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Morphologic and Volumetric Study of Paranasal Sinuses and Mastoid Air Cell System Using Different Methods: A Review

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ABSTRACT

The size and configuration of the paranasal sinuses and mastoid air cell system, which are the biggest air spaces in the human body, are important when planning endoscopic sinus procedures. As a result, various investigations using CT, MRI, cadaveric exams, and histological studies have been done to determine the size and volume of the paranasal sinuses. In assessing the disorders of the paranasal sinuses, computed tomography has acquired widespread recognition. It has been widely used in the assessment of malignant disorders. CT allows for simultaneous visualisation of both bone and soft tissue components. Environmental variables and hereditary illnesses have an impact on the development of the paranasal sinuses. Age had an effect on the growth of both the paranasal sinuses and the mastoid air cell. The paranasal sinuses have a high correlation between their volumes, indicating that they are in proportion to one another. The architecture of the paranasal sinuses, their evolution, the many materials and methods used to research them, and the probable variations in their size and volume are all discussed in this article.

Key Words: Paranasal sinuses; Computed tomography; Volume

1. INTRODUCTION

The paranasal sinuses and the middle ear/mastoid systems are the biggest air spaces in the human body. Its anatomy is intricate and varies from person to person. Significant structural changes between the two sides can be detected in the same person [2]. The paranasal sinuses are characterised by pneumatic properties. The development of paranasal sinuses can be influenced by genetic disorders, environmental factors, and previous infections [3]. The surgical therapy of chronic or recurrent sinusitis has been revolutionised by recent improvements in making use of assessment of mucociliary activity and pathophysiology of the nasal cavity and paranasal sinuses. Accurate diagnosis of illnesses and alterations in the architecture of the paranasal sinus is required to perform endoscopic sinus surgery efficiently [12]. After these changes are identified, functional endoscopic sinus surgery can be performed, which normally involves minimally invasive procedures and can give noticeable relief from chronic sinusitis symptoms.

2. METHODOLOGIES

Advanced technologies such as computed tomography was used in the majority of the research. The volume of the paranasal sinuses and the mastoid air cell were determined automatically and immediately using three-dimensional reconstruction software utilising continuous non-overlapping slices of CT images of the paranasal sinuses [1] .Some investigations used CT scans of patients to retrospectively analyse the paranasal sinuses and temporal bone, and the volumes were derived using the area measuring feature of CT scans [2,7,9] .CT scan pictures of entire section series were used to estimate a subject's sinus volume. These pictures were framed and printed on films. The total volume of the sinuses was calculated using a square grid test technique with six distinct point densities between test spots [3] .CT scans have been used to examine the paranasal sinuses in disorders such as orbital tumours, benign sinus diseases, and surgery of the paranasal sinuses and skull base [16,18,23] .It was also utilised to analyse the sinuses in combination with a clinical assessment and normal radiological examination[22]. Radiographs were obtained and analysed on a computer in a dimly lit room as part of a research. Reconstructed axial and coronal sections were used to measure the sinuses [4]. Another study looked at the paranasal sinuses with dry crania utilising the water displacement volume measurement method and CT scans of dry crania [7,8,24]. The papilloma of the paranasal sinuses was also discovered via histologic studies[14]. Radiographs of dried skulls of new-borns were used to examine the development of the paranasal sinuses[19].

3. DISCUSSION

Finding literature about paranasal sinuses using Google Scholar and PubMed was a breeze. An effort was made to locate papers relating to experiments conducted using cadavers and CT scans utilising various approaches. Each study's methodology and results were compared, as well as the potential for significant error for each technique. There are articles on studies that have been conducted in various parts of the world. The majority of them are studies from Turkey, Europe, and other Asian nations such as Saudi Arabia.

3.1 DEVELOPMENT

At the age of 12, the nasal cavity and paranasal sinuses have almost completed their development and have reached adult paranasal sinus size and morphology. The choanae reach the end of their growth and transform from circular to a rectangle shape with a height twice its width (19). At the moment of birth, the maxillary sinus is the first to develop and contains fluid. Until the end of the 18th year, the maxillary sinus, which is present at birth, grows in size. Vertical, horizontal, and anteroposterior alterations are all part of the development pattern [25]. The upward expansion of the whole frontal recess into frontal bone from one of the pits of the frontal recess from one of the cells of the ethmoid infundibulum or, more rarely, from ethmoid bulla might cause frontal sinus [11].

3.2 MAXILLARY SINUS

The roots of the upper premolars and molars protrude into the floor of the maxillary sinus, which is located in the maxilla. The inferior turbinate, the uncinated bone above it, and the ethmoid behind form its medial wall, which is open and filled with inferior turbinate [15]. The width, length, and height of the maxillary sinuses, as well as the total distance across both sinuses, were measured using helical CT to determine the gender of adults. The researchers concluded that maxillary sinus dimensions measurements are useful in studying sexual dimorphism and that they tend to stabilise after the second decade.

When other techniques of sexing are not certain, a reconstructed CT picture can provide valuable measures for maxillary sinuses and might be utilised for sexing. In terms of maxillary sinus breadth, length, and height, there was a significant sex difference. The left maxillary sinus height was the best recognised variable between genders among these characteristics [4] .The volume of the maxillary sinus varied between 5 and 22 ml. Female preponderance is evident in the small volume class of maxillary sinus volume when compared to gender (5-9 ml). The medium volume groups (10-14 ml, 15-19 ml)7 had a well-balanced gender contribution. It was also discovered that the frontal sinus and mastoid air cell have a propensity to expand quicker and become larger than the maxillary and sphenoid sinuses.

3.3 SPHENOID SINUS

The ostium of the sphenoid sinus is located 1 cm above the point where the posterior choana slips away into the oropharynx in the posterior wall of the nose. It has a tight relationship with the optic nerve and the carotid artery [15]. The degree of sphenoid sinus pneumatisation might vary greatly. It might be presellar or conchal depending on the degree of pneumatisation [8]. Mucosal thickening and polyps or cysts of the sphenoid sinuses were found in 20.6 percent and 4.5 percent of the patients, respectively, suggesting that sphenoid sinus surgery is extremely dangerous due to changeable changes of the cavity[6].

3.4 FRONTAL SINUS

Measurements of the frontal sinus volume have revealed that it increases quite quickly around puberty. Following that, the volume of the left frontal sinus was found to be greater than that of the right, although the difference was not statistically significant [5]. The presence of a frontal sinus was discovered in 75 percent of instances by the age of ten, and the number of cases rapidly rose after that. On the images of all patients, the frontal sinus was seen around the age of [17]. There were no significant differences between males and females. The amount of drainage from the frontal sinus varies depending on embryological development. In a substantial percentage of patients, it drains independently from the other para nasal sinuses, and the frontal sinus is commonly spared when ethmoid or maxillary sinusitis is present[11].The frontal sinuses do not form in the majority of instances, according to research [8].

3.5 ETHMOIDAL SINUS

The ethmoidal sinus has various anatomical forms, including hallers cell, frontal cell, and onodi cell, however they are not frequent. In the top and lateral aspects of the nasal cavity, there are roughly 8-15 ethmoid air cells that emerge from a bony labyrinth [15]. To avoid significant complications during surgery, the endoscopic surgeon must be extremely cautious. Haller's cells come in a variety of sizes, and when they're big enough, they can constrict the maxillary sinus ostium or the ethmoid infundibulum [8] .The posterior ethmoid cells have the potential to invade the posterior ethmoid capsule or migrate to the optic nerve's medial aspect. Spheno ethmoid cells (onodi cells) are positioned between the sphenoid sinus and the floor of the anterior cerebral fossa and are known as spheno ethmoid cells. Onodi cells were found in coronal scans in 5% of patients, according to a study [12].

3.6 COMPUTED TOMOGRAPHY IN ASSESSMENT OF PARANASAL SINUSES

The water reference bag and small aperture in earlier head scanner units made them unsuitable for scanning the base of the skull and facial region. The introduction of cranial CT in 1973 had an immediate and significant impact on neurological diagnosis [22] . In the invagination of disorders of the paranasal sinuses, computed tomography has gained widespread recognition. It is commonly used in the assessment of malignant disorders. CT allows the examiner to see both bone and soft tissue features at the same time by using broad window settings [18].

The volumetric relationship between mastoid air cells and paranasal sinuses was assessed using three-dimensional morphometric evaluation of para nasal sinuses and mastoid air cell system using CT. After controlling for the effect of age, no significant linear regression relationship was found between the volumes. In both males and females, they were shown to have a remarkable linear relationship with age. The right maxillary sinus volume to left maxillary sinus volume and the right mastoid air cell volume to left mastoid air cell volume had the highest association and the most significant differences in both sexes[2].

The utility of CT in the identification of illnesses of the nasal cavity, paranasal sinuses, and post nasal region was investigated in a research. CT verified the clinical and radiological results, contributed little new information, and recognised the soft tissue component of invasive tumours by displaying their shape and obturation of normal face planes in individuals with benign illness. CT may not always be able to distinguish between soft tissue mass edges and normal soft tissue. The outcomes of clinical examination and conventional radiography were found to be highly correlated in the majority of the individuals investigated. CT scans reveal the whole extent of the illness process, which aids in preoperative care, radiation area design, and therapeutic response monitoring [22].

3.7 VOLUMETRIC CORRELATION OF PARANASAL SINUSES

There was no interaction in the pneumatisation of the three paranasal sinuses (frontal, maxillary, and sphenoid) and mastoid air cells, according to a three-dimensional morphometric analysis performed using CT with regard to paranasal sinuses in a juvenile population. Age had an effect on the expansion of both the paranasal sinuses and the mastoid air cell, and there was a strong linear regression association with age [1].The paranasal sinuses have a high correlation between their volumes, indicating that they are in proportion to one another. Sexual dimorphism was discovered using correlation analysis. For female participants, there was a strong link between the maxillary frontal and maxillary ethmoidal sinuses. Except for the frontal-sphenoid sinuses in the male group, the volumes of all four sinuses were highly associated.

4. CONCLUSION

Anatomical measurements, injections of various materials into cadavers, and plain radiography were used to generate knowledge on human paranasal sinus pneumatisation. Computed tomography and magnetic resonance imaging with axial, sagittal, and coronal sections have recently been introduced, allowing for a more precise examination of the structures. The benefits of 3D CT imaging and its potential utility in quantitative analysis are frequently used. The complicated architecture and possibly dangerous morphometry of the sinuses tend to result in a wide range of symptoms and potentially severe problems. Inadequate knowledge of the exact anatomy raises the risk of iatrogenic surgical errors that can be catastrophic. The best understanding of sinus morphology aids in the determination of dissection boundaries and, as a result, may assist to lessen the risk of problems.

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