopic sinus surgery (FESS).

Keywords: *CT Scan, Ethmoid Sinus, Optic Nerve, Paranasal Sinuses, Sphenoid Sinus, X-Ray.*

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Introduction

It was 1984 when functional endoscopic sinus surgery was introduced.[1] The use of this technique has increased over time, and it has become very popular because it is minimally invasive and it's a highly effective surgical technique that can be safely used in the head and neck region, as it is the region of high variability.[2]

A lot of literature documents the anatomical variations present in the sphenoid sinus, due to which it becomes difficult to perform surgeries in this region. Accurate evaluation should be carried out in order to avoid possible complications, especially ophthalmic complications, which may occur if the surgeons are unaware of the degree of protrusion of the optic nerve within the sphenoid sinus.[3] For this

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purpose, preoperative computed tomography (CT) of the sphenoid sinus region becomes mandatory as it is also the gold standard for investigation of pathologies and evaluation of the Paranasal air sinuses. Pneumatization in the sphenoid sinus shows different patterns and is classified as sellar, presellar, conchal, and mixed types. The sellar variation grows beneath the sella turcica region, posing a threat to the optic nerve and carotid artery locations. People with presellar or conchal sinuses show less pneumatization, making access to surgery difficult. The exact structure of the sphenoid sinus helps doctors plan better surgical strategies, especially during FESS.[4]

Sphenoidal sinuses are irregularly shaped, paired bony cavities in the skull. The sinuses lie posterior to the upper part of the nasal cavity within the sphenoid body. Surgical access is challenging since it is located most posterior to the rest of the paranasal sinuses. Studies report varying pneumatization, which can range from very little to quite extensive.[5] The major development or growth of the sinuses occurs post-puberty. At birth, they are present as minute cavities.[6] Most frequently, an anatomical septum separates the sinus. This may deviate from the midline in about 75% of individuals, thus the two halves of the sinus become of unequal size and shape.[7] Additional accessory bony septa are also present in the sphenoid sinus cavity, which may further divide it partially into smaller sections. Structures that traverse the sphenoid sinus, like the internal carotid artery, pterygoid canal, and the trigeminal maxillary nerve branch, may produce bony ridges that project into the cavity from its lateral walls.[8] In addition, the optic nerve projection in 15% of cases has also been documented. The sphenoid sinus and these structures are anatomically related. These structures generate indentations in the sinus walls because they develop before the sinuses do, so that in well-pneumatized cavities, the only thing separating the sinus from adjacent structures is a thin bony plate.[9] Pneumatization affects the sphenoid body, the pterygoid processes, and the greater wing, two additional sphenoid bone segments. The usual procedure of prolonged pneumatization increases the likelihood of nearby neurovascular structures projecting into the sinus.[9]

The optic nerve runs next to the sphenoid and posterior ethmoid sinuses in a close anatomical position at their superolateral edge. When the sphenoid sinuses are highly pneumatized, the optic nerve crosses directly through the sinus space, increasing the risk of iatrogenic injury and blindness during endoscopic sinus surgery procedures.[10-14]

Therefore, a thorough understanding of the anatomy of the sphenoid sinus and its associated structures is a necessary precondition to prevent direct optic nerve injury, which can result in severe complications like blindness.[15-17]

Methods

The study was carried out at the Radiology Department, Ziauddin University, Karachi, Pakistan from January 2017 to May 2017 after obtaining approval from the Institutional Review Board of the institute vide letter no: 00311116MLANA, held on 2nd December 2016. Two hundred seventy participants were included for CT scans. The age range was between 21 and 60 years. Subjects belonged to both genders. Subjects with a history of chronic rhinosinusitis, nasal polyposis, or any sinonasal tumors were excluded from the study. Any history of facial fractures, surgeries involving the sinus area, or congenital craniofacial anomalies was also excluded.[18]

This study involved patients requiring CT of the brain and head. A 16-slice Toshiba Alexion CT scanner was utilized.

The X-ray beam from the scanner revolved around the patient's head, producing images from various perspectives. Sequential axial slices were obtained, and then volume data were produced. Using volume data, multiplanar reconstructions were created in several planes, including the sagittal, axial, and coronal planes. Using the bone algorithm, 3D volume generated images were created. Images were evaluated in both coronal and axial planes. We examined the CT images in coronal views and used bone windows for analysis. We then recorded our findings on a data sheet. DeLano's classification was used to evaluate the optic nerve.

The optic nerve can be classified into four types based on its anatomical relationship with surrounding structures. In type 1, the optic nerve passes directly adjacent to the sphenoid sinus. Type 2 is characterized by the optic nerve causing an indentation in the wall of the sphenoid sinus. In type 3, the optic nerve traverses through the sphenoid sinus itself. Lastly, type 4 involves the optic nerve being located adjacent to both the sphenoid sinus and the posterior ethmoidal air cells. This classification aids in understanding the anatomical variations that may have clinical or surgical significance. (16–21), DeLano et al. (1996) divided the diverse interactions between the optic nerve and posterior paranasal sinuses into four kinds. Data was analyzed on SPSS version 26. The chi-squared test was used to analyze the variables. Frequencies and percentages were taken out for categorical variables. The mean and standard deviation were taken out of the numerical variables for the optic nerve.

Results

CT scans from 270 patients were analyzed. (Figure-1). This study included one hundred sixty male and 110 female patients. The age ranged from 20 to 60. The type of optic nerve on the right and left sides was recorded separately for each patient.

We observed the frequency of different types of optic nerve on both sides in different age groups. On the left side, the 3rd and 6th decades of life show the highest frequencies of type I optic nerve, followed by type II and type III optic nerve, respectively. However, frequency of type IV optic nerve was found to be the least. A different trend for only type III and type IV optic nerves was observed in the 4th decade of life, where it was seen that type III and type IV optic nerves remained the least, with a value of 8%. When observing the 5th decade of life, type I and type IV optic nerve follow a similar pattern, but a difference in the trend of type II and type III optic nerve was unique. Here, type III optic nerve showed the second highest value with a percentage of 21%, followed by type II optic nerve, which was found to be 18%. (Table-1).

On the right side, in each 3rd, 4th ,5th, and 6th decades of life, type I optic nerve shows the highest frequency, followed by type II and III optic nerve, respectively. Type IV optic nerve also shows a similar pattern to that of the left side, remaining the least among all four optic nerve types. (Table-3).

An insignificant difference among the frequency of types of optic nerve in different age groups on the left (*P*-value=0.515) and right (*P*-value=0.738) sides was noted. (Table-1 and 2).

We also observed bilateral or unilateral (left or right) presence of each type of optic nerve in our sample. (Table-3).

Type I optic nerve was found in 160 individuals. Out of these, 142 individuals showed type I optic nerve bilaterally. Ten individuals had this type of optic nerve on the right side, and eight individuals had it on the left side only.

The bilateral presence of type II optic nerve was found in 57 individuals. 15 individuals had this type of optic nerve on the right, and 16 individuals had this type of optic nerve only on the left side. A total of 88 individuals had type II optic nerves.

We observed the bilateral presence of type III optic nerve in 19 individuals. This type of optic nerve was present in 12 individuals on the right side and 10 individuals on the left side. A total of 41 individuals showed type III optic nerve.

The fewest individuals from our sample showed type IV optic nerve. Out of 27, only six individuals showed bilateral presence of type IV optic nerve. This type was found in 9 individuals on the right side and 12 individuals on the left side.

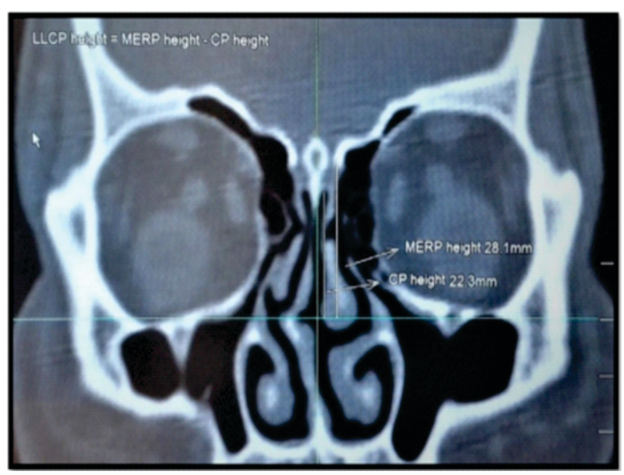

Fig.1: Normal CT scan of coronal view in bone window. Showing the structures involved in the formation of the ethmoid roof

Showing LLCP is the lateral lamina of the cribriform plate, MERP is the medial The ethmoid roof point CP is the cribriform plate

Table-1: Frequency of types of optic nerve in different age groups on the left side

Age groups	No of individuals	Type 1		Type 2		Type 3		Type 4		*Chi Square-value*	*P-* value
	n	n	%	n	(%)	n	(%)	n	(%)		
20-30	90	52	58%	27	30%	8	9%	3	3%	8.196	0.515
31-40	73	40	55%	21	29%	6	8%	6	8%		
41-50	39	21	54%	7	18%	8	21%	3	8%		
51-60	68	37	54%	18	26%	7	10%	6	9%		
Total	270	150	100%	73	100%	29	100%	18	100%		

Table-2: Frequency of types of optic nerve in different age groups on right side

Age groups	No of individuals	Type 1		Type 2		Type 3		Type 4		*Chi-Square value*	*P*-value
	n	n	%	n	%	n	%	n	%		
20-30	90	51	57%	27	30%	8	9%	4	4%	6.019	0.738
31-40	73	43	59%	17	23%	7	10%	6	8%		
41-50	39	20	51%	9	23%	8	21%	2	5%		
51-60	68	38	56%	19	28%	8	12%	3	4%		
Total	270	152	100%	72	100%	31	100%	15	100%		

Table-3: Frequency of types of optic nerve on unilateral and bilateral sides

Optic Nerve Types	Bilateral		Right		Left		Total	
	n	%	n	%	n	%	n	(%)
I	142	88.8 %	10	6.3 %	8	5 %	160	100 %
II	57	64.8 %	15	17 %	16	18 %	88	100 %
III	19	46.3 %	12	29.3 %	10	24.4%	41	100 %
IV	6	22.2 %	9	33.3 %	12	44.4 %	27	100 %

Discussion

The frequency of optic nerve types in various age groups on both the right and left sides in connection with the posterior paranasal sinuses has been studied for the first time in Pakistan in our study, to the best of our knowledge. The frequency of optic nerve types in various age groups was not found to be documented in any literature, however numerous international studies have done so, but it was noted that the sample sizes used in these reports were smaller than the sample sizes used in our study, which may have been one of their limitations.

In addition to that, literature documenting the frequencies of different types of optic nerve (unilateral and bilateral) on the two sides is scarce.

In the year 2023, a study was published on the Indian population[19]. The results of this study are very much in accordance with our study. According to this study on the bilateral side, type I optic nerve ranks 1st , followed by type II and type III optic nerve. The frequency of type IV appears to be least. However, on comparing the configuration of unilateral aspects of each type of optic nerve, it was noted that considerable differences were present. Most individuals show type IV and type III optic nerves on the left and right sides, respectively. Our study shows higher frequencies of type IV optic nerve on the right and left sides, with type III optic nerve having the second highest frequencies on each side. The presence of type I optic nerve on the right and left sides remains the least in our study, which is similar to the results of this study. The left-sided involvement of the type III optic nerve is higher than that of the type II optic nerve.[14]

Another study conducted in India quite recently shows completely different results.[1] According to this study, both type II and type III optic nerves rank 3rd bilaterally. Type IV ranks 2nd, and type I is the most frequently occurring type of optic nerve bilaterally. On comparing the right side for each optic nerve, it was noted that the type I optic nerve was followed by the type IV and type III optic nerve, with type II occurring least on the right side. A completely different pattern has been shown on the left side, where type I optic nerve is followed by type II and type IV optic nerve, with type III ON occurring to be the least. The relationship between optic nerves and posterior Paranasal sinuses varies in different age quartiles based on Delano's classification of optic nerve using CT. The prevalence of different types of optic nerve relationships to posterior Paranasal sinuses according to Delano classification was determined in a study by Bragg.[20] The study found that type 1 had a prevalence of 61.8%, type 2 had a prevalence of 17.8%, type 3 had a prevalence of 7.6%, and type 4 had a prevalence of 12.8%.[1] However, no specific studies have been found that directly addressed the variation of optic nerve types in different age quartiles on two sides based on Delano's classification of optic nerve using CT.

A clear difference is seen in different types of optic nerve across various populations.[21] This may be due to the fact that the above-mentioned studies have smaller sample sizes and that they also included patients suffering from sinusitis, whereas we included individuals with intact head and neck anatomy. One study also included patients aged above 5 years. This can give misleading results as sinus development completes by the age of 18.

Conclusion

There is a dire need for preoperative evaluation before performing endoscopic sinus surgery, as there is a vast difference in the occurrence of different optic nerve types on our population's right and left sides. Careful bilateral and unilateral evaluation can help minimize the hazardous consequences that often occur after endoscopic sinus surgery.

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Conflict of Interest: The authors declare no conflict of interest

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Author Contributions

ML: Manuscript writing for methodology design and investigation
IR: Data acquisition, curation, and statistical analysis
SM: Revising, editing, and supervising for intellectual content
MS: Validation of data, interpretation, and write-up of results
SA: Writing the original draft, proofreading, and approval for final submission
NH: Conception and design of the work