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RESEARCH ARTICLE

RELATIONSHIP OF THE OPTIC NERVE TO THE POSTERIOR ETHMOID AND SPHENOID SINUSES – A CT BASED ANATOMICAL STUDY

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ABSTRACT

Background: A meticulous knowledge of the anatomy of sphenoid sinus and its related adjacent structures preoperatively is crucial in order to prevent unintentional damage to the vital structures like optic nerve which can cause blindness and injury to internal carotid artery which can result in fatal haemorrhage. **Material and Method:** Our CT scan based study was conducted by Postgraduate Department of Anatomy in collaboration with Department of Radiodiagnosis and Imaging, Government Medical College, Srinagar for a period of 1 year. Since the aim of our study was to evaluate normal variations, cases found to harbor pathology or disease enough to distort or obscure the regional anatomy were excluded from the study. Relationship of optic nerve with sphenoid sinus was studied using De Lano's classification. **Result:** In our study of 200 cases (400 sides), in majority of sides i.e. 286 (71.50%) optic nerves of type1 were found, type 2 optic nerves were found in 88(22%) sides, type 3 in 19 (4.75%) sides and least 7(1.75%)optic nerves were of type 4. Protrusion of optic nerve into sphenoid sinus was seen in 20 (10%) cases, bony wall dehiscence of optic nerve was seen in 8 (4.00%) cases, protrusion of internal carotid artery (ICA) into sphenoid sinus was seen in 25 (12.50%) cases, bony wall dehiscence of internal carotid artery was seen in 4 (2.00%) cases and pneumatization of anterior clinoid process was seen in 50 (25%) cases. **Conclusion:** Detailed preoperative analysis of anatomy and knowledge of individual variations of the sphenoid sinus and its boundaries is essential to prevent serious complications in surgical area.

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INTRODUCTION

The acquisition of an excellent definition of the sinus anatomy and related structures can be done by means of Computer Tomography (CT) scan which is the gold standard in the study of such structures. Anatomically, sphenoid sinus is related to several important vital structures. Pituitary gland lies above the sphenoid sinus while optic nerve and internal carotid arteries traverse its lateral wall. A detailed knowledge of the anatomy of sphenoid sinus and its related adjacent structures preoperatively is crucial in order to prevent unintentional damage to the vital structures like optic nerve and internal carotid artery (Cheung *et al.,* 1993). It can be assessed according to DeLano's classification (1996). Anatomic configurations that predispose the optic nerve to injury include the type 2 or type 3 optic nerve relationship, bone dehiscence over the nerve and pneumatization of the anterior clinoid process (Heskova *et al.,* 2009). Cross-sectional imaging has proven to be a valuable tool for preoperative planning and has provided insight of any anatomical variation present. Thus, the goal of this study was to gather this knowledge in an effort to reduce the rate of complications in endoscopic sinus surgery or if trans-sphenoid pituitary surgery is contemplated.

MATERIALS AND METHODS

This cross sectional observational study was conducted by Postgraduate Department of Anatomy in collaboration with Department of Radiodiagnosis and Imaging, Government Medical College, Srinagar for a period of 1 year. Ethical clearance was obtained from institutional ethical committee for the study. This study was done on 200 cases (120 males and 80 females). In this study patients referred to department of radiology for CT Nose and Paranasal sinus by other departments for various reasons were studied for normal anatomical variations in structures around sphenoid sinus. Any history of trauma, previous surgery or pathology distorting normal anatomy in sinonasal region were excluded from the study. The cases of age<20 years were excluded due to the developmental stages of the paranasal sinuses. Non-contrast CT scan Nose and Paranasal sinuses (NCCT Nose &PNS) was done using Siemens Somatom Emotion 16 slice Multidetector

Spiral CT scan and data was acquired in axial plane. Reconstruction was done in coronal and sagittal planes using 3mm slice thickness. Relationship of optic nerve with sphenoid sinus was studied using DeLano's classification: Type1- Adjacent to sphenoidal sinus,Type2- Indentation on sphenoidal sinus, Type3-Optic nerve traversing sphenoidal sinus, Type4- Adjacent to sphenoidal and posterior ethmoidal air cell (DeLano *et al.,* 1996). In 200 cases, 400 optic nerves of right and left sides were studied. Results were presented in 400sides. Protrusion of optic nerve (ON) and internal carotid artery was noted as the presence of more than half the circumference of the concerned structure bulging into the sinus cavity with or without defects in their bony margins. Dehiscence of bony wall of optic nerve or internal carotid artery was seen as absence of visible bone density separating the sinus from the concerned structure. Pneumatization of anterior clinoid process (ACP) was also assessed in this study. Coronal CT scans were preferred for the detection of protrusion of the ON into Sphenoid sinus and bony dehiscence of optic nerve while the relationship of internal carotid artery (ICA) to the sphenoid sinus was studied in axial CT scans. CT scans were evaluated with radiologist's opinion in all the cases.

RESULTS

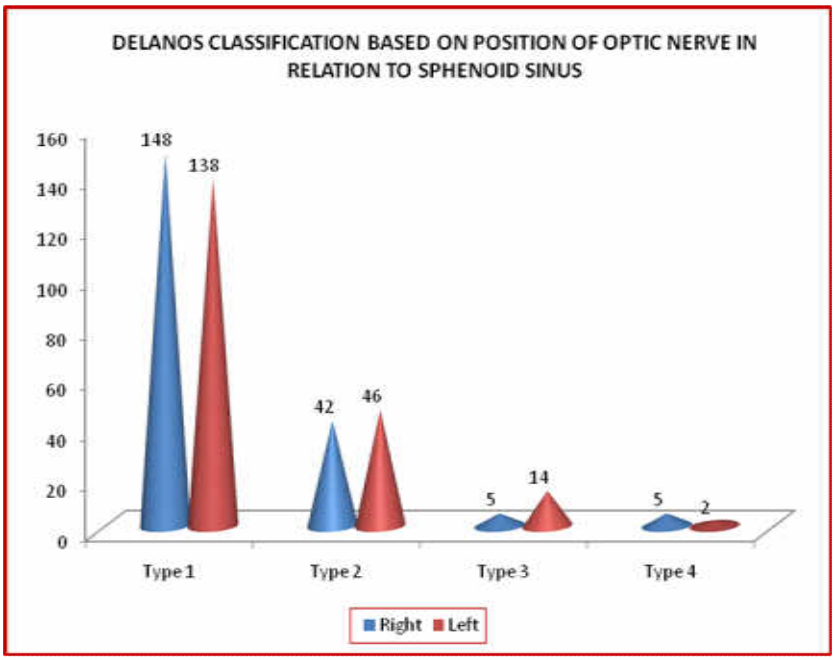
In our study of 200 cases (400 sides), in majority of sides i.e. 286(71.50%) optic nerves of type1 were found, type 2 optic nerves were found in 88 (22%) sides, type 3 in 19 (4.75%) sides and least 7 (1.75%)optic nerves were of type 4 which can be read from table I.In our study of 200 cases, as shown in table no II; protrusion of optic nerve into sphenoid sinus was seen in 20 (10%)cases. 4% on right side, 4% on left side and bilateral in 2% cases. Bony wall dehiscence of optic nerve was seen in 8 (4.00%) cases. 2.00% on right side, 1.50% on left side and bilaterally present in 0.50%.Pneumatization of anterior clinoid process was seen in 50 (25%) cases. On right side in 5.00%, on left side in 8.00% and bilaterally present in12.00% cases. Also protrusion of internal carotid artery(ICA) into sphenoid sinus was seen in 25 (12.50%) cases. On right side in 5 (2.50%) cases, on left side in 3 (1.50%) cases and protrusion of ICA was bilateral in 17 (8.50%).Also bony wall dehiscence of internal carotid artery was seen in 4(2.00%) cases, on right side in 3 (1.50%) cases and on left side in 1(0.50%).

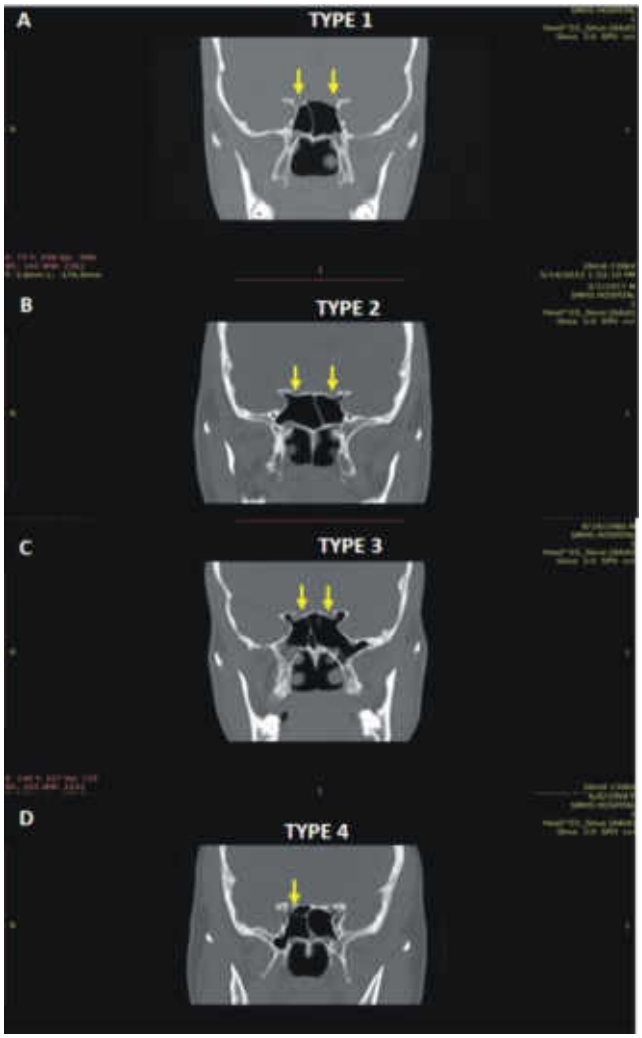
Table 1. Delanos classification based on position of optic nerve in relation to sphenoid sinus (N=200,Total No of Sides=400)

Delanos Classification	Right	Left	Total no of sides	Total percent(%)
Type 1	148	138	286	71.50
Type 2	42	46	88	22.00
Type 3	5	14	19	4.75
Type 4	5	2	7	1.75
Total	200	200	400	100.00

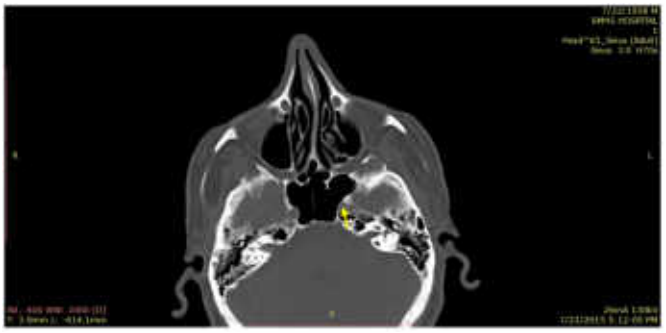
Table 2. Structures in Relation to Sphenoid Sinus on NCCT NOSE & PNS (N=200) (PERCENT)

		Protrusion of optic nerve	Bony wall dehiscence of optic nerve	Protrusion of internal carotid artery	Bony wall dehiscence of internal carotid artery	ACP pneuma-tization
Present	Right side	4.00	2.00	2.50	1.50	5.00
	Left side	4.00	1.50	1.50	0.50	8.00
	Bilateral	2.00	0.50	8.50	--	12.00
	Total	10.00	4.00	12.50	2.00	25.00
Bilaterally absent		90.00	96.00	87.50	98.00	75.00
Total		100.00	100.00	100.00	100.00	100.00

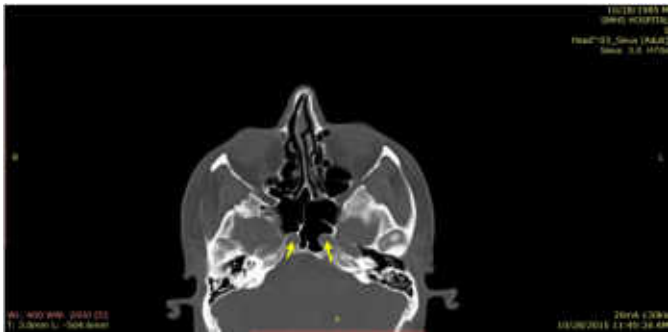




A, B, C, D coronal computed tomography (CT) scan showing optic nerve of type 1, 2, 3, 4 (Delano's Classification) with arrows



The axial computed tomography (CT) scan showing dehiscent internal carotid artery on left side (arrow)



The axial computed tomography (CT) scan showing bilateral protrusion of internal carotid artery into sphenoid sinus (arrows)

The coronal computed tomography (CT) scan showing bilateral anterior clinoid process pneumatization (arrows)

DISCUSSION

Several anatomic variations of the ethmoid and sphenoid sinuses increase the risk for injury of adjacent structures during endoscopic sinus surgery. Inadvertent injury to these structures can result in uncontrollable bleeding, retrobulbar hematoma with acute proptosis, stretching of the optic nerve can result in blindness, violation of the subarachnoid space with resultant pneumocephalus or cerebrospinal fluid rhinorrhea (Markalous *et al.,* 2000; Bademci, 2005). CT scan provides excellent anatomical soft tissue and bony details, close image in correlation to the surgical field, and an important "roadmap" to paranasal sinus anatomy (Stammberger, 1993; NafiAygun, 2006). Damage of the optic nerve is serious complication of intranasal sinus surgery. The accuracy of CT in the detection of bone dehiscence has been documented previously in studies of the relationship of the carotid artery to the sphenoidal sinus (Johnson, 1985; Kennedy, 1990). A dehiscence in the bone covering the artery may lead to direct contact of the artery with sinus mucosa which may lead infection occuring within the cavernous sinuses (Kazkayasi, 2005). The main purpose of the radiological evaluation of paranasal sinuses and related structures is to achieve the most possible precise description of the regional anatomy and to look for the presence and extent of a condition (Zinreich, 1998; Mafee, 1994).

In our study in majority of sides i.e.71.50% optic nerves were of type1, type 2 optic nerves were found in22% sides, type 3 in 4.75% sides and least 1.75% optic nerves were of type 4. Mark *et al.* (1996) studied the relationship between the optic nerves and the posterior paranasal sinuses and reported type 1 in 76 %, type 2 in 15 %, type 3 in 6 % and type 4 in 3%.Pra Urusopone (2014) retrospectively reviewed CT scan of PNS of 75patients (150 optic nerves). Author found type 1 in 76%, type 2 in 9.3%, type 3 in 5.4% and type 4 in 9.3%. A Turkish study by Sapçi *et al.* (2004) reported Type 1 in 64%, Type in 22% of the cases, types 3 in 7% and 4 in 7% of cases. Observations made by above mentioned authors follow the same trend as observed in our study. Most common type of optic nerve being type 1 followed by type 2 as per Delano's classification. In our study, protrusion of optic nerve into sphenoid sinus was seen in 20 (10%) cases. Bony wall dehiscence of optic nerve was seen in 8 (4.00%) cases and pneumatization of anterior clinoid process was seen in 50 (25%) cases. Pra Urusopone (2014) reported protrusion of ON in 4%Casesand dehiscence of bony wall in 10.7%cases while Turna et al (2014) in his retrospective study found protrusion of ON in5.5% of cases and dehiscence of optic nerve in 1.5%cases in Turkish population, to which our study is comparable. Also our study is consistent with study done in Turkey by Birsen Unal *et al.* (2006) who reported anterior

clinoid process pneumatizationin 24.1%. In our study protrusion of internal carotid artery(ICA) into sphenoid sinus was seen in 12.50% cases and bony wall dehiscence of internal carotid artery was seen in 2.00% cases consistent with Turna et al (2014) who reported protrusion of ICA in 3% of cases and dehiscence of ICA in 0.5% of cases while Fasunla et al. (2012) in a study on black African population reported protrusion of the ICA into the sphenoid sinus in 27.3%caseswhile dehiscence of the bony sphenoidal wall of the internal carotid artery was reported in 10.9%cases.Observations noted in our study is less as compared to Fasunla et al. (2012), which may be attributed to different racial pattern. In review of literature, there is no detailed data available on anatomical variations of optic nerve and its relation with sphenoid sinus in our population. Our study is first of its kind from this part of world. Data generated by this study can be used as a reference for the future studies. This study may also be of immense value to radiologists, Otorhinolaryngologists and neurosurgeons in diagnosing and preventing the damage to vital structures like optic nerve during surgery.

Conclusion

With the expanding role of endoscopic sinus surgery (ESS), proper understanding of the anatomy of the sphenoid sinuses and related structures has become increasingly important **.**Our findings strongly insist that CT scan is ideal preoperative investigation to detect the position of optic nerve and bony variation in order to protect the complication and increase efficacy of endoscopic sinus surgery.

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