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Investigation on the relationship of dimensions of the maxillary sinus drainage system with the presence of sinusopathies: a cone beam computed tomography study

Ana Beatriz Gomes de Carvalho[a], Andre Luiz Ferreira Costa[b,*], Acácio Fuziy[b], Afonso Celso Souza de Assis[a], José Ribamar Castro Veloso[b], Luiz Roberto Coutinho Manhães Junior[a], Mauro Pedrine Santamaria[a], Sérgio Lucio Pereira de Castro Lopes[a]

[a] Department of Diagnosis and Surgery, São José dos Campos School of Dentistry, São Paulo State University (UNESP), São José dos Campos, SP, Brazil
[b] Department of Orthodontics and Radiology, University of São Paulo City (UNICID), São Paulo, SP, Brazil

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ABSTRACT

Objective: This study sought to assess the relationship between the dimensions of the maxillary sinus drainage system with the content of sinuses.
Design: Three-hundred cone beam computed tomography images were selected from a database (105 males and 195 females). The images were assessed by a single investigator, trained and calibrated, performing image analysis. The length of the infundibulum and the ostium height in both maxillary sinuses were measured. The data were analyzed using Minitab 1, using 5% as a critical *p*-value.
Results: A significant gender difference was also found for presence in the normal content of sinus for females and presence of antral pseudocyst for males ($p < 0.05$). Subjects with normal content in the maxillary sinus present lower ostium height values. There were statistically significant with presence of and higher ostium height values and antral pseudocyst ($p < 0.01$).
Conclusion: The current study results demonstrated that some sinusopathies were significantly related to dimensions of maxillary sinus drainage.

1. Introduction

Maxillary sinuses (MS) appear as a small invagination during the fourth month of foetal life, remaining as such and limited to the medial portion of the maxillary bone. With the individual's growth, sinuses expand and occupy a large extension within the maxillary bone, reaching the maximum development after the second dentition (Sperber, 1980). They may vary in terms of shape and size, with variations between the right and left sides not being infrequent in the same individual.

The paranasal sinuses are directly related to the roots of upper teeth, causing them to be affected by inflammatory odontogenic processes which alter their content and normal physiology (Khojastepour, Mirhadi, & Mesbahi, 2015; Maillet, Bowles, McClanahan, John, & Ahmad, 2011). In this way, changes of inflammatory origin may lead to symptoms similar to those found in sinusal pathologies, in which the reciprocal is true.

The lining mucosa of the sinuses resembles that of respiratory epithelium as it contains ciliated cylindrical cells and caliciform cells producing mucus. This mucus is normally drained by a system called ostiomeatal complex, which is composed of ostium of maxillary sinus, ethmoidal infundibulum, uncinate process, ethmoidal bulla, semilunar hiatus, frontal recess, middle meatus and middle conchae (Kinsui, Guilherme, & Yamashita, 2002). After reaching the drainage opening of the maxillary sinus (i.e. ostium), the mucus passes through a small canal which communicates with the nasal cavity (i.e. infundibulum). Both are medially limited by the uncinate process and laterally by the ethmoidal bulla. In turn, the infundibulum opens near into the middle nasal conchae called semilunar hiatus (Parks, 2014; Poleti et al., 2014). These drainage structures of maxillary sinuses are anatomically located above their respective floor, which makes drainage dependent basically on the functioning of the ciliary system of the lining epithelium in the inferior-superior direction.

In dentistry, computed tomography allows the practitioner to

* Corresponding author at: Department of Orthodontics and Radiology, School of Dentistry, University City of Sao Paulo, Rua Cesario Galeno, 448, Sao Paulo, SP, 03071-000, Brazil.
E-mail address: alfcosta@gmail.com (A.L. Ferreira Costa).

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identify and delineate pathological processes in the paranasal sinuses (Bulbul, Yanik, & Demirpolat, 2017). Cone beam computed tomography (CBCT), a method improved in the late 1990s, has been used to study dentomaxillofacial structures with a significantly lower dose of radiation compared to the fan-beam computed tomography (Scarfe, Farman, & Sukovic, 2006). This imaging examination method provides high definition images of calcified tissues as well as slices in anatomical planes without overlapping and volumetric aspects of the craniofacial structures (Raghav, Karjodkar, Sontakke, & Sansare, 2014).

In the literature, one can observe some studies (Da Silva et al., 2017; Maillet et al., 2011; Parks, 2014; Poleti et al., 2014; Raghav et al., 2014) using this examination method for investigation of the physiology and pathologies related to paranasal sinuses, including variation in the ostiomeatal complex. However, there is no study relating the ostial height of maxillary sinus to the presence of sinusopathies of inflammatory origin or length of the infundibulum. These factors may cause the patients to develop a predisposition to inflammatory processes, thus influencing dental semiology as well as planning of surgical interventions for maxillary sinuses, such as arthroplasties and bone grafts in the region of the maxilla.

The objective of this study was to assess the relationship of positioning and dimensions of the maxillary sinus drainage systems with the presence of pathologies.

2. Materials & methods

2.1. Study sample

This study followed the universally accepted standards for research in human beings and was approved by the Institutional Review Board of the UNESP (protocol number 55687116.8.0000.0077).

A total of 300 CBCT images (600 maxillary sinuses) were selected from the examination database of patients from at the Oral & Maxillofacial Radiology Division, School of Dentistry of São José dos Campos, UNESP. The scans were retrieved from the database in the DICOM (Digital Imaging and Communications in Medicine) format. The images were acquired with the scanner i-CAT Next Generation (Imaging Science International, Hatfield, PA, USA) operating at a FOV (field of view) encompassing the entire middle third of the face (8.0 cm height), thus enabling full evaluation of the maxillary sinuses and their respective drainage system with a 0.25-mm voxel size.

Two calibrated dentomaxillofacial radiologists reviewed and discussed the CBCT scans. All the scans were selected according to the following inclusion/exclusion criteria:

2.2. Inclusion criteria

Age above 18 years old for both genders; absence of implants or prior surgeries in the posterior regions of the maxilla; absence of inflammatory processes of endodontic origin (periapical inflammatory lesions) near the floor of the corresponding maxillary sinuses which might cause sinusopathies; absence of floor continuity in the cases of sinusopathies; absence of local bone grafts.

2.3. Exclusion criteria

Impaired visualization of details; low sharpness images resulting from patients' movements during scanning, or with artifacts.

The images of the right and left maxillary sinuses were analysed individually based on their contents (Carmeli, Artzi, Kozlovsky, Segev, & Landsberg, 2011; Ritter et al., 2011), resulting in the following classification (Fig. 1):

a) Normal (I): Hypodensity;
b) Presence of mucous thickening (II): Image of density in the soft parts with linear aspect in association with their walls;
c) Presence of antral pseudocyst (III): Image of density in the soft parts with circular aspect in association with their walls;
d) Partial opacification (IV): Image of density in the soft parts resulting in partial opacification, but presenting regions of internal hypodensity;
e) Total opacification (V): Image of density in the soft parts resulting in total opacification.

2.4. Methodology for image analysis

The scans selected were imported to Xoran software (Xoran Technologies, Ann Arbor, Michigan, USA) and multiplanar reconstruction images were generated. Adjustments were made in the medial and occlusal planes so that the hard palate on the coronal slices was coincident with the horizontal line exhibited on these slices. All measurements were performed by one dentomaxillofacial radiologist with 12 years of experience in interpreting CBCT.

After such adjustment, the entire extension of the right maxillary sinus (and then the left one) was examined individually in the anteroposterior sense on the coronal window in order to determine the lowest point of the floor. In the slice in which this point was identified, the guiding horizontal line of the axial slice was tangentially positioned at the point of interest, remaining fixed on this level and being shown in this position even when the coronal slice was changed, thus emphasising the lowest point of the maxillary sinus floor. Next, the coronal slice showing all structures of the ostiomeatal complex was selected. In this slice, a vertical line was drawn, with the ruler tool, perpendicular to the guiding horizontal line, leaving the centre of the ostium of the maxillary sinus, thus determining the distance (in millimeters) between the ostium and the lowest point of the corresponding maxillary sinus, ostium height (FOD), Fig. 2.

The length of the infundibulum (LI) of the corresponding maxillary sinus was determined in the slice with better visualisation. The tool ruler was used to measure the distance (in mm) between the centre of the ostium and the most upper point of the uncinate process, passing through the infundibulum (Fig. 3).

After a 15-day interval, all the measurements were repeated for analysis of intra-rater reliability.

Data on ostium heights, infundibulum length and type of content corresponding to the two maxillary sinuses of each patient were tabulated. Next, statistical test was applied for assessing a possible relationship between these variables.

2.5. Statistical analysis

The agreement between the two evaluation times was verified through scatter plots and the Lin's concordance correlation coefficient. The Student *t*-test was used to compare the genders in relation to the linear parameters and also to compare the maxillary sinuses content in relation to the linear parameters. To compare the genders in relation to the maxillary sinuses content, the Chi-Square test was used. The McNemar test was used to compare the sides in relation to the changes. The confidence level used in the analysis was 5%. All data were statistically analyzed using Minitab 16 (Minitab, Inc., State College, PA, USA).

3. Results

Analysis of the scatter plots showed that there was an almost perfect concordance to the intra – examiner for two measurement times for FOD and LI on both sides (i.e. right and left sides) and in both genders (males and females), Lin's concordance correlation coeficiente > 0.999.

Student's *t*-test was used for comparison between genders and the linear measurements (FOD and LI) made. The results are shown in Table 1. It was found that male individuals had, on average, higher values of FOD on both right and left sides and higher values of LI on the