VARIATIONS OF SURGICAL ANATOMY IN AND AROUND SPHENOID SINUS: A COMPUTED TOMOGRAPHIC STUDY

Surgery

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ABSTRACT

Radiological anatomy is evaluated in three dimensions for preoperative and paroperative surgical planning, which helps the surgeon to identify his or her limits of dissection during surgery and avoid complications. Patients attending OPD at Institute of Otorhinolaryngology and Head & Neck Surgery, Kolkata, India with features of sinonasal disease were advised CT scan depending upon the symptoms and course of the disease. 100 study subjects (200 sides) were selected during the study period between 01/01/2019 to 30/06/2020. Septa related directly related to ICA in 31%(n=31) cases of whom 12 patients (12%), 8 patients (8%) and 11 patients (11%) had septa related to right ICA, left ICA and bilaterally ICA respectively. Septa attachment to optic nerve is seen in 27%(n=27) patients, of whom 10 patients (10%), 11 patients (11%) and 6 patients (6%) had attachment related to right optic nerve, left optic nerve and both optic nerves, respectively. On the right side ICA protrusion and pneumatization of ACP were both present in 8(8%) patients and on the left side in 7(7%) patients. Chi-Square test indicated a statistically significant association ($P < 0.001$). Pneumatized ACP and ON protrusion consistently encountered on the right and left side in 7 patients (7%) and 8 patients (8%) respectively. Chi-Square test indicated a significant association between ACP pneumatization and ON protrusion ($P < 0.001$). This resolution helped in better demonstration of complicated sphenoid sinus anatomy well. Hence, we support 1 mm triplanar CT Scans for preoperative imaging assessment for all sinus surgeries.

KEYWORDS

SURGICAL ANATOMY, SPHENOID SINUS, CT scan, sinus surgeries

Introduction:

Sphenoid sinus is regarded as most variable cavity of human body. With its highly variable pneumatization, difficult accessibility and its close relation with vital neurovascular structures; sphenoid sinus poses a challenge to endoscopic sinus surgeons around the world. With pneumatization ranging from absent to extensive² the sphenoid sinus is irregular cavity per se. Pneumatization occasionally extends into the anterior and posterior clinoid processes, pterygoid processes, greater and lesser wings of sphenoid, clivus, vomer, palatine bone, ethmoid bone and occipital bone^{3,4}. Protrusion and dehiscence of surrounding structures are closely related to sphenoid sinus pneumatization.

Protrusion is defined as, when there is presence of a circumference of a structure at any degree into the sinus cavity.⁵

Dehiscence is defined as when any bony defect was observed in a bulge.⁶ The more the neurovascular structure bulge into the sphenoid sinus or the greater their dehiscence, the greater is the chance of accidental damage during surgery.⁶

Computerised tomography (CT) scan is the most precise imaging technique to demonstrate paranasal sinuses. Bony details are assessed by wide window settings and soft tissue by narrow window settings. Triplanar cuts are used to read anatomical details. Among them coronal cuts give most of the information from operative point of view. Radiological anatomy is evaluated in three dimensions for preoperative and paroperative surgical planning, which helps the surgeon to identify his or her limits of dissection during surgery and avoid complications.

Of late Sphenoid sinus disease clearance or approach to pituitary fossa made surgeons aware to better understand the anatomy of sphenoid.

Materials and Methods:

Patients attending OPD at Institute of Otorhinolaryngology and Head

& Neck Surgery, Kolkata, India with features of sinonasal disease were advised CT scan depending upon the symptoms and course of the disease. 100 study subjects (200 sides) were selected during the study period between 01/01/2019 to 30/06/2020.

Study design: Cross-sectional study

Inclusion criteria: All CT scans of paranasal sinuses of patients greater than or equal to 18 yrs. of age.

Exclusion criteria: Presence of neoplastic pathology or radiological signs of trauma altering sphenoid sinus anatomy.

CT scans were performed following a course of antibiotic and nasal decongestant. Prior to performing CT scans patients were instructed to clean their nose by blowing out any secretion. CT scan cuts were taken while patients were lying supine and gantry angulation was set at perpendicular to orbitomeatal line. One (1) mm., thickness cuts were taken from anterior table of frontal sinus to posterior extent of sphenoid sinus. Images were acquired in the axial plane and then reconstructed in coronal and sagittal planes.

CT scan analysis began with reading of coronal cuts in anterior to posterior directions. In more anteriorly placed cuts the superolateral cells are from posterior ethmoidal group and inferomedial is the sphenoid sinus; subsequent posterior cuts show sphenoid anatomy more clearly.

Sphenoid sinus pneumatization is better seen in sagittal cuts. If non-pneumatized it presents as a small pit, conchal type. Pneumatization extending into the anterior wall of the sella turcica known as the pre-sellar type. And when pneumatization engulfs entire sphenoid body and behind sella turcica it is known as sellar type. Pneumatization is asymmetrical with respect to midline. Sphenoid sinus invariably deviates to one side creating two unequal sinus cavities giving rise to sphenoid dominance on the other side. Anterior and posterior deviation

of the intersphenoid septum are better assessed in axial cuts. The sphenoid sinus ostium is better identified in sagittal cuts. If present each accessory septa within sphenoid sinus is traced and looked for any attachment to Internal carotid artery(ICA) and optic nerve. Optic nerve which is a bulge superolaterally and internal carotid artery which bulges posteroinferiorly are studied for any dehiscence of the overlying bone. Position of opticocarotid recess (OCR) should be looked for. The entire course of the optic nerve and its relation to Onodi cell is assessed in axial cuts. Anterior clinoid process pneumatization were looked into. Bony thickness over the ICA with or without dehiscence were noted. Any protrusion or dehiscence of maxillary and vidian nerve in the lateral recess of the sphenoid were noted. Presence of Onodi cell and its relation with Optic nerve was read carefully. Extension of pneumatization beyond sphenoid sinus were also documented. Prevalence of each variation of sphenoid were noted in each group individually.

Results & Analyses:

Among the 100 study participants age wise distribution was 18-20 years (10%),

20-40 years (65%), 40-60 years (20%) and 60-80 years (5%). There was male preponderance (55%) seen during study.

Regarding types of sphenoid pneumatization it is found to be sellar type predominant (86%) and presellar type (in 14%). No conchal type of sphenoid sinus was detected in this study population. Prevalence of anterior clinoid process pneumatization found in 18% cases (n=18) and it was present bilaterally in 10%(n=10), on the right side in 5%(n=5) and on the left side in 3%(n=3) patients. The prevalence of pneumatization of greater wing of sphenoid was 4%, among which 1% was bilateral (n=1) and 1% (n=1) and 2%(n=2) were involving right and left sides respectively. Pneumatized pterygoid process found in 34% (n=34) of study subjects (right 10%, left 11%, bilateral 13%).

Table I Prevalence of Anatomical variation of sphenoid sinus and related structures (n = 100)

	Bilateral	Right sided	Left sided	Total
Pneumatization				
ACP	10%	5%	3%	18%
GWS	1%	1%	2%	4%
PP	13%	10%	11%	34%
Protrusion				
ICA	15%	8%	5%	28%
ON	14%	5%	6%	25%
MN	8%	8%	7%	23%
VN	9%	4%	5%	18%
Dehiscence				
ICA	2%	6%	3%	11%
ON	5%	8%	4%	17%
MN	1%	1%	2%	4%
VN	4%	6%	9%	19%

ACP=Anterior clinoid Process
GWS= Greater wing of sphenoid
ON= Optic nerve
VN= Vidian nerve

PP= Pterygoid process
ICA= Internal Carotid Artery
MN= Maxillary nerve

Internal Carotid Artery (ICA): ICA protrusion into the sphenoid sinus encountered in 28% (n=28%) patients of whom 15 patients (15%) were bilateral, 8 patients (8%) were right sided and 5 patients (5%) were left sided. Dehiscence of bony wall on the ICA were seen in 11% of patients (n=11) of whom 2 patients (2%) were bilateral, 6 patients (6%) were right sided and 3 patients (3%) were left sided.

Optic Nerve (ON): Optic Nerve protrusion was present in 25% (n=25) patients. Protrusion were bilateral, right sided left sided in 14(14%), 5(5%) and 6(6%) respectively. Bony wall of optic canal showed dehiscence 17%(n=17) patients of whom 5(5%) were bilateral, 8(8%) were right sided and 4(4%) were left sided.

Maxillary Nerve (MN): The protrusion of maxillary canal (Foramen Rotundum) was encountered in 23%(n=23) patients of whom 8(8%) were bilateral, 8(8%) were right sided and 7(7%) were left sided. Bony wall of the maxillary nerve canal was dehiscence in 4%(n=4) patients of whom 1 patient(1%), 1 patient (1%) and 2 patients(2%) were bilateral,

right sided and left sided respectively.

Vidian Nerve (VN): The vidian canal protruding into the sphenoid sinus cavity was present in 18%(n=18) patients of whom 9 patients (9%) were bilateral, 4 patients (4%) were right sided and 5 patients (5%) were left sided. The bony wall of the vidian canal was identified dehiscence in 19%(n=19) patients of whom 4 patients (4%), 6 patients (6%) and 9 patients (9%) were bilateral, right sided and left sided respectively.

Onodi cells: Onodi cells found in 19% (n=19) cases of whom 2 patients had bilateral (2%), 7 patients (7%) had right sided and 10 patients (10%) left sided.

Septations: In this study total of 200 septa were seen in axial plane and 286 in coronal plane.

TABLE II (No. Of Septations)

No. of septations	Axial plane	Coronal plane
0	4	0
1	30	15
2	28	25
3	30	29
4	6	23
5	0	6
6	0	2
TOTAL	200	286

Septa related directly related to ICA in 31%(n=31) cases of whom 12 patients (12%), 8 patients (8%) and 11 patients (11%) had septa related to right ICA, left ICA and bilaterally ICA respectively.

Septa attachment to optic nerve is seen in 27%(n=27) patients, of whom 10 patients (10%), 11 patients (11%) and 6 patients (6%) had attachment related to right optic nerve, left optic nerve and both optic nerves, respectively.

**Wall thickness of sphenoid sinus and adjacent to ICA with & without septa :-
Table-III**

	Right ICA		Left ICA	
	Septa	No Septa	Septa	No Septa
Mean width (mm)	0.83	0.94	0.87	0.94
Range (mm)	0.6-1.2	0.6-1.8	0.6-1.2	0.6-1.9

Association between ACP pneumatization & ICA protrusion :-

On the right side ICA protrusion and pneumatization of ACP were both present in 8(8%) patients and on the left side in 7(7%) patients. Chi-Square test indicated a statistically significant association ($P < 0.001$).

Association between ACP pneumatization & ON protrusion :-

Pneumatized ACP and ON protrusion consistently encountered on the right and left side in 7 patients (7%) and 8 patients (8%) respectively. Chi-Square test indicated a significant association between ACP pneumatization and ON protrusion ($P < 0.001$).

Discussion

The type and extent of pneumatization of sphenoid sinus is an important decision making factor for surgery at sellar region. A detailed understanding of preoperative surgical anatomy of sphenoid sinus and surroundings by CT Scan is essential for planning of surgical approach and preventing complication. Special considerations are to be given to course, protrusion and dehiscence of ICA and Optic Nerve (ON) along with evaluation of intersinus septa and its attachments.

Fig 1 Bilateral Lateral Recess Pneumatization Of Sphenoid Sinus

Fig 2 Bilateral anterior clinoid process pneumatization

Fig 3 Bilateral Optic Nerve Canal Dehiscence And Vidian Canal Dehiscence

Fig 4 Bilateral Optic Canal Dehiscence

Fig 5 Onodi Cell With Pneumatization Of Right Clinoid Process

Fig 6 Right ICA dehiscence

Fig 7 Dehiscence Of Left Foramen Rotundum

Fig 8 Sphenoid Sinus Pneumatization Around Vidian Canal Bilateral

Fig 9 Pneumatization Around Left Sided Foramen Rotundum

The sphenoid sinus, depending upon the extent of pneumatization, described as sellar, presellar and conchal types.^(7,8,9) In our study population no conchal type sphenoid sinus was observed. In prior studies incidence of conchal type is reported to be 0-3%^(7,8,10). The presellar type was present in 14% (n=14, Male=6, Female=8) of the study subject. The incidence of presellar type incidence in the literature reported to be 5.5%-27%^(7,8,9,11,12). The sellar type of sphenoid sinus is present in 86% of whole of the group (n=86, M=49, F=37). In previous studies reported incidence of sellar type of sphenoid ranges between 59-86%^(7,8,9,10).

Internal Carotid Artery (ICA):

It is important to identify protrusion and/or dehiscence of ICA because inadvertent injury may lead to life threatening neurovascular sequelae. In our study ICA protrusion were present in 28% (n=28) cases and dehiscence were present in 11% (n=11) cases. Previous studies demonstrated ICA protrusion between 26%-30.3% cases^(13,14,15) dehiscence between 4.8% - 23% cases^(13,14,15,16,17).

Optic Nerve (ON): In this study optic nerve protrusion were found in 25% (n=25) patients and dehiscence in 17% (n=17) patients. In prior studies optic nerve protrusion were demonstrated between 8%-38.2%^(18,19,20,21).

And optic nerve dehiscence was found in 4% -24% cases.^(10,20,21,22) If there is protrusion or dehiscence the chances of optic nerve injury is more. And if the surgeon damages the nerve within the sinus, the risk of blindness is high.²³ Compressive pathology if present result in optic nerve ischaemia and make it very susceptible to injury.²⁴ Protrusion of optic nerve and ICA may coexist with ipsilateral pneumatization of Anterior clinoid process or in the presence of Onodi cells¹³.

Maxillary nerve: The protruded or dehiscence maxillary nerve is likely to be injured during functional endoscopic sinus surgery (FESS) and may give rise to neuralgia later. In our study maxillary nerve protrusion is seen in 23% (n=23) patients and dehiscence in 4% (n=4) patient which correlate well with study conducted by Unal Birsen et al.¹⁴

Vidian nerve: The total cases with vidian nerve protrusion stands 18% (n=18) patients in our study. It correlates well with the study conducted by Lang and Keller et al.²⁵. Dehiscence of the vidian nerve are encountered in 19% cases in this study population. In literature percentage of dehiscences reported between 22%-37%^{26,27,28,29}.

Inter Sphenoid Septum (ISS): The intersphenoid septum varies in number and point(s) of attachment on the sphenoid sinus wall. But it often inserts on the bony covering of the ICA. In previous studies the prevalence of inter sphenoid septum insertion into the bony covering of ICA is between 4.9%-89%^(30,31,32) and in our study the prevalence is 31% (n=31). While performing endoscopic trans sphenoidal surgery, the septa should be removed for exposing floor of sella turcica, thereby creating adequate surgical corridor⁽³²⁾. And it should be done with extreme caution and without making avulsion fracture of the septum. Both the sellar and presellar types of sphenoid sinus have strongly significant associations with the presence of ISS insertion into the ICA (P<0.001).

Previous studies report the majority of septa being asymmetrical^(33,34). To detect septa studying coronal plane is superior compared to axial plane.

Extended pneumatization of sphenoid sinus

Into the pterygoid process: Pneumatization of Pterygoid process is said to be present if it extends beyond a horizontal plane crossing to Vidian canal. In our study pterygoid process pneumatization was present in 34% (n=34) subjects. The pterygoid processes are pneumatized in 25-40% of adults^(13,35).

Into the anterior clinoid process (ACP): In our study ACP pneumatization was found in 18% (n=18) patients. We took CT Scan cuts at 1 mm thickness. In previous studies ACP pneumatization were present between 2.3% to 37.5%^(13,14,22,36,37). The reported prevalence rates vary considerably. It can be due to ethnic difference or due to thinner CT Scan section. Pneumatization of ACP forms optico carotid recess in lateral wall of sphenoid. There is statistically significant relationship was observed between pneumatization of ACP and the protrusion of optic nerve. Therefore, ACP pneumatization is a good indicator of ON and ICA protrusion.

In the greater wing of sphenoid: Pneumatization of greater wing of sphenoid was considered when it extends beyond a vertical line crossing foramen rotundum. In our study 4% (n=4) patients showed pneumatization of greater wing of sphenoid. In previous studies it was found between 1.8% - 20%^(27,38,39).

Onodi Cells: It is important to identify Onodi cells preoperatively in CT Scan and also during surgery as not to mistake it with sphenoid sinus and avoid optic nerve surgical trauma. In our study Onodi cell was found in 19% (n=19) cases. In previous studies Onodi cells reported between 18.4% to 63.5%^(40,41).

Nowadays intraoperative surgical navigation is increasingly used during FESS and Sellar approach. The sphenoid sinus pneumatization pattern can be directly fed into computer workstation and used for navigation. It is important to assess variations of sphenoid sinus to decrease complications and to perform surgery accurately.

Conclusion

In our study we used CT Scan with 1 mm section thickness. This resolution helped in better demonstration of complicated sphenoid sinus anatomy well. Hence, we support 1 mm triplanar CT Scans for preoperative imaging assessment for all sinus surgeries.

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Conflict of interest

There are no conflict of interest.

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