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Original Research Paper

Anatomy

ANATOMICAL VARIATIONS OF SPHENOID SINUS AND ITS RELATED STRUCTURES IN NORTH INDIAN POPULATION

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ABSTRACT The sphenoid sinuses are deeply seated in the skull and is most inaccessible paranasal sinus in the skull. It is in close association with vital structures such as internal carotid artery, optic nerve and maxillary nerve. Variation in anatomy of sphenoid sinus is common and important to avoid serious complication in transsphenoidal surgery. A study was conducted on 120 patients to find out prevalence in variation in sphenoid sinus at a tertiary health centre in North India. Analysis of MDCT, paranasal sinuses for protrusion and dehiscence of internal carotid artery, optic nerve and maxillary nerve. Protrusion of internal carotid artery, optic nerve and maxillary nerve was observed in 42.5%, 20.4% and 16.7% cases. Dehiscence of internal carotid artery, optic nerve and maxillary nerve was observed in 16.7%, 42.5% and 17.5% cases. Prior knowledge of variant anatomy of sphenoid sinus will reduce surgical complication associated with trans sphenoidal and functional endoscopic surgeries.

KEYWORDS :

INTRODUCTION

Computerized tomography is the most precise imaging technique to demonstrate paranasal sinuses. CT screening of paranasal sinuses has the advantages of showing bony details (using wide window settings) and good soft tissue outlines (using narrow window setting). Axial and coronal views may be useful for delineating the anatomical landmarks of the sinonasal cavity. The coronal computed tomography study has become the most requested and the precise imaging technique for demonstrating the para nasal sinuses.

In spite of the complex anatomy and important surgical relationships of the sphenoid sinus, to our knowledge only a few relevant studies have been done in India especially in Northern part of our country. The aims of this study are to demonstrate the interrelationship of the anatomic variations of sphenoid sinus and its related structures, and to determine the ability of coronal CT scan to identify these variations.

MATERIAL AND METHODS

The study was conducted by the Department of Anatomy in collaboration with the Department of Radio-Diagnosis, Indira Gandhi Medical College, Shimla after the approval by the hospital ethics committee on 120 CT (PNS) scans using GE light speed 64 slice CT scanner in supine position with angulation parallel to the infraorbitomeatal line.

The subjects of 18 years and above were included. Pregnant or lactating women, Patients with known past history of significant allergic reaction to the contrast media, Patients with history of previous para nasal sinus surgery or intervention and Patients having carcinoma paranasal sinus or other pathology resulting in erosion and destruction of bone were excluded from the study. The images were acquired in the axial plane and then reconstructed in axial, coronal and sagittal plane. The images were reconstructed with 0.625 mm thickness and transferred to Advantage Window workstation. The reconstructed images were viewed in axial, sagittal and coronal planes.

The criteria for defining dehiscence and protrusion were according to as per Hewaidi et al[1] (2008).

1. Dehiscence is defined as the absence of the visible bone density which separates the sinus from the course of the concerned structures.
2. The protrusions of the internal carotid artery and the optic nerve were determined by the finding of any degree of protrusion of the structures into the sinus cavity.
3. The presence of air density around the maxillary nerve in at least one coronal section was accepted as protrusions of the maxillary nerve.
4. Optic nerve protrusion was classified into four types as described by Delano et al[2] (1996):

(I) Adjacent to sphenoidal sinus.
(II) Indentation on sphenoidal sinus.
(III) Optic nerve traversing sphenoidal sinus.
(IV) Adjacent to sphenoidal and posterior ethmoidal air cells.

Following parameters were evaluated

1. PROTRUSION

1a Internal carotid artery protrusion: The grading of protrusion of internal carotid artery depending upon how much circumference of the internal carotid artery was protruding into the sphenoid sinus. The grading pattern is as follows:

- C0 – when internal carotid artery did not have any contact with sphenoid sinus (Fig. 2).
- C1 – when internal carotid artery had < 180 degree contact with the sphenoid sinus (Fig. 3).
- C2 - when internal carotid artery had = 180 degree contact with the sphenoid sinus (Fig. 4).
- C3 - when internal carotid artery had >180 degree contact with the sphenoid sinus (Fig. 5).

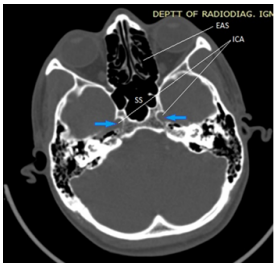

Fig.1: C0 - No protrusion of internal carotid artery. (no contact with sphenoid sinus). (EAS-Ethmoidal air sinus, ICA-Internal carotid artery, SS-Sphenoid sinus)

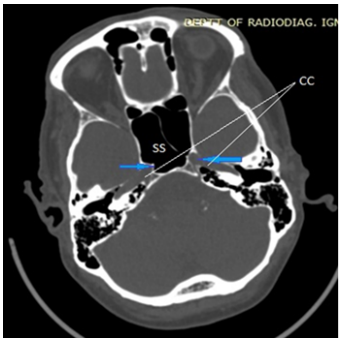

Fig. 2: C1- Bilateral protrusion of internal carotid artery (< 180 degree) (CC-Carotid canal, SS-Sphenoid sinus)

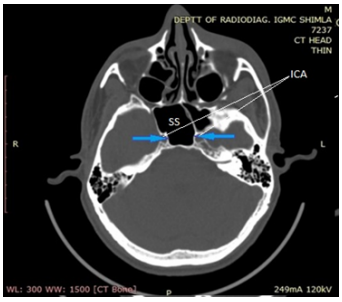

Fig. 3: C2 – Bilateral protrusion of internal carotid artery (=180 degree) (SS – sphenoid sinus, ICA – Internal carotid artery)

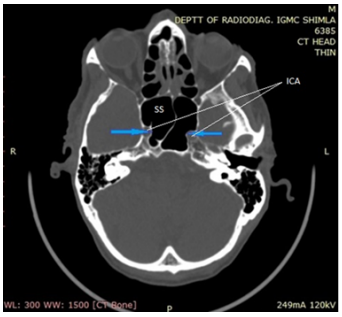

Fig. 4: C3 – Bilateral protrusion of internal carotid artery (>180 degree) (SS – sphenoid sinus, ICA – Internal carotid artery)

1b Optic Nerve Protrusion

As per the types of protrusion of optic nerve into sphenoid sinus by Delano et al[2] (1996), we found: -

- Type I: - optic nerve is immediately adjacent to the sphenoidal sinus (Fig. 6).
- Type II: - optic nerve cause an impression on the lateral sphenoidal sinus wall (Fig. 7).
- Type III: -optic nerves course through the sphenoidal sinus rather than simply run adjacent to the sinus (Fig. 8).
- Type IV: - optic nerves course immediately lateral to the posterior ethmoidal and sphenoidal sinus (Fig. 9).

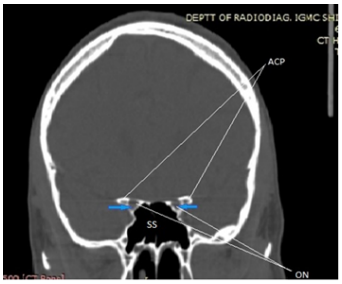

Fig. 5: Delano Type I- Bilateral protrusion of optic nerve (adjacent to sphenoid sinus) (ACP- Anterior clinoid process, ON-Optic nerve, SS – Sphenoid sinus)

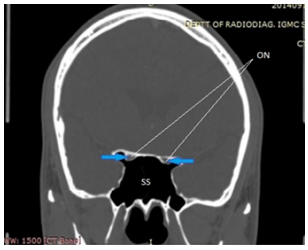

Fig. 6: Delano Type II- Bilateral protrusion of optic nerve (indentation on sphenoid sinus) (ON-Optic nerve, SS – Sphenoid sinus)

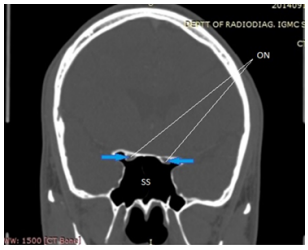

Fig. 7: Delano Type III- Bilateral protrusion of optic nerve (optic nerve traversing sphenoid sinus) (ON-Optic nerve, SS – Sphenoid sinus)

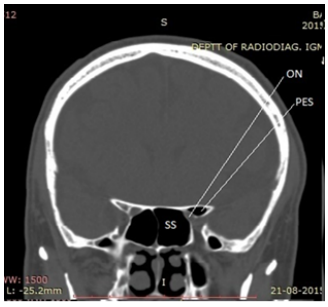

Fig. 8: Delano Type IV- Unilateral protrusion of optic nerve (adjacent to sphenoidal and PES- posterior ethmoidal air cells) (ON-Optic nerve, SS – Sphenoid sinus)

1c Prevalence of Maxillary Nerve Protrusion: Maxillary Nerve protrusion into Sphenoid Sinus on right and left side.

RESULTS

In our study, patients in 18-20 years were 5 (4.2%), 21-40 years' age group 44 (36.7%), 41-60 years' group 38 (31.7%), 61-80 years' group were 33 (27.5%), and commonest age group was between 21-40 years. Out of 120 patient's males were 71 (59.2%) and females were 49 (40.8%). Male preponderance was seen in our study.

1. PROTRUSION

3a. Internal Carotid Artery Protrusion

In our study 42.5% patients had protrusion of Internal Carotid artery into the Sphenoid Sinus, 20.8% of these patients had protrusion of Internal Carotid artery bilaterally in the Sphenoid sinus (Fig. 1), 7.5% on right and 14.2% on the left side.

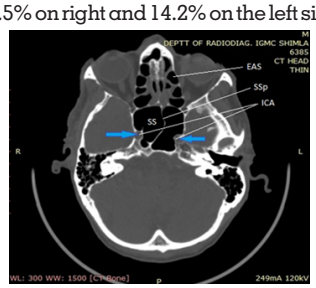

Fig. 9: Bilateral protrusion of internal carotid artery into the sphenoid sinus. (EAS-Ethmoidal air sinus, SSp-Sphenoidal septum, ICA-Internal carotid artery, SS-Sphenoid sinus)

3b. Optic Nerve Protrusion

As per the types of protrusion of optic nerve into sphenoid sinus by Delano et al, we found Type I is most common form i.e. 74.6% and Type II being 2nd most common form i.e. 21.25%. Type III and Type IV were present in 3.75% and 0.41% respectively. Type I to type III nerves does not come in contact with the posterior ethmoidal air cells. (Table 1)

3c. Prevalence of Maxillary Nerve Protrusion

16.7% patients showed Maxillary Nerve protrusion into Sphenoid Sinus in our study, 7.5% had bilateral protrusion (Fig. 10) and 5% on right and 4.2% on left side.

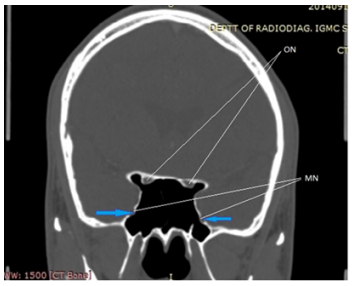

Fig. 10: Bilateral protrusion of maxillary nerve into sphenoid sinus. (ON-Optic nerve, MN-Maxillary nerve)

Fig. 11: Bilateral dehiscence of internal carotid artery into sphenoid sinus (SS – sphenoid sinus, ICA – Internal carotid artery)

2. DEHISCENCE

1. Internal Carotid Artery Dehiscence

Dehiscence of Internal Carotid artery was seen in 16.7% of patients in our study and it was bilateral in 3.3% patients (Fig.11). 5% on right and 8.3% on left side had dehiscence of Internal Carotid Artery. (Table 2)

2. Prevalence of Maxillary Nerve Dehiscence

Maxillary nerve was dehiscent in 17.5% of our patients and it was bilateral in 4.2% patients (Fig.10). It was 3.3% on right side and 10% on left side. (Table 3)

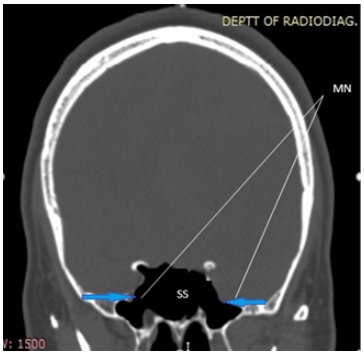

Fig. 12: Bilateral dehiscence of Maxillary nerve (MN-Maxillary nerve, SS- Sphenoid sinus)

3. Prevalence of Optic Nerve Dehiscence

Optic Nerve dehiscence was seen in 42.5% patients and in 15.8% had bilateral Optic Nerve dehiscence (Fig.13), and 7.5% on right and 19.2% on left side. (Table 4)

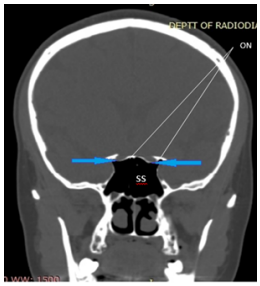

Fig. 13: Bilateral dehiscence of optic nerve (SS – sphenoid sinus, ON – Optic nerve)

DISCUSSION

Computerized tomography is the most precise imaging technique to demonstrate paranasal sinuses. To our knowledge only a few relevant studies had been done in India especially in Northern part of our country. We did this study to demonstrate the interrelationship of the anatomic variations of sphenoid sinus and its related structures, and to determine the ability of coronal CT scan to identify these variations in North Indian population.

1. INTERNAL CAROTID ARTERY

In our study, protrusion of internal carotid artery was seen into the sphenoid in 42.5% of patients, and dehiscence of the artery was seen in 16.67%. This prevalence was high, and it may be because of our criteria for defining protrusion and dehiscence.

In the study by Fuji et al[3], cadaver sphenoid bones had 8% of carotid arteries dehiscent of bone in the lateral sphenoid. In the study conducted by Elwany et al (1983) observed protrusion of carotid artery in 29% and dehiscence in 4.8% of patients, but they did not define their criterion.

In the study by Kennedy et al[4] (1990), dehiscence on the bony wall of the internal carotid artery was seen in 25% of patients. In some cases, they found that artery was only covered with a mucoperiosteal covering, coursing through the sphenoid sinus. In the study by Sirikci et al[5] (2000), protrusion of internal carotid artery was seen in 26.1% of patients and dehiscence of the artery in 23%.

In the study by Sareen et al[6] (2005), sagittal sections of 20 dried skulls showed dehiscence of the carotid artery in 5% cases. In the study by Birsen et al[7] (2006) protrusion of internal carotid artery was seen in 30.3% and dehiscence in 5.3% of patients. Both Sirikci[6] and Birsen[7] followed that protrusion of internal carotid artery or optic nerve into the sphenoid sinus as the presence of more than half the circumference of the concerned structures into the sinus cavity. Another author observed 55% intrasphenoid protrusion in 55% cases in coronal section and 57% cases in transverse section. [Lupascu[8], 2014]. In our study, we defined protrusion as presence of the circumference into the sinus cavity, at any degree. (Table 5)

It is important to recognize protrusion or dehiscence of artery, as in incidence of an injury; it is difficult to control bleeding and may lead to neurological sequelae. In presence of infection of sphenoid sinus, there can be damage to dehiscent or protruded internal carotid artery [Sirikei et al[5]., 2000]. We also did the grading of protrusion of internal carotid artery depending upon how much circumference of the internal carotid artery was protruding into the sphenoid sinus. (Table 6)

This grading pattern of internal carotid artery is not

comparable with previous studies as this is a new classification.

2b. OPTIC NERVE

Study conducted by us, showed that protrusion of the optic nerve in 25.41%, and dehiscence of the optic nerve was in 42.5% of our patients. This difference in prevalence in our study might be due to the definition we have taken to define protrusion and dehiscence. In the study by Fuji et al[3] (1979), 4% of optic nerves were dehiscent in the lateral wall sphenoid. Their study showed that most optic nerves were covered by a thin bone, which in 78% of cases is covered by a bone measuring 0.5mm or less. (Table 7)

Hewaidi et al[1] (2008) encountered the protrusion of the optic nerve in 35.6% patients and dehiscence of the nerve in 30.6% patients whereas in a study by Rudrash et al[9] (2012) the protrusion of optic nerve was seen in 10% patients and dehiscence of the optic nerve was seen in 5% of the patients. The reason for it may be due to the difference in the prevalence of anatomic variations in ethnic background [Delano et al[2]., 1996].

Delano et al[2] (1996) evaluated 300 optic nerves in 150 patients and found out type I protrusion in 76%, type II protrusion in 15%, type III protrusion in 6% and type IV protrusion in 3% optic nerves respectively. In our study we also evaluated 240 optic nerves in 120 patients as per the classification given by Delano et al[2] and found type I protrusion in 74.6%, type II protrusion in 21.25% optic nerves, type III in 3.75% and type IV optic nerve protrusion in 0.41% of optic nerves.

If there is any protrusion or dehiscence, optic nerve injury can be due to surgical trauma or may result in sinus disease complication. And if, the surgeon damages the nerve within the sinus risk of blindness is high [Maniglia et al[10]., 1989]. Moreover, blindness may result from infection of sphenoid sinus or may be due to pressure from a mucocele on the optic canal or nerve. Compression results in the optic nerve ischemia and venous congestion, and also, the optic canal is the place where optic nerve is least nourished, which makes it very susceptible to injury. Protrusion of the optic nerve and or internal carotid artery may coexist with ipsilateral pneumatisation of the anterior clinoid process [Anusha et al[11]., 2014].

2c. MAXILLARY NERVE

In our study maxillary nerve protrusion was seen in 16.67% of the patients and dehiscence of the nerve in 17.5%. In the study conducted by Birsen et al[7] (2006) Maxillary nerve protrusion was seen in 30.3% and dehiscence in 3.5%. The study conducted by Sareen et al[6], there was no sinus with maxillary nerve protrusion nor dehiscence [Sareen et al[6]., 2005]. (Table 8)

A study which was conducted by Hewaidi GH et al[1], showed that maxillary nerve protrusion was noted in 24.3% patients and that dehiscence of the nerve was noted in 13% patients. In the study by Rudrash et al (2012), the maxillary nerve protrusion was noted in 12.25% patients and dehiscence of the nerve was noted in 2.75% patients.

The different prevalence rates may be due to different definitions used or may be due to ethnic differences. The protruded or dehiscent maxillary nerve is likely to be injured in FESS. Also trigeminal neuralgia may result due to neuritis of a dehiscent maxillary nerve from a sphenoid sinusitis [Chong et al[12]., 1994].

Table 1. Optic Nerve Protrusion (as per Delano et al., 1996)

Description and Frequency of Optic Nerve Types				
Types	Description	Right Side	Left Side	Total (Percent)
I	Adjacent to sphenoidal sinus	90	89	179 (74.6)
II	Indentation on sphenoidal sinus	26	25	51 (21.25)
III	Optic nerve traversing sphenoidal sinus	3	6	9 (3.75)
IV	Adjacent to sphenoidal and posterior ethmoidal air cells	1	0	1 (0.41)
	Total	120	120	240 (100)

Table 2. Prevalence of Internal Carotid Artery Dehiscence

Total No. of Patients :- 120				
	Bilateral	Right	Left	Total
No. of Patients	4	6	10	20
Percentage	3.3	5	8.3	16.7

Table 3. Prevalence of Maxillary Nerve Dehiscence

Total No. of Patients :- 120				
	Bilateral	Right	Left	Total
No. of Patients	5	4	12	21
Percentage	4.2	3.3	10	17.5

Table 4. Prevalence of Optic Nerve Dehiscence

Total No. of Patients :- 120				
	Bilateral	Right	Left	Total
No. of Patients	19	9	23	51
Percentage	15.8	7.5	19.2	42.5

Table 5. Comparison of ICA protrusion and ICA dehiscence.

Study	Sample size	ICA protrusion (%)	ICA dehiscence (%)
Fuji eta al[3] (1979)	25	Not studied	8
Elwani et al[14] (1983)	50	29	4.8
Kennedy et al[4] (1990)		Not studied	25
Delano Meloni et al[2] (1996)	100	67	5
Siricki et al[5] (1999)	92	26.1	23
Sareen et al[6] (2005)	20	Not studied	5
Kazkayasi et al[13] (2005)	267	5.2	1.5
Birsen et al[7] (2005)	260	30.3	5.3
Hewaidi et al[1] (2008)	300	41	30

Table 6. Grading of relation of Internal carotid artery with sphenoid sinus (present study)

Grade	Relation of carotid artery with sphenoid sinus	Present study (%)
C 0	When internal carotid artery did not have any contact with sphenoid sinus	57.5
C1	When internal carotid artery had < 180 degree contact with the sphenoid sinus	31.25
C2	When internal carotid artery had = 180 degree contact with the sphenoid sinus	10
C3	When internal carotid artery had >180 degree contact with the sphenoid sinus	1.25

Table 7. Comparison of Optic nerve protrusion and Optic nerve dehiscence

Study	Sample size	Optic nerve protrusion (%)	Optic nerve dehiscence (%)
Fuji eta al[3] (1979)	25	Not studied	4
Teatini et al[15] (1996)	100	Not studied	8
Sirikci et al[5] (1999)	92	31	22
Kazkayasi et al[13] (2005)	267	4.1	0.7
Birsen et al[7] (2005)	56	31	8
Hewaidi et al[1] (2008)	300	35.6	30.6
Rudrash et al[9] (2012)	400	10	5
Present study	120	25.4	42.5

Table 8. Comparison of Maxillary nerve protrusion and Maxillary nerve dehiscence.

Study	Sample size	Maxillary nerve protrusion (%)	Maxillary nerve dehiscence (%)
Birsen et al[7] (2006)	56	30.3	3.5
Hewaidi et al[1] (2008)	300	24.3	13
Rudrash et al[9] (2012)	400	12.25	2.75
Present study	120	16.67	17.5

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