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Volumetric evaluation of maxillary sinuses using CBCTS: radiographic study

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Abstract. The evaluation of maxillary sinus volumes is fundamental for pre-surgical planning in this area, as well as for the diagnosis of sinusitis and the diagnosis and treatment of maxillary hypoplasia. This study aimed to assess changes in sinus volume over time as a function of different conditions, such as sex, orthodontic treatments like rapid palate expansion, and the presence of edentulism. The Cone-Beam Computed Tomographies of eighteen patients were selected, and their entire sinus volumes were segmented, enabling the measurement of the sinus volume in three spatial dimensions. The collected data were statistically analyzed using the T-Student test and ANOVA. The mean size of the measured right sinus volume was 14.42 cm^3, and that of the left sinus was 14.17 cm^3. No statistically significant difference was identified between the right and left maxillary sinus volumes, even in correlation with the considered factors (p-value > 0.05). The values found in the present study agreed with those in the literature, confirming the importance of radiographic evaluation of this structure for diagnosis and treatment planning.

Keywords: maxillary sinus, maxillary antrum, Cone Beam Computed Tomography, innovation technology, health.

INTRODUCTION

The paranasal sinuses serve both skeletal and respiratory functions. They lighten the skull and provide a structure that can withstand facial trauma while conferring resonance to speech and warming inspired air (Amine et al., 2020). Therefore, it is crucial to study the anatomy and volumetric extension of the maxillary sinus for diagnosis, verification of response to chemo- and radiotherapy in malignant tumors, and surgical planning (Thariat et al., 2021). Surgical treatments requiring a study of the full volume of the maxillary sinuses include endoscopy sinus surgery and maxillary floor lift for graft and implant placements (Giovannetti et al., 2019; Raponi et al., 2021). The literature reports that breathing patterns, dental problems, anatomical features,

gender, and age influence the maxillary sinus volume (Iturralde-Garrote et al., 2023).

This study aimed to measure in vivo the volumetric dimensions of maxillary sinuses in a European population and see if there is any association between the morphometric data with gender, orthopaedic treatment on the palate (rapid palatal expansion), and presence of edentulism.

MATERIAL AND METHODS

Eighteen Cone Beam Computed Tomography (CBCT) scans were collected from patients requiring surgical treatment in maxillary sinuses. The CT scans had a reading area measuring 23.8 cm in width and 19.3 cm in height, a grayscale of 14 bit, voxel dimension of 0.4/0.3/0.25/0.2 mm, and a field of view of 16.5 cm x 17 cm. The DICOM files were segmented using the open-source software INVESALIUS vers. 3.1, highlighting the airspace of the maxillary antrum on the three direction (axial, sagittal and coronal) in each sections (Figure 1).

Finally, the 3D volume rendering of the maxillary sinus was obtained (Figure 2).

Statistical analysis of the obtained data was performed using SAS University edition software. T-Student and One Way ANOVA tests were performed in the statistical analysis, with statistical significance assumed at p-value < 0.05.

RESULTS

The mean value of the right side was higher than the left side. The mean and standard deviation of the measured volume of the right maxillary sinus resulted in 14.42 $\pm$ 4.73 cm^3, and that of the left maxillary sinus was 14.17$\pm$ 4.79 cm^3. The minimum and maximum values found for the right maxillary sinus were 6.44 and 29.3 cm^3, and for the left sinus were 6.32 and 27.53 cm^3. The difference assessed by the T-Student test between the right and left sinuses was not statistically significant (p-value> .05). From the association of the volumetric values of the right and left maxillary sinus with the established categories (Rapid Palatal Expansion, presence of edentulism, and presence of sinusitis), it was possible to see how the edentulism and the sinusitis decrease the volume of maxillary sinuses, both left and right. However, the patients who underwent palatal expansion had different results from the left and right maxillary sinus (Table 1).

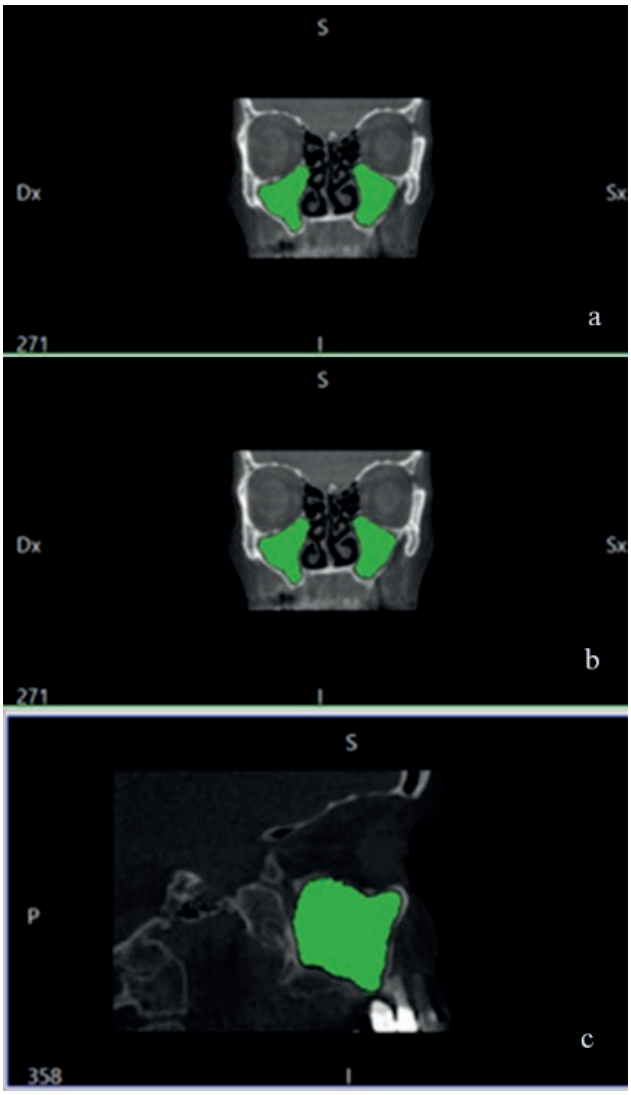

Figure 1. a. CBCT frontal section of the maxillary sinus; b. CBCT axial section of the maxillary sinus; CBCT sagittal section of the maxillary sinus.

DISCUSSION

The present study aimed to assess whether certain factors could influence the size of the right and left maxillary sinuses individually. The study referred to previous research that evaluated maxillary sinus size considering various factors. Emirzeoglu et al. (2007) evaluated 39 males and 38 females using computed tomography scans, which showed that the average size of the maxillary sinuses was 11.6 + 0.8 cm^3, smaller than the present study's findings. Pirner et al. (2009) conducted a study for pre-operative anatomical assessment in sinus surgery and found that the volume of the right maxillary sinus

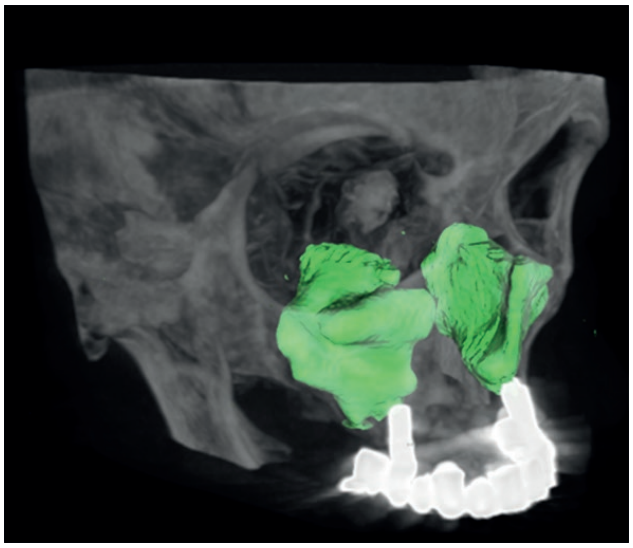

Figure 2. 3D rendering of the maxillary sinus segmentation's.

Table 1. One Way ANOVA statistical analysis of the association of right and left maxillary sinus volumetric values with the factors RPE (rapid palate expansion), presence of edentulism, and presence of sinusitis.

RIGHT MAXILLARY SINUS		ANOVA (P value)	LEFT MAXILLARY SINUS		ANOVA (P value)
Male	Female	>.05	Male	Female	>.05
14.038	14.597		14.281	14.125	
RPE YES	RPE NO	>.05	RPE YES	RPE NO	>.05
13.351	14.621		14.321	13.390	
EDENTULISM YES	EDENTULISM NO	>.05	EDENTULISM YES	EDENTULISM NO	>.05
13.694	18.295		13.564	17.424	
SINUSITIS YES	SINUSITIS NO	>.05	SINUSITIS YES	SINUSITIS NO	>.05
12.918	15.513		12.897	15.103	

was 17.4 cm^3, while the left was 17.9 cm^3, larger measurements than those reported in the present study. Urooge et al. (2017) reported a mean value of maxillary sinus volume of 16 cm^3, and Bangi et al. (2017) reported an average volume of 15.3 cm^3 in the right maxillary sinus and an average volume of 13 cm^3 in the left maxillary sinus, values that were in line with the present study's findings. Giacomini et al. (2018) experimented to determine the best method for measuring maxillary sinus volumes in a sample of 30 subjects, finding a mean value of 14.7 cm^3 between the right and left maxillary sinuses.

The literature has also investigated whether there is a dimensional variation of the maxillary sinus between oral and nasal breathing patients. Tikku et al. (2013) found that oral breathers had a smaller maxillary sinus volume than nasal breathers. Agacayak et al. (2017) analyzed 239 subjects, finding that the maxillary sinus of oral breathers was significantly smaller than that of nasal breathers. Additionally, studies have investigated the change in maxillary sinus volume following orthognathic surgery. Panou et al. (2013) evaluated 16 patients who underwent cone beams before and after surgical treatment for third classes, showing a significant reduction in the volume of the maxillary sinus. Okşayan et al. (2017) compared the volume of the maxillary sinuses in patients with high, low, or normal vertical size, finding a greater maxillary sinus size in the group with low vertical dimension compared to the group with high vertical dimension.

The present study found that the average volume of the maxillary sinuses was 14 cm^3 and emphasized the importance of studying maxillary sinus volumes for presurgical planning in the case of surgery in these areas and for the diagnosis and treatment of maxillary hypoplasia in oral respiratory patients.

CONCLUSION

The study of maxillary sinus volume is crucial because of its variability and essential in the diagnosis process of suspected sinusitis, to plan any endoscopic surgery in this area, to determine if the maxillary sinus lift is reliable and to quantify the amount of volume graft in case of alveolar bone regeneration surgery.

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