Journal of Taibah University Medical Sciences (2024) 19(1), 114–121

Taibah University

Journal of Taibah University Medical Sciences

www.sciencedirect.com

Original Article

Anatomical variation in the sphenoidal sinuses in patients with chronic rhinosinusitis: A CT scan study

Vinodhini Periyasamy, PhD[a,†], Radhakrishnan Sumana, M.D[b], Anupama Doddappaiah, M.D[c] and Rathinasabapathy Mythilikrishnan, M.D[a,*]

[a] *Department of Anatomy, Karuna Medical College, Vilayodi, Kerala, India*
[b] *Department of Anatomy, Velammal Medical College Hospital & Research Institute, Madurai, Tamil Nadu, India*
[c] *Department of Anatomy, Shridevi Institute of Medical Sciences and Research Hospital, Tumkur, Karnataka, India*

Received 6 May 2023; revised 13 September 2023; accepted 27 September 2023; Available online 7 October 2023

الملخص

أهداف البحث: يعد فهم تشريح الجيوب الأنفية أمرا بالغ الأهمية لتخطيط الجراحة قبل العملية. تهدف هذه الدراسة إلى تقييم العلاقة بين التغيرات التشريحية للجيوب الجبهية والتهاب الجيوب الأنفية المزمن باستخدام الأشعة المقطعية.

طرق البحث: أجريت دراسة وصفية على المرضى الذين يعانون من التهاب الجيوب الأنفية المزمن، والذين أحيلوا لإجراء الأشعة المقطعية إلى قسم التشخيص بالأشعة والتصوير، وتمت مقارنة المعلمات بين مجموعات الدراسة والسيطرة.

النتائج: من بين التغيرات التشريحية، كانت وجود أجزاء مساعدة مكررة داخل الجيب الجبهي، وانحسار وبروز الشريان السباتي الداخلي والعصب البصري مرتفعة في الذكور والإناث من الحالات مقارنة بالمجموعة المرجعية. بين التغيرات التشريحية في منطقة الجيوب الأنفية للمشاركين الذكور في مجموعات الدراسة، كان هناك ارتباط كبير مع بروز العصب البصري وانحساره. أظهر بروز العصب البصري في الذكور خطرا أعلى للإصابة بالتهاب الجيوب الأنفية المزمن بين مجموعة الدراسة.

الاستنتاجات: توفر المعرفة حول التغيرات التشريحية في الجيوب الجبهية فهما أفضل لحدود الاستئصال الجراحي خلال علاج جراحات الجيوب الجبهية.

الكلمات المفتاحية: التغيرات التشريحية؛ الأشعة المقطعية المحوسبة؛ التهاب الجيوب الأنفية المزمن؛ الشريان السباتي الداخلي؛ العصب البصري؛ الجيب الجبهي

Abstract

Computerized tomography (CT) of the skull base region has become an indispensable tool for endoscopic sino-nasal surgery.

Objectives: Fundamental knowledge of the sinus anatomy is crucial for preoperative surgical planning. The aim of this research was to evaluate associations between the anatomical variations sphenoidal sinuses and chronic rhinosinusitis (CRS) by using CT.

Methods: A descriptive study was performed on patients with CRS, who were referred to the department of radiodiagnosis and imaging for CT scanning. Parameters were compared between the study and control groups.

Results: Among the anatomical variations, the presence of bilateral accessory septa within the sphenoidal sinus, and dehiscence and protrusion of the internal carotid artery and optic nerve (ON), were high in men and women in the case group compared with the control group. Among the anatomical variations in the sinonasal region of the male participants, a significant association ($p < 0.05$) was observed with ON protrusion and ON dehiscence. ON protrusion (OR = 2.168) in men was associated with elevated risk of CRS in the study population.

Conclusion: Knowledge of the anatomical variations in the sphenoid sinuses enables better understanding of the

* Corresponding address: Department of Anatomy, Karuna Medical College, Vilayodi, Kerala, India.
E-mail: mythustan@gmail.com (R. Mythilikrishnan)
Peer review under responsibility of Taibah University.
† Present address: Assistant Professor, Department of Anatomy, Shridevi Institute of Medical Sciences and Research Hospital, Tumkur, Karnataka.

Production and hosting by Elsevier

 https://doi.org/10.1016/j.jtumed.2023.09.005

limits of surgical dissection during the treatment of sphenoid sinus surgeries.

Keywords: Anatomical variations; Chronic rhinosinusitis (CRS); Computerized tomography scan; Internal carotid artery; Optic nerve; Sphenoid sinus

Introduction

Chronic rhinosinusitis (CRS) is defined as inflammation of the paranasal sinuses (PNSs) and their respiratory mucosa lining lasting for at least 12 weeks despite medical treatment. CRS involves repeated bouts of acute infection or persistent chronic inflammation of the sinuses. The etiology can involve an allergy trigger, or a viral, fungal or bacterial infection.[1,2] The health of the sinuses is directly associated with the state of the osteomeatal openings. CRS interferes with the drainage and retention of mucus secretions. The most important causes of CRS are failure of resolution of acute infection and incomplete clearance of mucociliary secretions, as a result of obstruction.[3]

Conventional radiography has minimal value for drainage pathways, because the sinus walls are obscured by overlying structures. Standard radiological images are no longer recommended in the diagnosis of CRS, because of their poor specificity and sensitivity.[4] Computerized tomography (CT), the most precise technique available for PNS imaging, displays the bone, soft tissue and air in three dimensions.[5]

The sphenoidal air sinuses are two large irregular cavities separated by an intersphenoid septum located deep in the middle cranial fossa. Each sinus opens into a sphenoethmoidal recess. These sinuses are the least accessible of all PNSs. Septal number and location are important during endoscopic transnasal surgical procedures.[6]

Sphenoidal air sinuses relations are the pituitary fossa superiorly, cavernous sinus and its contents bilaterally and inferiorly choana, anteriorly by the ethmoidal complex, and posteriorly by the clivus.[6] The lateral walls contain vital structures such as the internal carotid artery (ICA), optic nerve (ON), maxillary nerve, Vidian nerve, orbit and its contents, cavernous sinus and anterior cranial fossa.[7,8] The ICA runs along the posterolateral wall of the sphenoidal sinus cavity. The ON is the second cranial nerve that runs from the orbital cavity through the optic canal to the middle cranial fossa over the roof of sphenoidal sinus cavity. Extensive pneumatization of the sinuses exposes the neurovascular bundle to the sinus cavity. The ICA and ON are exposed as they run through the sphenoidal sinus cavity, because of the absence of protective osseous walls.

Variations in the dehiscence or protrusion of the ICA and ON are important for surgeons performing trans-sphenoidal surgeries, to avoid fatal hemorrhage due to a ruptured ICA within the sphenoid sinus. Great caution is required during removal of the sinus septa, which are anchored to the ICA or ON walls. Detailed assessment of the presence, number and location of sinus septa is crucial to avoid iatrogenic morbidities during surgery.

Fundamental knowledge of the sinus anatomy is crucial for preoperative surgical planning. The aim of this research was to evaluate associations between anatomical variations in the sphenoidal sinuses and CRS by using CT scans.

Materials and Methods

Study design

The participants in the present study were patients at the department of radiodiagnosis and imaging at our institution. CT scans were performed as part of routine clinical evaluation for diagnostic purposes. Data were collected from the CT images of the referred patients. Informed consent was obtained from the patients willing to participate in the study.

This observational case control study (n = 800) was conducted in south India. Patients were categorized into a case group (n = 400) and a control group (n = 400), each comprising male (n = 200) and female (n = 200) participants 18–65 years of age.

Participants

The 800 patients were divided according to their diagnosis into 400 patients in the case group and 400 patients in the control group. Each group comprised 200 men and 200 women. The patients were between the ages of 18 and 65 years. The case group comprised patients clinically diagnosed with CRS that did not respond to medical treatment for more than 12 weeks. These patients were referred for radiological assessment by the ear, nose and throat department. The control groups were selected from patients without CRS, neurological, ophthalmological or neck pathologies.

Inclusion criteria. Patients clinically diagnosed with CRS were included in the study in the case group. The controls were selected from patients with non-ENT conditions referred from the departments of neurology or ophthalmology for headache, neck related diseases such as cervical pain, neurological diseases or other orbital pathologies.

Exclusion criteria. Patients with a history of previous endoscopic sinus surgery, patients with chronic sinusitis responding to medical management and patients not consenting to participate in the study were excluded. Patients with a diagnosis of nasopharyngeal tumors, polyps or previous facial corrective surgeries with alteration of the PNS anatomy were excluded. In addition, patients with copious discharge, extensive fungal masses, or benign or malignant tumors of the sinonasal mucosa were excluded from the study.

Case group: Patients clinically diagnosed with CRS not responding to medical treatment for more than 12 weeks were included in the case group.

Control group: Patients without CRS referred for neurological, ophthalmological or neck pathologies were selected for inclusion in the control group.

Methods

A CT scanner (Somatom Spirit (79627), Siemens AG, Germany) was used to identify the anatomical variation in the sinonasal region among participants. The machine was a spiral CT scanner collecting multiple slices. The anatomical variations in the nasal cavity and PNS, according to the CT scans, comprised accessory sphenoidal sinus septa, and protrusion and dehiscence of the ICA and ON.

The anatomical variation in the sphenoidal sinuses is shown in Figure 1a–d. Accessory septa of the sphenoidal sinuses were defined by the presence of accessory septa within the sphenoidal sinus. Chougule and Dixit have reported that these septa run in both directions, either in transverse or in vertical orientation.[9] The accessory septa within the sphenoidal sinuses appeared as complete or incomplete septa dividing the sinus cavity into unequal portions.

The ICA was seen in both axial and coronal slices of the CT scans. ICA protrusion was defined as the protuberance of the ICA into the sphenoidal sinus cavity with more than half the circumference. ICA dehiscence referred to absence of the bony wall separating the ICA from the sphenoidal sinus.[10]

The ON is the second cranial nerve that runs from the orbital cavity to the middle cranial fossa through the optic canal. Extensive pneumatization of the sinus cavity surrounds the optic canal, thus making the nerve prominently protrude into the sinus region.

ON protrusion is produced by indentation of the ON along the anterosuperior aspect of the sphenoidal sinus roof.[10] ON dehiscence was defined as dehiscence of the bone covering the ON along the walls of the sphenoidal sinus, as described by Al-Tameemi et al.[11]

The denudation of the bony covering of the ON led to exposure of the nerve in the sphenoidal sinuses (Figure 1b). Bilateral anterior clinoid process (ACP) pneumatization and exposure of the ON were clearly seen (Figure 1b).

Bilateral protrusion of the ON and ICA into the right and left sphenoidal sinuses was observed (Figure 1c). The ICA runs along the posterolateral wall of the sphenoidal sinus cavity. The ICA and ON are exposed as they run through the sphenoidal sinus cavity, owing to the absence of protective osseous walls. Bilateral protrusion of the ON was visualized in the reconstructed axial image with the attachment of the accessory sphenoidal septum.

The osseous wall encasing the ICA at the point of passage through the sphenoidal sinus became partially or completely dehiscent because of extensive pneumatization (Figure 1c and d).

Statistical analysis

Data analysis was performed in SPSS (version 21) package. Descriptive statistics was evaluated on the basis of means, percentages and standard deviations. Inferential statistics was applied with chi-square test for qualitative variables to test the significance of associations between anatomical PNS variation and CRS. The associations between CRS and the presence of anatomical PNS variation are reported as odds ratios with 95% confidence intervals.

Results

The distribution of anatomical variation in the sphenoidal sinus was identified with CT scans among the male and female participants, as shown in Tables 1 and 2, respectively.

Associations between the anatomical variation in the sinonasal region and mucosal thickening among the male and female participants are shown in Tables 3 and 4, respectively.

Assessment of the risk of development of CRS among male and female participants, on the basis of anatomical variations and mucosal thickening of the sinonasal regions, are shown in Tables 5 and 6, respectively.

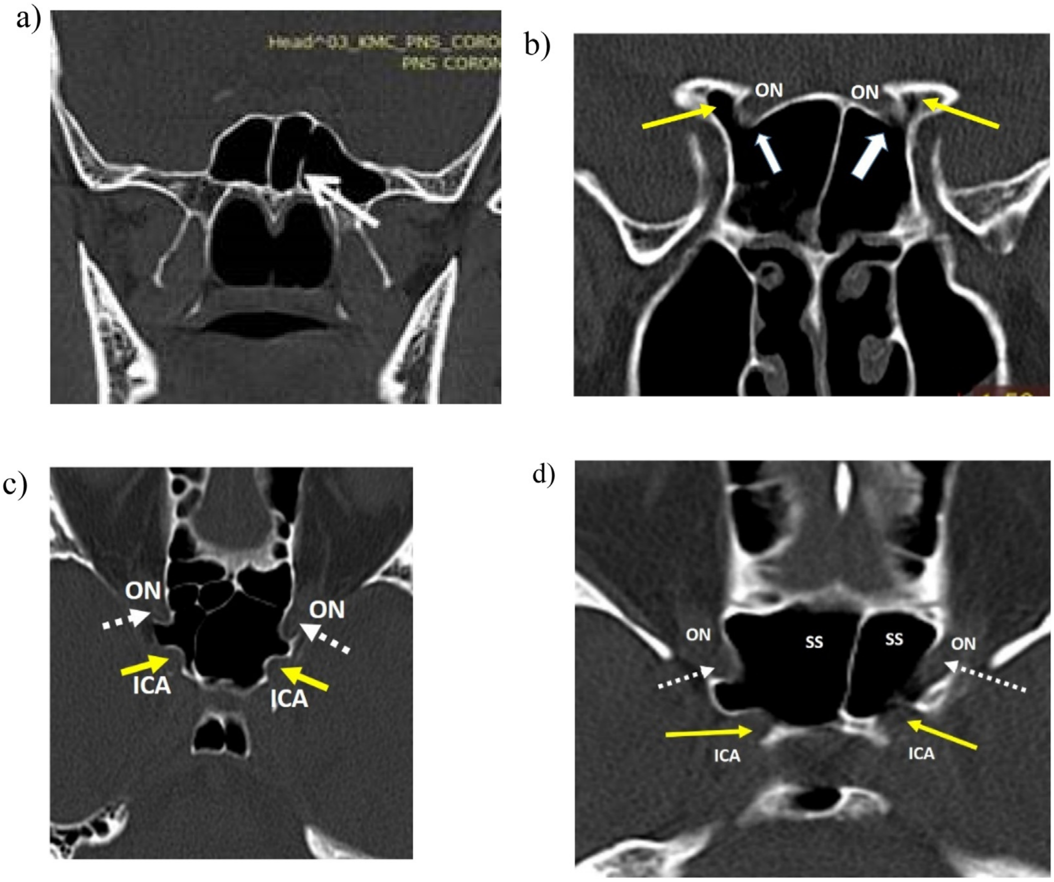

Figure 1: Anatomical variation in the sphenoidal sinuses identified in CT scan images. a) Coronal CT image of the sphenoidal sinus, showing left accessory sinus septa (white solid arrow). b) Coronal CT section showing bilateral anterior clinoid process pneumatization (yellow arrows) and bilateral protrusion of the optic nerve (ON) (white arrow) into the sphenoidal sinuses. Bilateral bone covering of the optic canal is absent. c) Axial CT section showing bilateral protrusion of the internal carotid artery (ICA) (yellow solid arrows) and bilateral protrusion of the optic nerve (white dotted arrows) into the sphenoidal sinuses. Bilateral bone covers the optic canal and ICA. d) Axial CT section image, showing bilateral protrusion of the optic nerve with dehiscence of the optic canal covering (white dotted arrows) into the sphenoidal sinuses (SS). Bilateral dehiscence of the osseous covering of the ICA (yellow solid arrows) is present. *A Siemens AG Somatom spirit scanner was used to assess PNS anatomical variation.*

Table 1: Distribution of anatomical variation in the sphenoidal sinus, identified with CT scans among male participants.

Anatomical variations in the sphenoidal sinus	Men (n = 400)					
	Cases n (%)			Controls n (%)		
	(n = 200)			(n = 200)		
	Absent	Unilateral	Bilateral	Absent	Unilateral	Bilateral
Accessory sinus septa	58 (28.7)	27 (13.5)	115 (57.5)	124 (62.0)	22 (11.0)	53 (26.5)
ICA protrusion	128 (64.0)	4 (2.0)	68 (34.0)	1 52 (75.5)	24 (12.0)	25 (12.5)
ICA dehiscence	126 (63.0)	14 (7.0)	60 (30.0)	161 (80.5)	14 (7.0)	25 (12.5)
Optic nerve protrusion	93 (46.0)	4 (2.0)	103 (51.0)	135 (67.5)	32 (16.0)	33 (16.5)
Optic nerve dehiscence	76 (38.0)	13 (6.5)	111 (55.0)	120 (60.0)	33 (16.5)	47 (23.5)
ACP pneumatization	129 (64.0)	8 (4.0)	63 (31.0)	152 (76.0)	18 (9.0)	30 (15.0)

The study groups were cases and controls. CT images were collected with a Siemens AG Somatom scanner and used to assess anatomical variation in the sphenoidal sinuses. Data are shown as frequencies (n) with percentages in parentheses (%). Abbreviations: ICA, internal carotid artery; ACP, anterior clinoid process; CT scan, computerized tomography scan; cases, patients with chronic rhinosinusitis; controls, healthy individuals without chronic rhinosinusitis.

Table 2: Distribution of anatomical variation in the sphenoidal sinus, identified with CT scans among female participants.

Anatomical variations in the sphenoidal sinus	Women (n = 400)					
	Cases n (%) (n = 200)			Controls n (%) (n = 200)		
	Absent	Unilateral	Bilateral	Absent	Unilateral	Bilateral
Accessory sinus septa	69 (34.0)	34 (17.0)	97 (48.5)	128 (64.0)	17 (8.5)	55 (27.5)
ICA protrusion	124 (62.0)	7 (3.5)	66 (33.0)	158 (80.5)	19 (9.5)	21 (10.5)
ICA dehiscence	137 (68.5)	16 (8.0)	47 (23.5)	161 (80.5)	26 (13.0)	13 (16.5)
Optic nerve protrusion	94 (47.0)	11 (5.5)	95 (47.5)	140 (70.0)	26 (13.0)	33 (23.5)
Optic nerve dehiscence	79 (39.5)	32 (16.0)	89 (44.5)	117 (58.5)	2 (1.0)	81 (40.5)
ACP pneumatization	120 (60.0)	9 (4.5)	70 (35.0)	143 (71.5)	4 (2.0)	53 (26.5)

The study groups were cases and controls. CT images were collected with a Siemens AG Somatom scanner and used to assess anatomical variation in the sphenoidal sinuses. Data are shown as frequencies (n) with percentages in parentheses (%). Abbreviations: ICA, internal carotid artery; ACP, anterior clinoid process; CT scan, computerized tomography scan; cases, patients with chronic rhinosinusitis; controls, healthy individuals without chronic rhinosinusitis.

Table 3: Association between the anatomical variation in the sinonasal region and mucosal thickening among male participants.

Anatomical variations in the sinonasal region	Study groups	Mucosal thickening among men		p value
		Present	Absent	
Accessory septa within the sphenoidal sinus	Cases	37	20	0.631
	Controls	87	55	
ICA protrusion	Cases	51	101	0.199
	Controls	21	27	
ICA dehiscence	Cases	57	104	0.342
	Controls	17	22	
Optic nerve protrusion	Cases	71	22	0.013*
	Controls	64	43	
Optic nerve dehiscence	Cases	47	29	0.013*
	Controls	73	51	
ACP pneumatization	Cases	94	35	0.073
	Controls	43	28	

The study groups were cases and controls. Abbreviations: ICA, internal carotid artery; ACP, anterior clinoid process. Chi square test was used. Levels of significance: $p > 0.01$** indicates highly significant, $p < 0.05$* indicates significant and $p > 0.05$ indicates nonsignificant. Cases, patients with chronic rhinosinusitis; controls, healthy individuals without chronic rhinosinusitis.

Table 4: Association between the anatomical variation in the sinonasal region and mucosal thickening among female participants.

Anatomical variations in the sinonasal region	Study groups	Mucosal thickening among men		p value
		Present	Absent	
Accessory septa within the sphenoidal sinus	Cases	47	22	0.379
	Controls	81	50	
ICA protrusion	Cases	99	24	0.792
	Controls	60	16	
ICA dehiscence	Cases	113	24	0.431
	Controls	49	14	
Optic nerve protrusion	Cases	70	24	0.247
	Controls	71	35	
Optic nerve dehiscence	Cases	49	30	0.414
	Controls	68	53	
ACP pneumatization	Cases	91	29	0.124
	Controls	52	27	

The study groups were cases and controls. Abbreviations: ICA, internal carotid artery; ACP, anterior clinoid process. Chi square test was used. $p < 0.01$** indicates highly significant, $p < 0.05$* indicates significant and $p > 0.05$ indicates nonsignificant differences. Cases, patients with chronic rhinosinusitis; controls, healthy individuals without chronic rhinosinusitis.

Table 5: Assessment of the risk of CRS development among male participants, according to anatomical variations and mucosal thickening of the sinonasal regions.

Anatomical variations in the sinonasal region		Mucosal thickening among men		OR	95% CI
		Present	Absent		
Accessory septa within the sphenoidal sinus	Cases	37	20	1.170*	0.617–2.219
	Controls	87	55		
ICA protrusion	Cases	101	27	1.540*	0.794–2.987
	Controls	51	21		
ICA dehiscence	Cases	104	22	1.410*	0.693–2.869
	Controls	57	17		
Optic nerve protrusion	Cases	71	22	2.168*	1.172–4.010
	Controls	64	43		
Optic nerve dehiscence	Cases	47	29	1.132*	0.631–2.032
	Controls	73	51		
ACP pneumatisation	Cases	94	35	1.749*	0.946–3.232
	Controls	43	28		

CT images obtained from a Siemens AG Somatom scanner were used to assess anatomical variation. Odds ratios (OR) and 95% confidence intervals (95% CI) were calculated. *Odds ratio >1 was considered to indicate risk. Abbreviations: ICA, internal carotid artery; ACP, anterior clinoid process; cases, patients with chronic rhinosinusitis; controls, healthy individuals without chronic rhinosinusitis.

Table 6: Assessment of the risk of CRS development among female participants, according to anatomical variations and mucosal thickening of the sinonasal regions.

Anatomical variations in the sinonasal region	Study groups	Mucosal thickening among women		OR	95% CI
		Present	Absent		
Accessory septa within the sphenoidal sinus	Cases	47	22	1.319*	0.712–2.444
	Controls	81	50		
ICA protrusion	Cases	99	24	1.100*	0.541–2.236
	Controls	60	16		
ICA dehiscence	Cases	113	24	1.345*	0.642–2.818
	Controls	49	14		
Optic nerve protrusion	Cases	70	24	1.438*	0.777–2.661
	Controls	71	35		
Optic nerve dehiscence	Cases	49	30	1.273*	0.713–2.272
	Controls	68	53		
ACP pneumatization	Cases	91	29	1.629*	0.872–3.044
	Controls	52	27		

CT images obtained from a Siemens AG Somatom scanner were used to assess the anatomical variations. Odds ratios (OR) with 95% confidence intervals (95% CI) were calculated. *Odds ratio >1 was considered to indicate risk. Abbreviations: ICA, internal carotid artery; ACP, anterior clinoid process; cases, patients with chronic rhinosinusitis; controls, healthy individuals without chronic rhinosinusitis.

Discussion

Functional endoscopic sinus surgery (FESS) is a minimally invasive technique used to restore sinus ventilation and normal function. The ability to treat PNS disease has been revolutionized by the advent of fiberoptic endoscopes and CT scanners.[12] FESS requires meticulous assessment and detailed description of both the nasal and paranasal regions.[13]

Spiral CT scans enable excellent surgical orientation in axial, coronal and sagittal sections, thus allowing for optimal evaluation of the sizes of the orbital and maxillofacial bony structures, intracranial soft tissues and the OMC region.[14,15] CT images clearly delineate mucosal thickening, sinus opacity, bone sclerosis and disease extent in CRS. In addition, CT scans define the underlying anatomic abnormalities that predispose people to sinusitis. Moreover, these scans are used for identifying key neurovascular structures, such as the orbital contents, ON and carotid artery in diseased areas—a process essential for surgical planning.[13,16,17] The appearance of bony details with wide window settings correlates exactly with the true measurements of the air spaces, and the thickness of soft tissue diseases and bone.[18,19]

Multiple septa appear to have transverse or vertical orientations. The main septum cannot be used as a reliable landmark for endoscopic procedures.[20] Attention must critically be paid to the insertion of the main and accessory septa along the osseous walls of structures such as the ON and ICA.[21] Two bulges produced by the ON and ICA are seen on the lateral wall of the sphenoidal sinus. The optic canal bulges into the anterior superior part of the sphenoidal sinus. The ICA bulges into the superolateral wall of the posterior part of the sinus.[22]

The ICA is seen in both axial and coronal slices of CT scans.[23] The osseous wall encasing the ICA while passing through the sphenoidal sinus becomes partially or completely dehiscent, owing to extensive pneumatization (Figure 1b). Pneumatization of the ACP exposes the ON in the sinus cavity.[24] Extensive pneumatization brings neurovascular structures, such as the ON, cavernous sinus, ICA and ACP, into proximity of the sinuses.[25–27]

This study was conducted to identify the presence of anatomical variations in patients with CRS (cases) and those with non-sinus diseases (controls) in the South Indian population undergoing CT scanning.

Among the women in the case group, bilateral presence of bilateral accessory septa within the sphenoidal sinus (48.5%); dehiscence (23.5%) and protrusion (33%) of the ICA; dehiscence (44.5%) and protrusion (47.5%) of the ON; and ACP pneumatization (35%) were more frequent in the case group than the control group (Table 1).

Distribution of anatomical variations in the sinonasal region and their associations with mucosal thickening by sex

Among the anatomical variations in the sinonasal region in male participants, we observed a significant association ($p < 0.05$) in the ON protrusion and ON dehiscence with prevalence of chronic rhinosinusitis. No other parameters showed significant associations in the study population (Table 3). Among the female participants, no anatomical variations in the sinonasal region showed significant associations (Table 4).

Assessment of CRS risk according to the anatomical variations and mucosal thickening of sinonasal region between study groups.

We examined anatomical variations and mucosal thickening in the sinonasal region to determine individuals' risk of developing CRS. OR values calculated for the anatomical variations and mucosal thickening in the sinonasal region in male (Table 5) and female (Table 6) participants were used to estimate the risk of developing CRS.

Among the anatomical variations in the sinonasal region in men, the calculated OR was highest for ON protrusion (OR = 2.168, 95% CI = 1.172–4.010). The chance of developing CRS was 2.168 times greater with the presence of ON protrusion. Hence, a man in the study population with ON protrusion might have a substantial risk of developing CRS.

The other anatomical variations in men had an OR >1, thus suggesting that these anatomical variations were associated with an elevated risk of CRS. All anatomical variations in the sinonasal region in women showed an OR >1, thus suggesting their presence was associated with elevated CRS risk.

This study may increase awareness of the existence of anatomical variations between individuals with versus without CRS. It provides valuable information for endoscopic sinus surgeons performing FESS procedures.[28,29] Iatrogenic injuries can lead to post-operative complications, such as diplopia, visual blindness, cerebrospinal fluid leakage, intra-cranial hemorrhage, dural penetration or intracerebral complications.[30–32]

Conclusion

The degree of pneumatization of the sphenoidal sinus varies from absent to extensive among individuals. Pneumatization of the sinuses leads to diverse anatomical variations in the surrounding neurovascular structures. A bulging or dehiscent ON and ICA increases the risk of injury during surgery. Even minimal damage to surrounding structures during surgery can lead to irrevocable outcomes such as blindness or massive bleeding. The outcomes of the present study shed light on conspicuous variations and may benefit society by improving patient quality of life.

Source of funding

This research did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors.

Conflict of interest

The authors have no relevant financial or non-financial interests to disclose. The authors have no competing interests to declare that are relevant to the content of this article. All authors certify that they have no affiliation with, or involvement in, any organization or entities with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript. The authors have no financial or proprietary interests in any material discussed in this article.

Ethical approval

The institutional clinical research ethics committee approved the work on October 12, 2015, in letter no. KMC/Cert./10-2015/36.

Consent

Written informed voluntary consent was obtained from all participants.

Authors contributions

VP conceived and designed the study, performed investigations and collected the resources. SR validated the study, performed formal analysis along with data curation, and helped in procuring the CT Film (resources). AD reviewed and edited the manuscript, and supervised the investigation. MK assisted in investigations and wrote the original draft. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

References

1. Reddy A, Kakumanu PK, Kondragunta C, Gandra NR. Role of computed tomography in identifying anatomical variations in chronic sinusitis: an observational study. **West Afr J Radiol 2018**; 25(1): 65.

2. Bergmark RW, Pynnonen M. Diagnosis and first-line treatment of chronic sinusitis. **J Am Med Assoc 2017**; 318(23): 2344–2345.
3. Raseman J, Guryildirim M, Beer-Furlan A, Jhaveri M, Tajudeen BA, Byrne RW, et al. Preoperative computed tomography imaging of the sphenoid sinus: striving towards safe transsphenoidal surgery. **J Neuro Surg Part B: Skull Base 2020**; 81(3): 251–262.
4. Kaku DR, Harugop AS. Correlation of computed tomography and nasal endoscopic findings in chronic rhinosinusitis: a hospital-based study. **Indian J Health Sci Biomed Res (KLEU). 2017**; 10(2): 116.
5. Srivastava M, Tyagi S, Kumar L. Comparative evaluation of chronic rhinosinusitis patients by conventional radiography, computed tomography and diagnostic nasal endoscopy (DNE). **Indian J Otolaryngol Head Neck Surg 2016**; 68(2): 173–178.
6. Fasunla AJ, Ameye SA, Adebola OS, Ogbole G, Adeleye AO, Adekanmi AJ. Anatomical variations of the sphenoid sinus and nearby neurovascular structures seen on computed omography of black Africans. **Can J Surg 2012**; 17(1): 57–64.
7. Turkdogan FT, Turkdogan KA, Dogan M, Atalar MH. Assessment of sphenoid sinus related anatomic variations with computed tomography. **Pan Afr Med J 2017**; 27.
8. Mamatha H, Saraswathi G, Prasanna LC. Variations of sphenoid sinus and their impact on related neurovascular structures. **Curr Neurobiol 2010**; 1(2): 121–124.
9. Chougule MS, Dixit D. Chougule MS, Dixit D. A cross-sectional study of sphenoid sinus through gross and endoscopic dissection in North Karnataka, India. **J Clin Diagn Res 2014**; 8(4): AC01–AC05.
10. Anusha B, Baharudin A, Philip R, Harvinder S, Shaffie BM. Anatomical variations of the sphenoid sinus and its adjacent structures: a review of existing literature. **Surg Radiol Anat 2014**; 36: 419–427.
11. De Lano MC, Fun FY, Zinreich SJ. Relationship of the optic nerve to the posterior paranasal sinuses: a CT anatomic study. **Am J Neuroradiol 1996**; 17: 669–675.
12. Aghdas MM, Shahidi N, Sheikhzadeh D, Ebrahimzadeh M. Quality of life in patients with chronic rhinosinusitis with nasal polyposis before and after functional endoscopic sinus surgery: a study based on sino-nasal outcome test. **ABC Med 2018**; 6(1): 11–14.
13. Bademc G, Unal B. Surgical importance of neurovascular relationships of paranasal sinus region. **Turk Neurosurg 2005**; 15(2): 93–96.
14. Zinreich SJ, Kennedy DW, Rosenbaum AE, Gayler BW, Kumar AJ, Stammberger H. Paranasal sinuses: CT imaging requirements for endoscopic surgery. **Radiology 1987**; 163: 769–775.
15. Fatterpekar GM, Delman BN, Som PM. Imaging the paranasal sinuses: where we are and where we are going. **Anat Rec 2008**; 291(11): 1564–1572.
16. Basu S, Agarwal PK. Redefining the need of CT scan in chronic rhinosinusitis-a rational approach. **J Evol Med Dent Sci 2019**; 8(30): 2412–2417.
17. Hiremath SB, Gautam AA, Sheeja K, Benjamin G. Assessment of variations in sphenoid sinus pneumatization in Indian population: a multidetector computed tomography study. **Indian J Radiol imaging 2018**; 28(3): 273.
18. Gibelli D, Cellina M, Gibelli S, Cappella A, Oliva AG, Termine G, et al. Relationship between sphenoid sinus volume and protrusion of internal carotid artery and optic nerve: a 3D segmentation study on maxillofacial CT-scans. **Surg Radiol Anat 2019**; 41(5): 507–512.
19. Famurewa OC, Ibitoye BO, Ameye SA, Asaleye CM, Ayoola OO, Onigbinde OS. Sphenoid sinus pneumatization, septation, and the internal carotid artery: a computed tomography study. **Niger Med J 2018**; 59(1): 7.
20. Hewaidi GH, Omami GM. Anatomic variation of sphenoid sinus and related structures in Libyan population: CT scan study. **Libyan J Med 2008**: 1–9.
21. Kapur E, Kapidžić A, Kulenović A, Sarajlić L, Šahinović A, Šahinović M. Septation of the sphenoid sinus and its clinical significance. **Int J Collab Res Intern Med Public Health 2012**; 4(10): 1793–1802.
22. Singh I, Goyal S, Bisht S, Lakshmi. ICA injury in sphenoid sinus during nasal endoscopic sinus surgery-A case report. **J Otolaryngol ENT Res 2016**; 5(2):00133.
23. Singh BP, Metgudmath RB, Singh D, Saxena U. Anatomical variations of sphenoid sinus among patients undergoing computed tomography of paranasal sinus. **Int J Otorhinolaryngol Head Neck Surg 2019**; 5(4): 888.
24. Joghataei MT, Hosseini A, Ansari JM, Golchini E, Namjoo Z, Mortezaee K. Variations in the anatomy of sphenoid sinus: a computed tomography investigation. **J Pharm Res Int 2019**; 29: 1–7.
25. Lu Y, Pan J, Qi S, Shi J, Zhang XA, Wu K. Pneumatisation of the sphenoid sinus in Chinese: the differences from Caucasian and its application in the extended transsphenoidal approach. **J Anat 2011**; 219(2): 132–142.
26. Sireci F, Danè G, Dispenza F, Vitali M, Peretti G, Canevari FR. Main corridors in the transphenoidal skull base surgery. In: Duncan LT, editor. **Advances in health and disease**, vol. 37. Nova Medicine and Health; 2021. pp. 177–189.
27. Hamid O, Fiky LE, Hassan O, Kotb A, Fiky SE. Anatomic variations of the sphenoid sinus and their impact on trans-sphenoid pituitary surgery. **Skull Base 2008**; 18(1): 9–15.
28. Saedi B, Sadeghi M, Akhavan-Khaleghi N, Seifmanesh H. Impact of endoscopic sinus surgery on the quality of life of patients with nasal polyposis. **B-ENT 2014**; 10(1): 59–65.
29. El Mograbi A, Soudry E. Ocular cranial nerve palsies secondary to sphenoid sinusitis. **World J Otorhinolaryngol -Head Neck Surg. 2017**; 3(1): 49–53.
30. Dolapsakis C, Kranidioti E, Katsila S, Samarkos M. Cavernous sinus thrombosis due to ipsilateral sphenoid sinusitis. **BMJ Case Reports CP 2019**; 12(1):e227302.
31. Bucher S, Kugler A, Probst E, Epprecht L, Stadler RS, Holzmann D, et al. Occurrence of occult CSF leaks during standard FESS procedures. **Rhinology 2018**; 56(2): 166–171.
32. Pires J, Gil P, Carvalho F, Paiva C, Pais RP, Silva L. Posterior orbital cellulitis as a complication of sphenoid sinusitis: a case report. **Acta Otorrinolaringol Gallega 2018**; (11): 38–43.

How to cite this article: Periyasamy V, Sumana R, Doddappaiah A, Mythilikrishnan R. Anatomical variation in the sphenoidal sinuses in patients with chronic rhinosinusitis: A CT scan study. J Taibah Univ Med Sc 2024;19(1):114–121.