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Surgical Anatomy of Variations in Sphenoid Sinus Pneumatisation using Computerized Tomography

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Abstract

Background: The cavity of the sphenoid sinus is a natural surgical route for accessing the middle cranial fossa. The extent of pneumatisation of the sphenoid is key to the preoperative evaluation of transsphenoidal, surgical procedures.

Aim: To determine the prevalence and variations in the extent of pneumatisation of the body of the sphenoid bone using computerised tomography (CT).

Methodology: Head CT scans of 323 patients were studied at the Radiology Department of the Usmanu Danfodiyo University Teaching Hospital, Sokoto, after ethical approval was granted. The CT scans were taken with a GE Bright Speed Multidetector Helical CT Scanner, and viewed with the Digital Imaging and Communication in Medicine (DICOM) viewer, powered by RadiAnt Version 4.2 software. Sphenoid sinus pneumatisation was defined by the anteroposterior extent of the sinus cavity of the sphenoid bone on sagittal images. The extent of pneumatisation was classified into four; conchal, presellar, sellar and postsellar, based on the position of the posterior wall of the cavity in relation to the anterior and posterior walls of the sellar turcica.

Results: The predominant type of pneumatisation was the postsellar. The prevalence of the different types of pneumatisation were: postsellar, 50.2%, sellar, 32.0%, presellar, 14.7%, and conchal, 3.1%. There was no statistically significant relationship between pneumatisation and sex ($X^2 = 0.585$), or age ($X^2 = 0.076$).

Conclusion: With the prevalence of the different types of pneumatisation, a pre-operative CT assessment of the sphenoid sinus anatomy is essential, whenever the options for a transsphenoidal access to the sellar is being contemplated.

Key words: Sphenoid, Anatomy, Variations, Pneumatisation, Surgery

Introduction

Pneumatisation is the most significant characteristic of the body of the sphenoid bone, such that, the expression of other sinus features, depends on it (1-3). The extent of pneumatisation of the sphenoid sinus is of critical preoperative concern to neuro surgeons and otolaryngologists, while determining an adequate transsphenoidal access to the base of the brain (4). Pneumatisation of the body of the sphenoid bone begins in the second or third year after birth, in a posterolateral direction, extending to, but not exceeding the spheno-occipital synchondrosis in the adult sinus (1,2). The sinus attains adult sizes at about 14 - 18 years, with slight increases resulting from absorption of the sinus walls with advancing age (1,2,4). Absence of pneumatisation by the tenth year after birth, is an evidence of a possible sphenoid sinus pathology (5). Although, sphenoid sinus agenesis is exceptionally uncommon (3), it is more frequently found in patients with craniofacial anomalies due to less well-developed paranasal sinuses (6, 7).

The emergence of endoscopic skull base surgery as a conventional surgical procedure, led to the need to obtain detailed information about the anatomy and variations in the extent of pneumatization of the sphenoid sinus (8). Notwithstanding the route of access to the pituitary gland and the surrounding base of the brain, the endoscopic method eventually involves trespassing the sphenoid sinus (4,9,10). Therefore, a detailed knowledge of the anatomical variations of the sphenoid sinus pneumatization could have a major influence on the surgical approach, survival of the patients and the chances of complications, when performing endoscopic sinus surgery for optic nerve decompression, pituitary hypophysectomy and management of diseases affecting structures in the neighbourhood of the sellar turcica (4,9). The trans-sphenoidal access is considered the standard endoscopic surgical approach to the base of the brain and the pituitary gland, when all other conditions are adequate (10,11). In addition, the trans-sphenoidal route is quicker, safer, less traumatic, presents an exceptional visualization of the pituitary gland and related structures, circumvents brain retraction, and reduces morbidity and mortality associated with brain base surgeries when compared with the transcranial route (4,10-12). In the prevailing circumstances, computed tomography (CT), is a valuable imaging technology, widely available for the assessment of sinus anatomy, via three-dimensional structural evaluation, with production of thin and multislice CT technology, submillimetre resolutions, multiplaner and volumetric recon-

struction with improved patient's comfort, and a reduction in radiation concerns (13-15).

Among Nigerians and Africans, there is a general paucity of CT based data, for a comprehensive and robust assessment of the sphenoid sinus to facilitate trouble-free transsphenoidal access to the base of the brain. Therefore, CT scan assessment of minute details of the sinus anatomy and variations in its extent of pneumatization will enable the surgeon to conclude on the most appropriate route to the brain base, in order to control and/or prevent post-surgical complications. The aim of this study, was to determine the prevalence and variations in the extent of pneumatisation of the body of the sphenoid bone among Nigerian adults, by means of a high-resolution CT scan, and an insight into their surgical anatomy.

Materials and Methods

Sphenoid sinus CT scans of 323 adult patients (age range, 18 - 80 years), taken over a period of five years (November 2014 - October 2019), were retrospectively studied at the Radiology Department of the Usmanu Danfodiyo University Teaching Hospital, Sokoto, after approval was granted by the institutional ethical committee. The head CT scans were obtained from the local data base and backed up external storage discs from the CT library. The images were taken with a GE Bright Speed Multidetector Helical CT (GE Healthcare, U.S.A, 2005) Scanner, at 200 mAs, 120 KVp, 15 cm Field of View, slice thickness of 2.5 mm, 512 X 512 matrix and a standard reconstruction algorithm. CT images of patients less than 18 years, those with evidence of sinus disease, craniofacial anomalies, skull base trauma and intracranial tumours that affect the normal anatomy of the sphenoid sinus, were excluded from this study. The images were viewed on the computer aided Digital Imaging and Communication in Medicine (DICOM) viewer, powered by the RadiAnt Version 4.2 software. The sphenoid sinus pneumatisation was defined by the anteroposterior extent of the cavity within the body of the sphenoid bone on sagittal CT images as previously described (16). The extent of pneumatisation of the sphenoid was classified into four; conchal, presellar, sellar and postsellar. This classification, was based on the position of the posterior wall of the cavity of the sphenoid sinus in relation to the anterior and posterior walls of the sellar turcica (16). For conchal pneumatisation, the posterior wall of the sphenoid sinus was anterior to, and separated from the anterior wall of the sellar turcica by an approximately 10 mm len gth of bone thickness (Figure 1). In presellar pneumatisation, the posterior sinus wall was just anterior to the anterior wall of the sellar turcica (Figure 2). The posterior wall of the sphenoid sinus was between the anterior and posterior walls of the sellar turcica in sellar pneumatisation (Figure 3), while in post sellar pneumatisation, the posterior sinus wall was located behind the posterior wall of the sellar turcica, in proximity with the clivus of the occipital bone (Figure 4).

Statistical analysis

Data was tabulated in Microsoft Excel Spreadsheet. IBM SPSS Statistics Version 22 software was used for data analysis, One-way analysis of variance (ANOVA), was used to compare mean values, while proportions were compared using chi-square test. P- value of less than 0.05 ($p < 0.05$) was considered to be statistically significant.

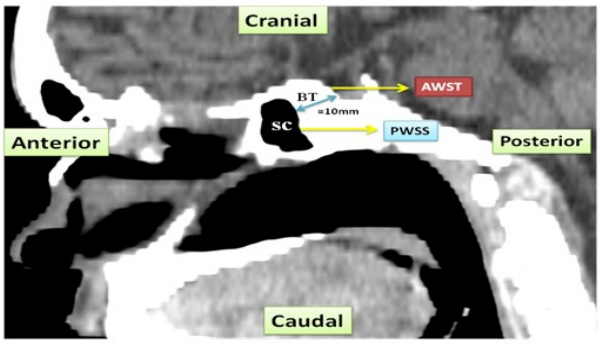

Figure 1: A sagittal CT slide of sphenoid sinus of a 78-year-old female demonstrating the conchal type of pneumatisation. BT = Bone Thickness (> or = 10mm), AWST = Anterior Wall of Sellar Turcica, PWSS = Posterior Wall of Sphenoid Sinus, SC = Sinus Cavity

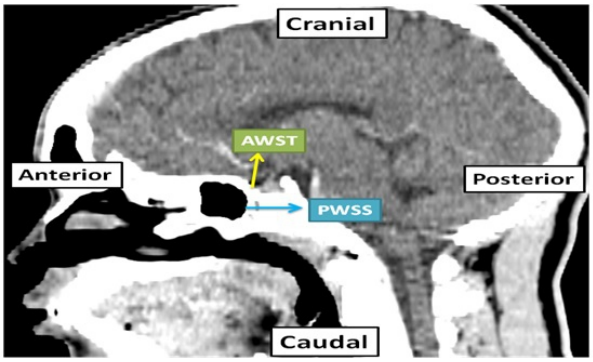

Figure 2: A sagittal CT slide of sphenoid sinus of a 42-year-old male showing presellar pneumatisation. AWST = Anterior Wall of Sellar Turcica, PWSS = Posterior Wall of Sphenoid Sinus

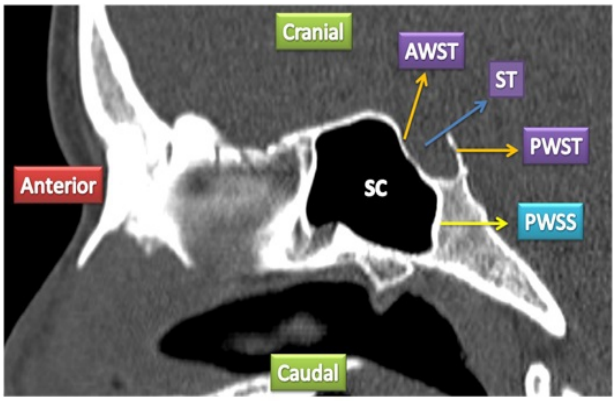

Figure 3: A sagittal CT slide of sphenoid sinus of a 23 year old female showing sellar pneumatisation. AWST = Anterior Wall of Sellar Turcica, ST = Sellar Turcica, PWST = Posterior Wall of Sellar Turcica, PWSS = Posterior Wall of Sphenoid Sinus, SC = Sinus Cavity

Results

Prevalence of the different types of pneumatisation.

In this study, all known types of pneumatisation were present. The most common was the postsellar type, while the least common, was the conchal pneumatisation. The prevalence of the different

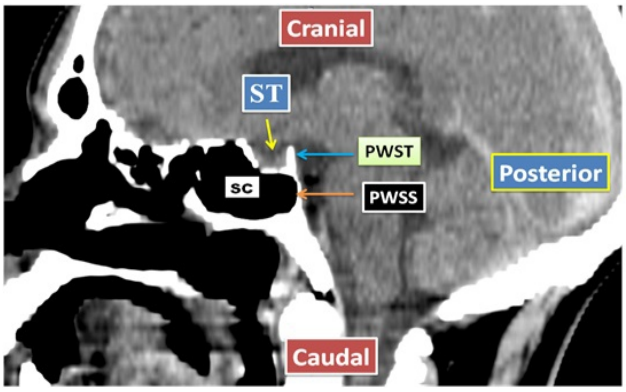

Figure 4: A sagittal CT Slide of Sphenoid Sinus of a 67year old female Showing Postsellar Pneumatisation. ST = Sellar Turcica, PWST = Posterior Wall of Sellar Turcica, PWSS = Posterior Wall of Sphenoid Sinus, SC = Sinus Cavity

types of pneumatisation are shown in Figure 5, and are as follows; postsellar, 50.2%, (162 subjects), sellar, 32.0%, (103 subjects), presellar, 14.7%, (48 subjects), and conchal, 3.1% (10 subjects).

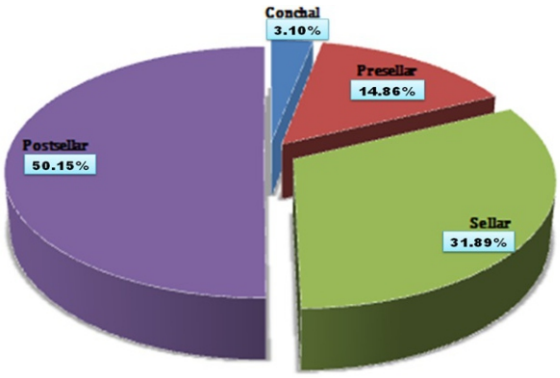

Figure 5: Prevalence's of the different types of pneumatisation of the sphenoid sinus of subjects used in this study

Table 1: Relationship between classification of the extent of pneumatisation of the sphenoid body and age group of subjects

Age groups (Years)	No. of subjects	Type of Pneumatization			
		Conchal (%)	Presellar (%)	Sellar (%)	Postsellar (%)
18 – 26	88	5 (5.68)	11 (12.50)	38 (43.18)	33 (37.50)
27 – 35	58	2 (3.45)	12 (20.69)	18 (30.03)	26 (29.55)
36 – 44	40	1 (2.50)	5 (12.50)	16 (40.00)	18 (45.00)
45 – 53	50	1 (2.00)	10 (20.0)	10 (20.00)	30 (60.00)
54 – 62	36	1 (2.78)	5 (13.89)	6 (16.67)	24 (66.67)
63 - 71	31	0 (0.00)	4 (12.90)	10 (32.26)	17 (54.84)
72 - 80	20	0 (0.00)	1 (5.00)	5 (25.00)	14 (70.00)
Total	323	10 (3.10)	48 (14.86)	103 (31.89)	162 (50.15)

$X^2 = 0.076$, df = 18. Data are expressed as Number (%) of the classes of pneumatisation across the different age groups.

The relationship between type of pneumatisation and age is presented in Table 2. There was no statistically significant relationship between the type of pneumatisation and age ($X^2 = 0.076$, Table 1), or sex ($X^2 = 0.585$).

Table 2: Relationship between the extent of pneumatisation of the sphenoid body and sex of subjects

Sex of Subjects	No. of Subjects	Type of Pneumatisation			
		Conchal (%)	Presellar (%)	Sellar (%)	Postsellar (%)
Males	216	7 (3.24)	32 (14.81)	74 (34.26)	103 (47.69)
Female	107	3 (2.80)	16 (14.95)	29 (27.10)	59 (55.14)
Total	323	10 (3.10)	48 (14.86)	103 (31.89)	162 (50.15)

$X^2 = 0.585$, df = 3. Data are expressed as Number (%) of the classes of pneumatisation between males and females.

Discussion

In conchal pneumatisation, the body of the sphenoid bone is poorly pneumatised. Transsphenoidal access to the sellar turcica is considered unfavourable and to some, it is a contraindication (17). However, in developed health centres with high definition intraoperative navigational or fluoroscopic imaging, and focused proficiency in endoscopic sinus surgery, poorly pneumatized sphenoid sinus, especially among the paediatric age group is no longer a contraindication for safe transpshenoidal access (18,19). Nevertheless, information from pre-operative CT assess ment of the sinus anatomy has prompted the application of these modifications as alternative approaches to safely circumvent obvious surgical difficulties (20). In addition, the size of the tumor also plays a significant role in determining the route of access, as such, for a safe and complete resection of larger tumors, the transcranial route could be considered (18,19, 20).

In this study, while conchal pneumatisation was the least common, 3.10%, it was higher than the prevalence range of 1.6% to 2.5%, reported in several studies (4,12,21,22,23). This population will therefore require careful planning of a transsphenoidal access to evade anticipated problems. In selected cases, drilling through the sphenoid bone, in patients with conchal pneumatization, in order to access and expose the sellar and parasellar regions is feasible. This is however, associated with increase in operating time, bleeding from the marrow, as well as a narrow operating field. This has also necessitated the use of a diamond burr embedded with provisions for thermocoagulation (18,24,25).

No conchal pneumatisation was identified in studies involving Americans in Gainesville, Florida (16,26), Nigerians in the southwest (27), and Port Harcourt and Yenagoa (28). Among a population Chinese subjects, Lu (29), found a 16%, and Kuan (25), reported a 37% prevalence of conchal pneumatisation. With postsellar pneumatisation, the possibility of a hyper-pneumatized sinus exists (4). This is usually associated with inherent thinning of the irregular bony floor of the middle cranial fossa, and the absence of an obvious prominence, produced by the sellar bulge (4). This increases the chances of inadvertent injury, with perforation of the cranial floor or the posterior wall, resulting in leakage of cerebrospinal fluid (30). In order to prevent this, the surgeon should proceed with caution, by avoiding excessive dissection, and restricting the operation field to known average diameters of sinus dimensions for such populations. This is achieved by keeping to the midline as much as possible, while approaching the sellar. This can be achieved further, by keeping an eye on the inferior attachment of the sinus septum to the sinus floor, the rostrum, vomer on the lower part, just below the base of the sphenoid, and in selected cases, employ the C-arm fluoroscope intraoperatively (4,30). Except the surgeon is well guided, the large area provided by a postsellar

pneumatisation may sometimes be misleading as having suff icient amount of operating field, until an unanticipated injury occurs. Postsellar pneumatisation is the most common type of pneumatisation in the current study. This is similar to the prevalence of 80% (27), at Ile - Ife, Osun state, Nigeria, then, among Hispanics and Caucasians, with 48.2% and 56%, respectively (12), 54% according to (16), and 57% (23). Postsellar pneumatisation was not seen in a study involving 30 cadavers (31), or among Chinese in Guangdong (29), in Pennsylvania, (21), and among Egyptians (32). Moreover, no prevalence of postsellar pneumatisation was reported in other studies (22,28). Sellar and presellar forms of pneumatisation are characterised by fewer surgical peculiarities when compared with the conchal and postsellar extremes (4,10,17). However, sellar pneumatisation, unlike in this study, was the predominant type of pneumatisation in previous studies (4,12,21,22,28-35). The prevalence of presellar pneumatisation from the current study (14.86%), fell within the range of 7.3% - 28.5%, reported by several studies (4,12,16,21,22,26-32).

Conclusion:

The incidence of the different patterns of sphenoid sinus pneumatisation is remarkable. This would require adequate, individualized preoperative CT evaluation, for information that could could be relevant to a safe trans-sphenoid skull base surgery.

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Conflict of interest

None

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