Variant septation of the sphenoid sinus in adult Nigerians: CT study

Beryl Ominde[1], Joyce Ikubor[2], Wilson Iju[1], Patrick Igbigbi[1]

[1] Department of Human Anatomy and Cell Biology, Delta State University, Abraka, Nigeria
[2] Department of Radiology, Delta State University Teaching Hospital, Oghara, Nigeria

SUMMARY

Preoperative evaluation of the sphenoid sinus septa is mandatory for safe endoscopic endonasal transsphenoidal surgery. This study aimed at elucidating the variant septation of the sphenoid sinus using computed tomographic images of adult patients. This observational study retrospectively evaluated 336 brain Computed Tomographic images of adult patients seen in a Nigerian Teaching Hospital. The study was approved by the Research Committee of the Hospital. The presence, number, location and attachment of the sphenoid sinus septum were studied and recorded. Statistical Package for Social Sciences version 23 was used to analyze the prevalence of the variants and compare them based on gender and side using the Chi-square test. The level of significance was considered at $p<0.05$.

The prevalence of a single complete septum was 179 (53.3%), while double and multiple septa had a frequency of 88 (26.2%) and 69 (20.5%) respectively. The complete septum was predominantly located in the paramedian position (185, 69.3%). The septa attached onto the carotid canal and optic canal in 91 (27.1%) and 46 (13.7%) patients respectively. The multiple and double septa had a high predilection for the carotid (52, 75.4%) and optic (32, 36.4%) canal insertions respectively. These patterns of septation did not show any significant relationship with gender or side ($P>0.05$). The single septum was the most prevalent and frequent in the paramedian location, while multiple and double septa commonly insert onto the carotid and optic channels respectively.

Key words: Sphenoid – Sinus – Septum – Canal – Surgery

INTRODUCTION

The sphenoid sinus (SS) has been described as the most surgically inaccessible sinus, owing to its deep location in the base of the skull (Singh et al., 2019). It is the first paranasal sinus to develop from the third to the fourth month of intrauterine life (Ominde et al., 2021). From birth to three years of age, it exists as a pit in the sphenoethmoidal recess (Degaga et al., 2020; Singh et al., 2022). Thereafter, pneumatization begins and proceeds posteriorly, leading to a visible definitive cavity at puberty (Fasunla et al., 2012; Wani et al., 2019). The sinus continues to expand with age, following the growth of the sphenoid bone. With advancing age, resorption of its bony walls causes further SS expansion (Kusch and Garcia, 2019).

Corresponding author:
Beryl S. Ominde. Department of Human Anatomy, Delta State University, P.M.B. 1, Abraka, Nigeria. Phone: +2347085458946. E-mail: berylominde@gmail.com

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The variant patterns of development and pneumatization of the SS have led to asymmetry in its shape, size, and septation (Wani et al., 2019). The varying aeration consequently contributes to the differences in number and locality of SS septa over and above the inconsistent position of the optic canal that houses the optic nerve and the carotid canal containing the internal carotid artery (ICA) (Ominde et al., 2021). The complete intersinus septum divides the SS into asymmetric compartments, while the incomplete intrasinus/ partial septa are within the sinus but do not divide it completely (Kusch and Garcia, 2019; Singh et al., 2022). The partial septa are a result of resistant pneumatization at the sites of fusion between various bone ossification centers (Ngubane et al., 2018). The SS septa may insert onto the neighbouring ICA canal or optic nerve canal (Secchi et al., 2018; Ismail et al., 2018). Studies in literature have documented the variation in the number, location and attachment of the SS septa in various populations (Famurewa et al., 2018; Wani et al., 2019; Degaga et al., 2020; Dziedzic et al., 2020; Singh et al., 2022;).

The SS serves as a surgical corridor in accessing the structures in the middle and posterior cranial fossa (Singh et al., 2022). Endoscopic endonasal transsphenoidal surgery is indicated in tumors within the sellar, suprasellar, and parasellar regions (Aksoy et al., 2017). During surgery, excessive traction on the septa may cause avulsion of ICA and optic canals, consequently damaging the neurovascular structures (Singh et al., 2019). The awareness of the number and locality of the SS septa is therefore mandatory preoperatively to minimize surgical complications. Computed Tomography (CT) is the imaging modality of choice for assessing the variant complex anatomical framework of the SS, in addition to the presence and extent of sinus disease (Secchi et al., 2018; Ominde and Igbigbi, 2021; Arutperumselvi et al., 2022). This study, therefore, aimed at elucidating the variant septation of the SS in adult patients who underwent CT imaging in a Teaching Hospital in Delta State, Nigeria.

MATERIALS AND METHODS

This research adopted the retrospective cross-sectional design of descriptive nature. Using purposive sampling technique, brain CT images of 336 patients with suspected intracranial tumors or bleeds and chronic headache, who presented to the Radiology Department of a Teaching Hospital within a duration of five years, spanning between 1 June 2015 and 30June 2020 were selected. These non-contrast brain CT studies were conducted using a 64-slice CT scanner (Toshiba Aquilon, Japan, 2009) and stored in the archives of the Department. The settings for image acquisition was at 120 kV and 300 mA in 3 mm thick axial CT slices. According to the protocol adopted by the Department, the axial slices were taken from the base of the skull to the vertex, to ensure the inclusion of the paranasal sinuses, which are also evaluated for incidental sinusitis in patients with a history of headache. Ethical approval was granted (EREC/PAN/2020/030/0371) by the institutions Research Committee prior to accessing the images. Images with adequate exposure, symmetry, and specified age and gender of the patient were used. The study included images of adults aged 20 years and above, owing to the fact that the SS reaches its adult size at 20 years (Ominde et al., 2021). We excluded all the images of patients below 20 years, images with visible craniofacial fractures and congenital anomalies, presence of sinonasal tumors, cysts or infection and evidence of previous sinus surgery or skull base surgery.

Using a slice thickness of 1.5mm and table increment of 1.5mm as the reconstruction parameters, the axial CT slices were reformatted into multiplanar coronal and sagittal sections. All the three views were displayed on bone window to allow accurate evaluation of the variant SS septa. The presence, number, and location of septa in addition to the attachment of the septa onto the carotid and optic canals on each side were assessed. A septum running from one wall of the SS to another and fully compartmentalizing it was regarded as a complete septum. In addition, a septum located within the sinus but failing to completely divide the SS was referred to as a partial septum (Kusch and Garcia, 2019). Data were recorded on datasheets and transferred to Statistical Package for Social Sciences (SPSS), version 23 (IBM® Armonk, New York), for analysis. The data were grouped based on side and gender.

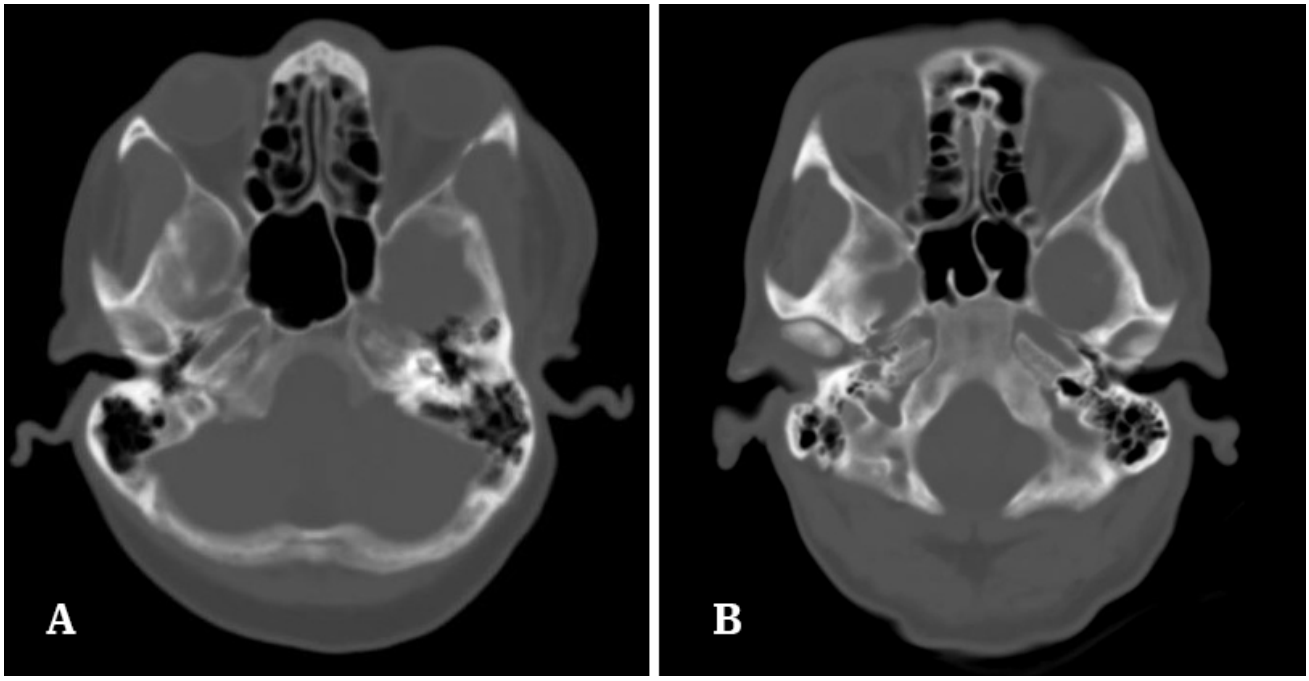

Fig. 1.- Axial CT images depicting the SS septa. **A**: single complete septum located paramedian **B**: Single complete septum with partial septa projecting in the sphenoid sinus bilaterally.

The prevalence of the variants was summarized in percentages based on the groupings. Thereafter, group comparisons were assessed using the Chi-square test, and these were considered significant at $p < 0.05$.

RESULTS

The study used 199 (59.2%) males and 137 (40.8%) females with a mean age of53.29±18.18 years. All the CT images evaluated had at least one sphenoid sinus septum present. The prevalence of a single complete septum was 179 (53.3%) (Fig. 1A). Double septa (comprising one complete and one partial septum) were observed in 88 (26.2%) patients. The remaining 69 patients (20.5%) had multiple septa comprising a single complete septum and ≥2 incomplete septa (Fig. 1B). The number of SS septa had no significant association with gender (P>0.05) (Table 1).

The single complete septum predominantly had a paramedian location (185, 69.3%), while a midline location of the intersphenoid septum was observed in 82 (30.7%) patients. The partial septa were more preponderant within the right SS (88, 56.1%) than the left (69, 43.9%) SS. However, this was not statistically significant (p=0.063).

The attachment of the SS septum onto the carotid canal was observed in 91 patients (27.1%), and commonly occurring unilaterally (62, 18.5%) than bilaterally (29, 8.6%) (Fig. 2A). The unilateral occurrence was higher on the right (42, 12.5%) than on the left (20, 6%) carotid canal. The insertion of the septa onto the optic canal occurred only unilaterally (46, 13.7%) with

Table 1. Number of sphenoid septa based on gender.

Number of septa	Total		Female		Male		P value
	N	%	N	%	N	%	
Single	179	53.3	76	55.5	103	51.8	0.504
Double	88	26.2	32	23.4	56	28.1	0.421
Multiple	69	20.5	29	21.2	40	20.1	0.381
Total	336		137		199		

a higher preponderance on the right (29, 8.6%) than the left (17, 5.1%) optic canal (Fig. 2B). The insertion of the septa onto the optic and ICA canals had no association with side or gender (P>0.05) (Table 2). Table 3 shows the prevalence of septal attachment onto the optic and carotid canals in different study populations. In the evaluation of the patients with SS septa, the prevalence of the septa attaching to the carotid canal was highest in patients with multiple septa (52, 75.4%), followed by double septa (33, 37.5%), and lastly single septum (6, 3.4%). On the other hand, optic canal insertions were predominant in patients with double septa (32, 36.4%), followed by multiple septa (13, 18.8%). Out of the 179 patients with a single SS septum, insertion onto the optic canal was only observed in one patient (0.6%).

DISCUSSION

A single complete inter-sphenoid septum was observed in 53.3% of cases, and this corresponded with the findings of Arutperumselvi et al. (2022) in India. This frequency was lower than 88.2% and higher than 46.9%, documented in previous Nigerian studies in Oyo and the Osun States respectively (Fasunla et al., 2012; Famurewa et al., 2018). Higher frequencies were documented in Ethiopia, India, Poland, and Belgium (Ismail et al., 2018; Wani et al., 2019; Degaga et al., 2020; Dziedzic et al., 2020). Double septa comprising

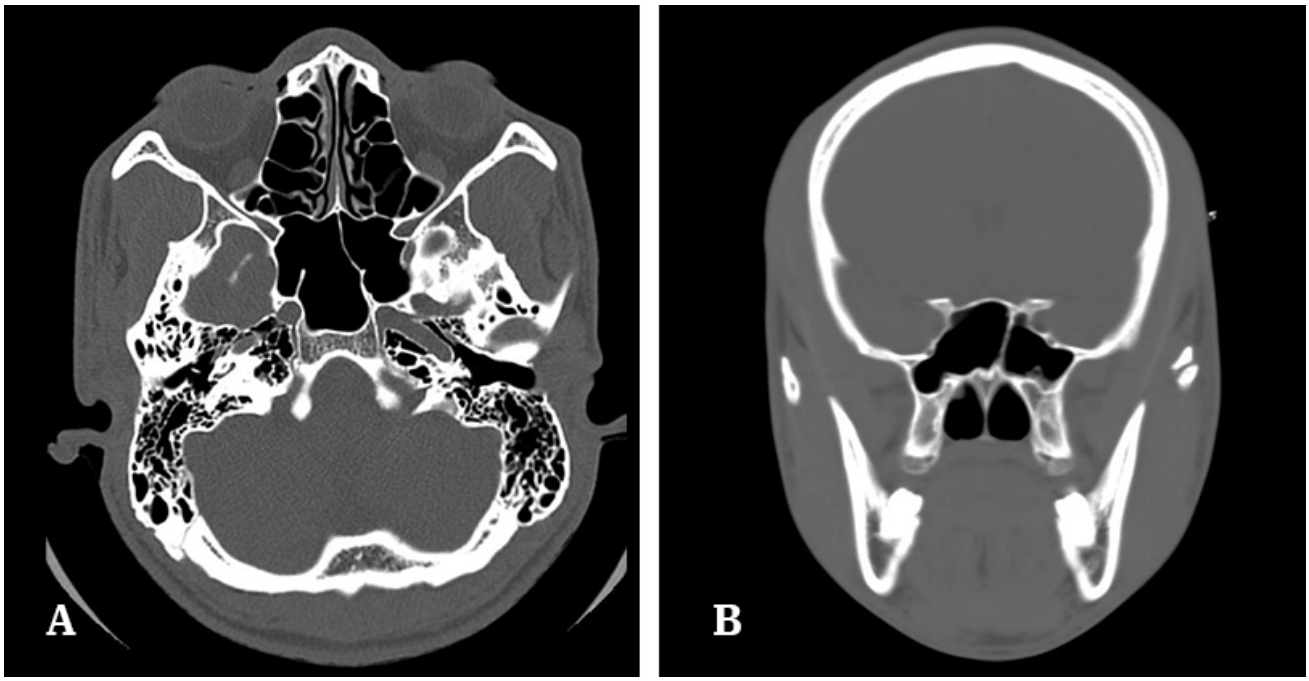

Fig. 2.- Axial CT images showing the sphenoid sinus septa attaching on: **A**: ICA canal bilaterally. **B**: left optic canal.

Table 2. Attachment of the sphenoid septa on to the carotid and optic canals.

Canal	Side	Total		Female		Male		*P value
		N	%	N	%	N	%	
Carotid	Right	71	21.1	28	20.4	43	21.6	0.796
	Left	49	14.6	23	16.8	26	13.1	0.342
	¶P value			0.184		0.149		
Optic	Right	29	8.6	12	8.8	17	8.5	0.945
	Left	17	5.1	4	2.9	13	6.5	0.138
	¶P value			0.247		0.396		

¶ P value for the side differences, * P value for gender differences

Table 3. Attachment of the SS septa onto the optic and carotid canals in different studies.

Author	Country	N	CT slice thickness	Septum attachment (%)	
				Carotid canal	Optic canal
Singh et al. (2022)	India	84	1 mm	29.7	27.4
Fasunla et al. (2012)	Nigeria	110	3 mm	4.5	
Wani et al. (2019)	India	591		Right 6.5 Left 23	0.4
Famurewa et al. (2018)	Nigeria	320	2.5 mm	31.6	
Aksoy et al. (2017)	Turkey	347	3 mm	47.7	17.5
Arutperumselvi et al. (2022)	India	100		20	
Joghataei et al. (2019)	Iran	129		76	
Sumaily et al. (2018)	Saudi Arabia	420	1 mm	16.4	29.4
Current study	Nigeria	336	3 mm	27.1	13.7

one complete and one incomplete septum were observed in 26.2% of cases, and this was higher than reports by Fasunla et al. (2012) and Wani et al. (2019) and lower than the 32% documented by Dziedzic et al. (2020). We observed multiple septa (single complete with ≥2 partial septa) in 20.5% of the patients, and this was lower than the frequency among the Nigerians of Osun State (Famurewa et al., 2018). Furthermore, this frequency was higher than the findings in India, but lower than the reports from Turkey (Aksoy et al., 2017; Wani et al., 2019). The awareness of multiple SS septa is important, since they are commonly seen in acromegaly (Dziedzic et al., 2020). Akin to Aksoy et al., (2017), we did not observe the absence of SS septa. This was contrary to Gibelli et al. (2019), Dziedzic et al. (2020), and Degaga et al. (2020), who documented the absence of SS septa in 21.9%, 2%, and 1% of their studied population respectively.

The location of the single complete septum was predominantly paramedian (69.3%). This was consistent with the reports by Ismail et al. (2018), and contrasted with Famurewa et al. (2018). According to Dziedzic et al. (2020), the low occurrence of the single midline septum infers that another midline anatomical landmark is required during transsphenoidal procedures. The frequency of the incomplete septa was not significantly associated with side of the sinus location. This was conflicting with the findings in Osun State, where the partial septa were predominantly on the left (Famurewa et al., 2018). Similar to the reports by Wani et al. (2019), the number and position of the SS septa were not influenced by gender. Therefore, their variance in the literature could be accredited to differences in genetics, ethnicity, race, environmental and geographical factors which influence the pneumatization patterns of the SS and ethmoid sinuses (Ominde et al., 2021). The awareness of the number of SS septa and their location is essential preoperatively to inform on the possible surgical challenges hence plan for a safe surgical route and technique.

The presence of SS septa attaching onto the carotid canal was observed in 27.1% of the skull images, and with a more frequent unilateral than bilateral occurrence. This prevalence was comparable to 29.7% documented by Singh et al. (2019). Our finding was lower than the 31.6% and higher than the 4.5% documented in previous Nigerian studies (Fasunla et al., 2012; Famurewa et al., 2018). Additionally, higher frequencies have been documented by Aksoy et al. (2017), Joghataei et al. (2019), and Dziedzic et al. (2020), while Dafalla et al. (2017) and Arutperumselvi et al. (2022) reported lower frequencies. Insertion onto bilateral carotid canals was observed in 8.6% of cases and this was slightly higher than the 6.9% and lower than the 14% reported by Famurewa et al. (2018) and Dziedzic et al. (2020), correspondingly.

The frequency of the septum inserting onto the wall of the optic canal (13.7%) was higher than the

observations by Wani et al. (2019) and Gibelli et al. (2019). On the contrary, higher frequencies in Saudi Arabia and India have been reported (Aksoy et al., 2017; Sumaily et al., 2018; Singh et al., 2019). Parallel to the documented reports by Wani et al. (2019), gender had no association with the insertion of SS septa onto the neurovascular canals. The variance in literature could be ascribed to race, ethnicity, genetics besides dissimilarities in the sample size and CT slice thickness used in evaluating the sinuses (Table 3).

Our study reports a higher tendency of the multiple septa to be inserted on to the carotid canal (75.4%), while the double septa are associated with a higher propensity for optic canal insertion. Similarly, Dziedzic et al. (2020) documented that multiple septa of the SS have a high tendency to insert onto the ICA canal. We further observed that the single septum rarely inserts onto the neurovascular canals. From these findings, this study suggests that, after the radiological evaluation for the number of SS septa, it is imperative to evaluate for their possible insertions to the optic and carotid canal preoperatively.

The awareness of the SS septa inserting onto neurovascular canals is important before endoscopic transnasal sphenoidal surgery to avoid excessive traction on the septum during neuro-navigation (Singh et al., 2019). Such septa require removal via drilling rather than fracture (Dziedzic et al., 2020). Avulsion of the bone that forms the canal wall may rupture the ICA, leading to massive bleeding which may be fatal. This is because the complex anatomy and deep location of the SS make it difficult to control the bleeding from the adjacent ICA. Subsequently, this causes retrobulbar hematoma with acute proptosis (Ominde and Igbigbi, 2021). It is recommended that the septum attaching on the ICA canal be drilled at high speed, parallel to the ICA course to avoid its injury (Dziedzic et al., 2020). Injury of the optic nerve by an avulsed SS septum may lead to blindness (Dafalla et al., 2017).

CONCLUSION

The single septum was the most prevalent and frequent in the paramedian location, while multiple and double septa commonly insert onto the carotid and optic channels respectively.

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