ORIGINAL ARTICLE

POSITIONAL VARIATION OF OPTIC NERVE IN RELATION TO SPHENOID SINUSES AND ITS ASSOCIATION WITH PNEUMATISATION OF ANTERIOR CLINOID PROCESS: A RADIOLOGICAL STUDY
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ABSTRACT: OBJECTIVE: The posterior most among the paranasal sinuses, the sphenoid sinuses exhibit high variability in their structure, pneumatisation and relation to surrounding neurovascular structures. The protrusion of optic nerve (ON) into the superolateral wall of the sinus has been reported in literature with varied incidence. The pneumatisation of sphenoid sinus and its extension to anterior clinoid process (ACP) is also been mentioned in few studies. The variability in the incidence and the inconsistency in the association between optic nerve protrusion and degree of pneumatisation seen in studies done in different ethnicity and with paucity of Indian studies necessitated this study on positional variation of optic nerve in relation to sphenoid sinuses and its association with pneumatisation of anterior clinoid process in South Indian ethnicity.

THE METHODS: CT scan images in coronal section collected from 114 patients with sinusitis with in the age group of 16-64 years belonging to both sexes were studied. The CT images were evaluated for the position of ON with sphenoid sinuses, protrusion of it into the sinus walls, bony dehiscence, pneumatisation of ACP. The position of ON was classified into Delano’s four types and their incidence noted. RESULTS: Type 1 position of ON was observed predominantly in 65.8% sides while Type 2, 3, 4 were seen in 29.8%, 1.8% and 2.6% sides respectively out of 228 sides studied. Associated bony dehiscence was noted in only 5 out of 228sides (2.1%) studied. The pneumatisation of ACP was observed in 23.6% of the CT scans studied. The association between ON protrusion and ACP pneumatisation was found to be statistically significant with P= 0.008. CONCLUSION: The varying position of ON, its protrusion with or without dehiscence in to the sphenoid sinus wall with statistically significant association with ACP pneumatisation in south Indian ethnicity warrants a systematic CT evaluation pre operatively to ensure efficient surgery with minimal complications.

KEYWORDS: Sphenoid sinus, Optic nerve, Anterior clinoid process, Pneumatisation.

INTRODUCTION: The sphenoid sinuses that are located at the skull base at the junction of the anterior and middle cranial fossae, are the posterior most among the paranasal sinuses. Previous studies have claimed that sphenoid sinuses exhibits high degree of anatomical variability in its structure, pneumatisation and relations.¹⁻⁸ Invagination of the nasal mucosa into the posterior portion of the cartilaginous nasal capsule between the third and fourth months of fetal development results in the growth of this sinuses.⁹
Surgically high risk neuro vascular structures like optic nerve (ON) supero laterally, carotid artery mid laterally, trigeminal nerve infero laterally and vidian nerve in the floor surrounds these sinuses. (Figure 1) Multitude of studies have claimed that ON bulges into anterior superior or superolateral part of sinuses with or without bony dehiscence in 4-70%.\textsuperscript{10-20} Another study reported contradictorily that the ON was not producing impression into the sinuses.\textsuperscript{21}

The relations of ON to sphenoid and posterior ethmoid sinus were classified into four types as: Type 1-the nerve does not contact or impinge on either the sphenoid or posterior ethmoid cells. Type 2-the nerve indents the sphenoid sinus, without contacting the posterior ethmoid cells. Type 3-the nerve runs through the sphenoid sinus, and it is surrounded by the pneumatised sinus for at least 50%. Type 4-the nerve courses close to both the sphenoid sinus and posterior ethmoid sinus.\textsuperscript{22}

Few authors have proposed that this varied relationship of the ON to the sphenoid sinus, is due to the inconsistent nature of the sphenoid sinus pneumatisation.\textsuperscript{10,23-26} They also hypothesised that extensive pneumatisation of the sphenoid sinus can bring it in close relations to vessels and nerves of the skull base resulting in irregularities or ridges in the sinus cavity.

The pneumatisation can extend further from its body into the clinoid processes, greater wings and pterygoid plates more often anteriorly and laterally.\textsuperscript{27,28} A study has proved that when the anterior clinoid process (ACP) is pneumatised, it encroaches on the ON resulting in superolateral protrusion into the sinus wall.\textsuperscript{29} Literatures reporting claimed the incidence of pneumatization of the ACP varied between 4\% and 54\%.\textsuperscript{12,16,19,22,25,30,31,37-40}

The previous studies have reported widely varying incidence of dehiscence of bone associated with different positions of ON in relation to sphenoid sinuses and ACP pneumatisation. There exists contradicting views regarding ON producing impression in the sinus wall in different ethnicity. Moreover, there is a definite paucity of extensive studies in Indian population. So, this study was done to establish the positional relation of ON to sphenoid sinuses and its association with pneumatisation of ACP in south Indian ethnicity.

**METHODOLOGY:** Radiologic data were collected from 114 coronal CT scans with a diagnosis of sinusitis constituting 228 sides, obtained from the Department of Radio diagnosis at our medical college hospital. Dual slice coronal CT images obtained by Wipro GE model 5114671/2 machine were analysed by two independent observers. CT images belonged to patients aged between 16 to 60 years of both sexes. While CT images of patients with prior sinus surgery, Sino nasal tumours, facial trauma and obscured sphenoid sinus pathology were excluded from this study. Also images from patients younger than 16 years were excluded because the extension of nasal cavity into the body of the sphenoid sinus is present before birth but does not reach its full extension until adolescence.

The positional relation of ON, its protrusion caused due to the course of the nerve through the sphenoid sinuses and presence of bony dehiscence were studied. The positional relation of ON was noted and classified into four types based on criteria of a previous study.\textsuperscript{22} The extension of pneumatisation into ACP was also noted. The significance of the association between ON protrusion and ACP pneumatisation was statistically measured by chi-square test (P<0.05) and the significance between the types of ON and ACP pneumatisation was analysed by using one way ANOVA. Institutional ethical committee clearance was obtained prior to the study.
RESULTS: The position of ON in relation to sphenoid sinuses was observed to be predominantly of Type 1 in 150 sides out of 228 sides studied (65.8%) (Figure 2) The Type 2, Type 3, Type 4 relations were seen in 68 sides (29.8%), 4 sides (1.8%) and 6 sides (2.6%) respectively (Figure 3, 4, 5). The thin bony plate separating ON from sinus was visualized to be dehiscent in 2.1% (Figure 4) The ACP pneumatisation was seen in 27 CT scan images (23.6%) of which unilateral, bilateral pneumatisation was 10 and 17 respectively (Figure 6, 7). The different types of ON positional relation and its separate association with ACP pneumatisation were found to be insignificant statistically. The association between ON protrusion and ACP pneumatisation was found to be statistically significant with P= 0.008.

DISCUSSION: The location of sphenoid sinus in the skull base with varying relation to vital neurovascular structures with only thin bony walls separating them, necessitates understanding of its anatomy prior to intervention so as to minimize iatrogenic injury to these surrounding structures.\(^\text{35,36}\)

The Type 1 ON was found to be the common type in all the studies including the present study except one study which found Type 2 position as the commonest position in relation to sphenoid sinuses (Graph 1).\(^\text{14,19,22,32,37}\)

The thin layer of bone covering the ON bulging into the sphenoid sinuses was reported to exhibit varied incidence of dehiscent up to 30.6% by previous studies.\(^\text{4,15,16,19,22,25,30,31,38,39,40}\) The incidence of dehiscence observed in the present study falls within this reported range, while another study claimed nil dehiscence of bone layer covering ON bulging into the sinuses (Table 1).\(^\text{12}\) This widely varying incidence of dehiscence of bony layer was hypothesized by few studies, to be due to varying size of sample studied, different ethnicity, varying patient profile, criteria used for defining dehiscence in radiological imaging and differing extension of pneumatisation.\(^\text{10,23-26}\) The protruding ON with dehiscence may lead on to surgical trauma, ischemia or venous congestion of nerve because the ON is least nourished in the optic canal making it very susceptible for these injuries. \(^\text{41}\) Studies had also proved that the protrusion of ON into the sphenoid sinuses as an etiologic factor for optic neuritis, orbital ocular diseases and post-operative complications such as blindness following sphenoid sinus surgeries.\(^\text{42,43,44,45}\)

A study claimed that increased sphenoidal sinuses pneumatization was associated with increasing optic nerve exposure.\(^\text{22}\) Considerably varying rates of prevalence of pneumatisation of ACP with extensive sphenoid sinuses pneumatization had been documented.\(^\text{12, 16, 19,22,25,30,31,37-40}\) The incidence of 23.6% in the present study falls within this reported prevalence range (Table 1). Racial differences in the population studied was proposed as the reason for this differing prevalence rates.\(^\text{37,39}\) Moreover, a study explained that the previous reports of prevalence of ACP pneumatisation which were based on thick-cut CT images might have underestimated the prevalence of this anatomic variant and the author had suggested thin sections CT images for precise observation of pneumatisation around sphenoid sinuses.\(^\text{39}\)

Studies have claimed, pneumatised ACP as an important indicator of ON protrusion into sphenoid sinuses and also its vulnerability to injury during sinus surgeries.\(^\text{22,39}\) Also it was reported that the type 2 or 3 ON was seen frequently associated with ACP pneumatisation.\(^\text{22}\) Even though the result of the present study also shows statistically significant association between ON
protrusion and ACP pneumatisation, it fails to statistically prove which type of ON positional relation is more significant.

The role of ethnicity on variations in anatomy of paranasal region had been reported by few African and Caucasian studies with very limited south Indian reporting.$^{37, 46, 47}$

**CONCLUSION:** The sphenoid sinuses shows positional variations of ON with Type 1 occurring predominantly with varying degrees of bony dehiscence and protrusion into the sinus wall in south Indian population. This variation in anatomical configuration might predispose to complications during sinus surgeries resulting in ON injury. Surgeries involving structures close to ACP necessitates a partial or complete anterior clinoidectomy and the presence of pneumatisation of ACP with its communication to sphenoid or ethmoid sinuses might result in technical difficulties during skull base neurosurgeries. The statistically significant association between protrusion of ON and ACP pneumatisation in south Indian ethnicity in this study proposes a detailed systematic CT bone window evaluation of the sphenoidal sinuses and its adjacent region as a pre surgical requisite for planning and ensuring a safe and efficient paranasal or neurosurgery procedures.

**Study** | **Anterior clinoid process pneumatisation** | **Incidence of bony dehiscence**
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Fujii et al$^4$ | - | 4%
Elwany et al$^{12}$ | 41.9% | 0%
Bademci et al$^{15}$ | - | 7.7%
Unal et al$^{16}$ | 24.1% | 16.9%
Heskova et al$^{19}$ | 26.5% | 11.7%
Delano et al$^{22}$ | 4% | 24%
Kazkayasi et al$^{25}$ | 12.9% | 0.7%
Sirikci et al$^{30}$ | 29.3% | 22.8%
Table 1: Incidence of ACP Pneumatisation and bony dehiscence

| Study            | Incidence Pneumatisation | Incidence bony dehiscence |
|------------------|--------------------------|---------------------------|
| Sapci et al      | 11%                      | 13.5%                     |
| Fasunla et al    | 14.5%                    | -                         |
| Araújo Filho     | 54%                      | 9.1%                      |
| Hewaidi et al    | 15.3%                    | 30.6%                     |
| Lupascu et al    | 10%                      | 5%                        |
| Present study    | 23.6%                    | 2.1%                      |

REFERENCES:

1. Onodi A. The optic nerve and the accessory cavities of the nose. Ann Otol Rhinol Laryngol 1908; 17: 1–61.
2. Schaeffer JP. The Nose, Paranasal Sinuses, Nasolacrimal Passageways, and Olfactory Organs in a Man: A Genetic, Developmental, and Anatomico-physiological Consideration. Philadelphia, Pa: Blakiston’s Son & Co, 1920: 190–193.
3. Peele JC. Unusual anatomical variations of the sphenoid sinuses. Laryngoscope 1957; 67; 208–237.
4. Fujii K, Chambers SM, Rhoton AL. Neurovascular relationships of the sphenoid sinus. J Neurosurg 1979; 50: 31–39.
5. Mafee MF, Chow JM, Meyers R. Functional endoscopic sinus surgery: anatomy, CT screening, indications, and complications. AJR Am J Roentgenol 1993; 160: 735–744.
6. Cheung DK, Attia EL, Kirkpatrick DA, Marcarian B, Wright B. Anatomic and CT scan study of the lateral wall of the sphenoid sinus as related to the transnasal transethmoid endoscopic approach. J Otolaryngol 1993; 22: 63–68.
7. Hudgins PA. Complications of endoscopic sinus surgery. Radiol Clin North Am 1993; 31: 21–32.
8. Önder Turna, Mustafa Devran Aybar, Yeşim Karagöz, Göksel Tuzcu Anatomic Variations of the Paranasal Sinus Region: Evaluation with Multidetector CT İstanbul Med J 2014; 15: 104-9.
9. Levine HL, Clemente MP, Sinus surgery: endoscopic and microscopic approaches, Thieme, New York, 2005, 6–12.
10. Renn WH, Rhoton Jr AL. Microsurgical anatomy of the sellar region. J Neurosurg. 1975; 43: 288-98.
11. Sethi, D. S, Stanley, R. E. & Pillay, P. K. Endoscopic anatomy of sphenoid sinus and sella turcica. J Laryngol. Otol 1995; 109: 951-5.
12. Elwany, S, Elsaeid, I, Thabet, H. Endoscopic anatomy of sphenoid sinus. J. Laryngol. Otol 1999; 113: 122-6.
13. Citardi MJ, Gallivan RP, Batra PS, Maurer CR Jr, Rohlfing T, Roh HJ, Lanza DC. Quantitative computer-aided computed tomography analysis of sphenoid sinus anatomical relationships. Am J Rhinol 2004; 18: 173-178.
14. Batra PS, Citardi MJ, Gallivan RP, Roh HJ, Lanza DC. Software-enabled CT analysis of optic nerve position and paranasal sinus pneumatization patterns. Otolaryngol Head Neck Surg 2004; 131: 940-945.
15. Bademci G, Unal B. Surgical importance of neurovascular relationships of paranasal sinus region. Turkish Neurosurgery 2005; 15(2):93-6.
16. Unal B, Bademci G, Bilgili YK, Batay F, Avci E. Risky Anatomic Variations of Sphenoid Sinus for Surgery. Surg Radiol Anat 2006; 28: 195-201.
17. Tan HK, Ong YK. Sphenoid sinus: An anatomic and endoscopic study in Asian cadavers. Clin Anat 2007; 20: 745-750.
18. Davoodi M, Saki N, Saki G, Rahim F. Anatomical variations of neurovascular structures adjacent sphenoid sinus by using CT scan. Pak J BiolSci 2008; 129(6): 522-5.
19. Heskova G, Mellova Y, Holomanova A, Vybohova D, Kunertova L, Marcekova M, Mello M. Assessment of the relation of the optic nerve to the posterior ethmoid and sphenoid sinuses by computed tomography. Biomed pap Med Fac Univ Palacky Olomouc, Czech Repub 2009; 153: 149-152.
20. Suresh Sukumar, Sushil Yadav. Study on Sphenoid Sinuses Variants in Magnetic Resonance Imaging of South Indian Population international jounal of scientific research 2012; 1(2): 147-148.
21. SarteenD, Agarwal AK, Kaul J M & Sethi A. Study of sphenoid sinus anatomy in relation to endoscopic surgery. Int. J. Morphol 2005; 23(3): 261-266.
22. DeLano MC, Fun FY, Zinreich SJ. Relationship of the optic nerve to the posterior paranasal sinuses: a CT anatomic study. AJNR Am J Neuroradiol 1996; 17(4): 669-75.
23. Jho HD, Carrau RL. Endoscopic endonasal transsphenoidal surgery: Experience with 50 patients. J Neurosurg 1997; 87: 44-51.
24. Rhoton Jr AL. The sellar region. Neurosurgery 2002; 51: 335-74.
25. Kazkayasi M, Karadeniz Y, Arikan OK, Anatomic variations of the sphenoid sinus on computed tomography, Rhinology 2005, 43(2): 109–114.
26. Gupta AK, Bansal S, Sahini. Anatomy and its variation for endoscopic sinus surgery. Clin.Rhinol An Int J 2012; 5(2): 55-62.
27. Climelli D. Contributo alla morfologia del seno sfenoidale,Oto-rino-laringol Ital, 1939, 9: 81–86.
28. Vidić B. The postnatal development of the sphenoidal sinus and its spread into the dorsum sellae and posterior clinoid processes, Am J Roentgenol Radium Ther Nucl Med, 1968, 104(1): 177–183.
29. Bolger WE, Butzin CA, Parsons DS. Paranasal sinus bony anatomic variations and mucosal abnormalities: CT analysis for endoscopic sinus surgery. Laryngoscope 1991; 101(1 Pt 1): 56-64.
30. Sirikci A, Bayazit YA, Bayram M, Mumbuç S, Güngör K, Kanlikama M. Variations of sphenoid and related structures, Eur Radiol 2000; 10(5): 844–848.
31. Sapçi T, Derin E, Almaç S, Cumali R, Saydam B, Karavuş M. The relationship between the sphenoid and the posterior ethmoid sinuses and the optic nerves in Turkish patients, Rhinology 2004; 42(1): 30–34.
32. Birsen U, Gulsah B, Yasemin K, et al. Risky anatomic variations of sphenoid sinus for surgery. Surg Radiol Anat 2006; 28: 195-201.
33. Mikami T, Minamida Y, Koyanagi I, Baba T, Yamashita T, Houkin K. Anatomical variations in pneumatization of the anterior clinoid process Neurosurg 2007; 106: 170–174.
34. Wang J, Bidari S, Inoue K, Yang H, Rhoton A Jr. Extensions of the sphenoid sinus: a new classification. Neurosurgery 2010; 66: 797-816.
35. Ciobanu IC, Motoc A, Jianu AM, Cergan R, Banu MA, Rusu MC. The maxillary recess of the sphenoid sinus, Rom J Morphol Embryol, 2009, 50(3): 487–489.
36. V. Budu, carmen aurelia mogoantă, b. Fănăță, I. Bulescu. The anatomical relations of the sphenoid sinus and their implications in sphenoid endoscopic surgery Rom J Morphol Embryol 2013, 54(1): 13 16.
37. A.J. Fasunla, S.A. Ameye, O.S. Adebola, G. Ogbole, A.O. Adeleye, A.J. Adekanmi. Anatomical Variations of the Sphenoid Sinus and Nearby Neurovascular Structures Seen on Computed Tomography of Black Africans. East and central African journal of surgery 2012, 17(1): 57-64.
38. Araújo Filho BC, Neto CP, Weber R & Voegels RL. Sphenoid sinus symmetry and differences between sexes. Rhinology 2008; 46(3): 195-199.
39. Hewaidi GH, Omami GM. Anatomic Variation of Sphenoid sinus and Related Structures in Libyan population: CT Scan Study. Libyan J Med 2008; AOP: 080307, Vol. 3, No.: 3: 128-133.
40. Lapascu M, Comsa GH, Zainea V. anatomical variations of the sphenoid sinus-a study of 200 cases.ARS Medica Tomitana 2014; 2(77): 57-62.
41. Stammberger H, & Kopp W. In: Functional Endoscopic Sinus Surgery: The Messerklinger Technique 1991; 210: 67-8.
42. Mellinger WJ. Optic nerves and their relations in the sphenoidal region. Tr. Pacific Coast Oto-Ophth Soc 1937; 22: 85.
43. Tunis JP. Sphenoidal sinusitis in relation to optic neuritis. Laryngoscope 1912; 22: 1157-1164.
44. Blum ME, Larson A. Mucocele of the sphenoidal sinus with sudden blindness. Laryngoscope 1973; 83: 2024-2049.
45. Maniglia AJ. Fatal and Major Complications Secondary to Nasal and Sinus Surgery. Laryngoscope 1989; 99: 276-283.
46. Badia L, Lund VJ, Wei W, Ho WK. Ethnic variation in sinonasal anatomy on CT-scanning. Rhinology 2005; 43: 210-214.
47. Idowu OE, Balogun BO, Okoli CA. Dimensions, Septation, and Pattern of Pneumatization of the Sphenoidal Sinus. Folia Morphol (Warsz) 2009; 68: 228-232.
Figure 1: Showing sphenoidal sinus (SS) and its relations; FR - foramen rotandum, VC - vidian canal

Figure 2: Yellow arrow showing Type - 1 position of optic nerve

Figure 3: Yellow arrow showing Type - 2 position of optic nerve
Figure 4: Yellow arrow showing Type - 3 position of optic nerve with bony dehiscence (DH) on the left.

Figure 5: Yellow arrow showing Type - 4 position of optic nerve in relation to posterior ethmoidal (PE) air cells.

Figure 6: Red arrows showing anterior ethmoid processes with unilateral pneumatization (P) on left side.
Figure 7: Red arrows showing anterior clinoid processes with bilateral pneumatisation (P)

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