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Full Length Research Paper

Volumetric measurements and anatomical variants of paranasal sinuses of Africans (Nigerians) using dry crania

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The aim is to determine the volume of each sinus and to highlight the anatomical variants that are common in Nigerians' dry crania. Twenty- four dried skulls of Nigerians from which the temporal bones had earlier been dissected were studied. A 0° sinus endoscopy (Telescope) was utilized to visualize the paranasal sinuses and their degree of pneumatization was noted. Vernier caliper was employed to measure the distance between the anterior and posterior nasal spine. The height, width, depth and volume of each of the sinuses were determined. The anatomical variants were noted. Aplasia of the frontal sinuses was found in 58% of the studied specimen. There was bilateral aplasia in 50% of the specimen while unilateral aplasia occurred in 8% and on the left side. The volumes of the paranasal sinuses were significantly smaller in the studied crania. In all the paranasal sinuses, the right side was found to be larger than the left except for the maxillary sinus where the left side was found to be larger. Ethmoid showed anatomic variants such as haller Cell, frontal cell, onodi cell and the supra orbital cell. Pre sellar pneumatization was found in 20% of the sphenoid while sellar pneumatization was found in 80%.

Key words: Anatomical variants, paranasal sinuses, volume, dried crania, Nigerians.

INTRODUCTION

During fetal development, the paranasal sinuses originate as invagination of the nasal mucosa into the lateral nasal wall, frontal, ethmoid, maxilla and the sphenoid bones. This unique development explains the enormous amount of anatomical variation. Detailed anatomical knowledge of the complicated nasal and paranasal sinus architecture is very important for the success of surgical procedure in this area. Knowledge of the anatomical relationships and variants helps surgeons to avoid complications. Computed tomography (CT) is an excellent means of providing anatomical information of this region, thus, it has been used to determine the anatomic variations of the nose and paranasal sinuses widely reported in literature. Fewer studies were done on crania and even less on crania of Africans of Nigerian descent. This could be as a result of the fact that Nigeria is a resource poor country where radiological imaging and the facilities for functional endoscopic sinus surgery (FESS) may not be readily available or affordable.

The knowledge of the sinuses can also be acquired through repeated dissection on the nose and the para-nasal sinuses (Prescher, 2009). The sound knowledge of this region will assist the surgeon to be more confident and be familiar with the common anatomic variants, some of which may be associated with serious complications during surgery, and to avoid them; especially because rhinosinusitis is the second most common otorhinolaryngological (ORL) disease in our practice (Eziyi et al., 2010).

This work studied 24 dried skulls of Africans of Nigerian

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Table 1. Pneumatization of frontal sinuses.

Bilateral aplasia No. (%)	Unilateral aplasia No. (%)	Total No. (%)
12 (50)	2 (8)	14 (58)

descent for the gross anatomy of the nose and the paranasal sinuses, with the aim of determining the size and volume of each sinus and to highlight the anatomical variants that are common in these specimens.

MATERIALS AND METHODS

Twenty-four mixed sex samples of adult dry crania from which temporal bone had been earlier dissected were obtained from the Department of Anatomy and Cell biology of the Obafemi Awolowo University and were examined. All examinations on the dry crania were done in a standardized manner and in compliance with all ethical guidelines. The nasal and paranasal sinuses were studied. The nasal aperture was measured in transverse dimension. The distance between the anterior nasal spine and the posterior nasal spine of each cranium was measured with a vernier caliper; the distance between the anterior nasal spine and the cribriform plate was also measured.

A 0° sinus endoscope was used to examine the ethmoids and the sphenoid sinuses for anatomical variant (such as the presence of hallers, frontal cells, supra orbital cells, and onodi cells) in the intact skull. The volume of each of the paranasal sinuses were measured using water displacement volumetry. The skull was then sectioned in a coronal plane after the skull cap had been removed with a hand saw. The paranasal sinuses were then better exposed for inspection and measurements.

Linear measurements (anterioposterior length, height, and the width) of the sinuses were made using a vernier caliper. The anterioposterior length was defined as the longest distance from the most anterior point to the most posterior point of the sinus. The height of the sinus was defined as the longest distance from the lowest point of the sinus floor to the highest point of the sinus roof. The width was defined as distance between the most medial and lateral points of the sinuses. The degrees of pneumatization were also noted. Data analysis was done using Statistical Package for Social Science version 17, and results were presented using simple frequency, and percentages.

RESULTS

Nose

Twenty four adult human dried skulls were studied; the mean nasal aperture (the transverse diameter) was 2.73 ± 1.8 cm, and the mean of the distance between the anterior nasal spine (ANS) to the posterior nasal spine (PNS) was 4.48 ± 1.42 cm. The mean of the distance between the anterior nasal spine and cribriform plate was 4.42 ± 1.04 cm.

Paranasal sinuses

Frontal sinus

Asymmetry was found in all the specimens. There was aplasia of the frontal sinus in 14 (58%) of the specimen (Table 1). This was bilateral in 12 (50%) (Figure 1) and unilateral in 2 (8%) on the left. The average volume on the right was 4.44 ±1.59 cm^3 and 3.35 ±1.73 cm^3 on the left (Table 2).

Ethmoid sinuses

The average volume of these sinuses on the right was 5.08 ± 2.82 cm^3, and 4.77 ± 2.04 cm^3 on the left. Anatomical variants such as supra orbital, haller and onodi cells were seen in 1 (4%) each. This variation was found to be unilateral in all and was found to occur on the left side in each of the variant. Frontal cells was seen in 2 (8%) of the specimen, and associated with frontal sinus aplasia in the two cases.

Sphenoid sinuses

The average volume was 5.38 ±5.64cm^3 on the right and 4.23 ±1.99 cm^3 on the left. The types of pneumatization seen in the specimen were pre sellar (20%), sellar in (80%), while concha was not found in any of the studied specimen.

Maxillary sinuses

The average volume on the right was 11.59 ± 5.36 cm^3 and 14.98 ± 10.77cm^3 on the left. Asymmetry of the maxillary sinus was found in 100% of the dried skull. No bony septum was found within the sinuses.

DISCUSSION

A clear understanding of the anatomy of the nose and the paranasal sinuses is vital for a successful endoscopic sinus surgery (Kantarci et al., 2004; Polavaram et al., 2004). This knowledge will give the surgeon the needed confidence as well as help the surgeon in avoiding complications. The presence of anatomic variations in the paranasal sinuses has necessitated that the surgeon be more familiar with this in addition to a careful surgical technique so as to increase patient safety.

The distance between the anterior nasal spine and the posterior nasal spine, and the anterior nasal spine and the cribriform plate were found to be almost equal and statistically significant. The mean values were 4.42 and 4.48 cm respectively. This might be an approximate estimate of the level of the dura and this measurement might be worthy of note in nasal endoscopic surgery, since the distance is almost equal and are significantly statistically correlated.

The transverse diameters of the nasal aperture were also almost constant. It was 2.6 cm in 50% of the cases

Figure 1. Showing bilateral aplasia of the frontal sinus on two of the dry crania.

Table 2. Volumetric measurement of the paranasal sinuses.

Sinus	Right (cm^3)	Left (cm^3)
Frontal	4.44 ± 1.73	3.35± 1.73
Ethmoids	5.08 ± 2.83	4.77± 2.04
Maxillary	11.59 ± 5.36	14.98± 10.77
Sphenoid	5.38 ± 5.64	4.23± 1.99

and the mean value was 2.73 ± 1.8 cm. The significance of this is not yet obvious but it might be important when rhinoplasty is being considered in an African nose.

Frontal sinus

Nambiar et al. (1999) had described the uniqueness of the frontal sinus and has likened it to the human fingerprint which is unique to an individual. The frontal sinus was absent in 58% of the specimen. 50% of the specimen had bilateral absence of frontal sinus while eight percent had unilateral absence. Figure 1 is quite high and the significance of this finding is yet to be appreciated. Aydinlioglu et al. (2003) reported a bilateral and unilateral absence of frontal sinuses in 3.8 and 4.8% of cases respectively while Nowak and Mehls (1977) reported 3.4 and 7.4% respectively. A unilateral absence of the frontal sinus was also reported to be 1% by Schuller (1943). Natsis et al. (2004) also in a study on 18 cadavers found only one with frontal aplasia. The underdevelopment or aplasia of the frontal sinus though high in this study, is a rare phenomenon in Caucasian that occurs unilaterally in about 4% of cases and bilaterally in approximately 5% of cases.

It is customary for Nigerian Africans to carry heavy loads on their head. Whether this has a role to play in frontal sinus agenesis will need to be further investigated. It has been suggested that the frequency of an absence of the frontal sinus shows racial differences. The data on the prevalence of frontal sinusitis is also not available in our environment. Future studies will hopefully elucidate the significance.

The size of the frontal sinus is highly variable. The left and right frontal sinuses develop independently, thus it is common to find one larger than the other due to unequal reabsorption of diploe during sinus development. The size of the frontal sinus may be related to environmental factors. Koertvelyessy (1972) who studied the frontal sinus of 153 Eskimo crania reported that the degree of pneumatization correlates positively with degree of environmental coldness in which the population lives. The extent of pneumatization results in the individual size and shape of the frontal sinus. An absence of pneumatization in the frontal bone results in frontal sinus aplasia.

Ethmoidal sinuses

The average volume is shown in Table 2. The right was found to be larger than the left. The mean volume found in this work was significantly smaller when compared with the works of Emirzeoglu et al. (2007) who reported a mean volume of 11.8 ± 0.4 cm^3. However, their work was

Table 3. Ethmoidal variations.

Haller (%)	Onodi (%)	Supra orbital (%)	Frontal cells (%)
1 (4%)	1 (4%)	1 (4%)	2 (8%)

based on computer tomography scan and measurements were made on the films rather than on the skull. Anatomical variants such as frontal cells, supra orbital cell, haller cell and onodi cell were seen in this study. Although their occurrence was not common (Table 3), their existence in Nigerians must be appreciated, especially by the nasal endoscopic surgeon. These variants were noticed on the left side only. The endoscopic surgeon has to be mindful of this in order to avoid serious complication at surgery. Haller cells are ethmoid cells that extend along the floor of the orbit. They vary in size and when large, can narrow the ostium of the maxillary sinus or the ethmoid infundibulum. An onodi cell is a posterior ethmoid cell that extends lateral and superior to the sphenoid sinus and abuts the optic nerve. The agger nasi cells are extramural cells and represent the most anterior ethmoid cells.

Sphenoidal sinuses

The degree of pneumatization of the sphenoid sinus may vary considerably. Depending on the degree of pneumatization, the sphenoid sinus can be described as postsellar, presellar or conchal. The mean volume of this sinus on the right was 5.08 $\pm$ 5.64 cm^3, and 4. 23 $\pm$ 1. 99 cm^3 on the left. This was also found to be smaller when compared with mean volume of 13.6 ± 0.7 cm^3 in Europeans (Emirzeoglu et al., 2007). Presellar pneumatization was found in 20% while postsellar pneumatization predominates. This finding agrees with the existing literature (Yune et al., 1975). None of the specimen showed anterior clinoid or concha pneumatization.

Maxillary sinuses

It was observed in this study that the volume is smaller than what obtains in the Europeans. Fernandes (2004) in his study also found that the European cranial had significantly larger antral volumes than the Zulu crania. A mean sinus volume of 11.59 ± 5.36 and 14.98 ± 10.77 cm^3 on the right and left sides respectively found in our study was similar to previous works (Ariji et al.,1994; Uchida et al.,1998; Gosau et al., 2009). We noticed a difference in the maxillary sinus volume of both sides, with the left having a slightly bigger volume than right. This agrees with the existing literature (Bailey et al., 2006). Other authors could not find significant differences concerning side, sex, and age (Ariji et al., 1994; Uchida et al.,1998; Shibli et al., 2007).

Conclusion

Aplasia of the frontal sinus was found in the majority of the Nigerian African skulls investigated. The volumes of all the paranasal sinuses were significantly smaller than what obtains in the literature. The ethmoidal sinus demonstrates such anatomical variants as hallers cell, frontal cells, and onodi cell. These variants though not very common, were all found on the left side of the crania. Sellar pneumatization of the sphenoid sinus predominates but a significant number (20%) had pre Sellar pneumatization. Further study on the anatomy of the nose and paranasal sinuses in Africans will be beneficial.

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