ОРИГИНАЛЬНАЯ СТАТЬЯ

PREVALENCE OF ANATOMIC AND PATHOLOGIC FINDINGS IN THE MAXILLARY SINUS DETECTED THROUGH CONE-BEAM COMPUTED TOMOGRAPHY IN THE ROUTINE OF STOMATOLOGY

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Purpose. To investigate the prevalence of anatomic and pathologic findings in the maxillary sinus detected through cone-beam computed tomography (CBCT) in the routine of Stomatology.

Materials and methods. The sample consisted of 954 CBCT scans from male (n: 330) and female (n: 624) patients aged between 2 and 86 years (mean age: 33 years). CBCT scans were taken from each patient for dental and maxillofacial diagnosis and treatment planning. The iCAT CBCT device and the inherent VisionQ software package (Imaging Science International, Hatfield, PA, USA) were used. X2 test was used to associate the anatomic and pathologic findings with patients' sex and age.

Results. In both males and females, the most prevalent anatomic and pathologic findings in the maxillary sinus were, respectively, the sinus septa (21.2%) and thickening of the sinus mucosa (62.3%). Higher prevalence of maxillary sinus findings were detected within patients in the age range from 12 and 18 years ($p<0.05$). CBCT exams showed a high prevalence of anatomic and pathologic findings in the maxillary sinus that may have a significant clinical relevance.

Conclusions. Stomatologists, Maxillofacial Surgeons and Physicians must properly interpret CBCT exams and must be aware of the occurrence of anatomic and pathologic findings prior to procedures that involve the maxillary sinus.

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РАСПРОСТРАНЕННОСТЬ АНАТОМИЧЕСКИХ И ПАТОЛОГИЧЕСКИХ НАХОДОК В ВЕРХНЕЧЕЛЮСТНЫХ СИНУСАХ, ВЫЯВЛЕННЫХ ПРИ КОНУСНО-ЛУЧЕВОЙ КОМПЬЮТЕРНОЙ ТОМОГРАФИИ, В ПРАКТИКЕ СТОМАТОЛОГА

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Цель. Изучить распространенность анатомических и патологических находок в верхнечелюстном синусе, обнаруженных с помощью конусно-лучевой компьютерной томографии (КЛКТ), встречающихся в практике стоматолога.

Материалы и методы. Исследование включало 954 КЛКТ-изображения у мужчин (n: 330) и женщин (n: 624) в возрасте от 2 до 86 лет (средний возраст: 33 года). КЛКТ выполнялась каждому пациенту для обследования зубов и челюстно-лицевой области и планирования лечения. Использовалось устройство iCAT КЛКТ и встроенный программный пакет VisionQ (Imaging Science International, Hatfield, PA, США). Тест X2 использовался для сопоставления анатомических и патологических данных с полом и возрастом пациентов.

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Результаты. Как у мужчин, так и у женщин наиболее распространенными анатомическими и патологическими находками в верхнечелюстном синусе были перегородка синуса (21,2%) и утолщение слизистой оболочки синуса (62,3%) соответственно. Более высокая распространенность находок в верхнечелюстном синусе встречалась у пациентов в возрасте от 12 до 18 лет (p<0,05). КЛКТ- исследования показали высокую распространенность анатомических и патологических находок в верхнечелюстном синусе, которые могут иметь значительную клиническую значимость.

Выводы. Стоматологи, челюстно-лицевые хирурги и врачи должны правильно интерпретировать КЛКТ-изображения и должны знать об анатомических и патологических находках до вмешательств, которые затрагивают верхнечелюстной синус.

Ключевые слова: компьютерная томография, диагностика, верхнечелюстной синус, стоматология.

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Introduction.

Stomatology is a wide field in health sciences that comprehends the diagnosis and management of oral conditions in the interface of Dentistry and Medicine [1]. In this field, clinical, histopathologic and imaging exams are often combined to reach optimal outcomes [2]. Cone-beam computed tomography (CBCT) emerged in the last decades as a valuable diagnostic tool to guide and support clinical decisions, especially in the dental practice [3, 4]. CBCT scanning is performed in a single rotation basis in which a cone-shaped beam of x-rays penetrates the anatomic region of interest towards a digital detector [3]. The scanning process culminates in axial, sagittal and coronal slices that allow a combined multiplanar navigation and the analysis of three-dimensional reconstructions [5]. Despite the higher dose of radiation compared to conventional dental radiographs, such as panoramic and periapical, CBCT contributed to stomatology with a unique and detailed access to head and neck anatomy.

The maxillary sinuses are bone cavities distributed bilaterally in the middle third of the human skull [6]. In the inner surface, the sinus is covered by a mucous membrane [6]. The upper, lower and lateral limits of the maxillary sinus consist of the floor of the orbit, the alveolar bone and the lateral wall of the nasal cavity, respectively [6]. Functionally, these sinuses may play a role in voice resonance, encephalic thermal isolation and balance of pressure in the nasal cavity [6]. Development timing of the maxillary sinus starts around the twelfth week of intrauterine life up to the eighteenth year of age [6, 7]. Normally, the sinuses are found in CBCT scans as anatomic spaces filled with air– consequently appearing with evident hypodensity [8]. However, their shape and size may change based on anatomic variations and pathologic conditions. I) hypoplasia (9), sinus septa (10) and pneumatization (11); and II) mucoceles (12), thickening of the sinus mucosa (13) and oroantral communication (14) and are examples of I) anatomic variations and II) pathologic conditions that may be found in CBCT exams.

Clinically, these alterations and conditions have an essential part prior to therapeutic procedures in Dentistry and Medicine, such as endodontic treatments (15), diagnostic surgeries (16), dental implant placements (17), dental extractions (18), maxillofacial orthopedics/orthodontics (19) and management of trauma (20). Knowing the morphology of the maxillary sinus and the prevalence of anatomic variations and pathologic conditions is an important step to encourage evidence-based practices. In this context, this study aimed to investigate the prevalence of anatomic variations and pathologic conditions in CBCT scans of patients that underwent dental treatment.

Materials and methods.

This study was conducted after the approval of the local Committee of Ethics in Human Research (project number: 980.997).

A retrospective cross-sectional observational investigation was designed. The initial sample consisted of one thousand CBCT scans of male (n: 330) and female (n: 624) patients aged between 2 and 86 years (mean age: 33 years). The images

were acquired from each patient using the iCAT CBCT imaging device (Imaging Science International, Hatfield, PA, USA). The CBCT device was set with a field of view of 16x13cm, voxel size of 0.25, time of acquisition of 26.7 seconds, and mA and kVp of 37.07 and 120, respectively. The use of CBCT scanning was justified for diagnostic and/or therapeutic stomatological purposes for all the patients.

According to the inclusion criteria, only images of patients that underwent dental treatment between the years of 2015 and 2017 were selected. Time restriction was applied to sampling to fit the exact period in which the CBCT device was installed at the local imaging facilities. The exclusion criteria considered ineligible for analysis CBCT scans with poor image quality (e.g. due to improper head angulation and head movement during scanning) and with missing information regarding patients' sex, date of birth and date of image acquisition. After exclusion, CBCT scans of 954 patients (n: 1908 maxillary sinuses) remained eligible for analysis.

Image analysis was performed separately by two trained examiners. Dell Inspiron Small Desktop (Dell Technol., Round Rock, TX, USA) personal computers were used combined with Dell LCL LED 18.5" (Dell Technol., Round Rock, TX, USA) monitors. DICOM files from each patient were imported to the VisionQ (Imaging Science International, Hatfield, PA, USA) imaging software package previously installed in the personal computers. The images were analyzed in a dark room in multiplanar view mode through simultaneous navigations in axial, sagittal and coronal slices. Anatomic variations and signs of pathologic conditions were searched in the contour and into the maxillary sinuses. In a standard spreadsheet the imaginological findings detected during the process of image analysis were registered together with patients' information of sex and age.

The obtained data was analyzed firstly within descriptive statistics. Next, Chi-square test (X2) was used to associate the prevalence of anatomic variations and pathologic conditions of the maxillary sinus with the sex and age of patients. Specifically for the association of maxillary sinus findings with age, the sample was stratified in age groups (n: 34 patients aged <12 years; 94 between 12-18 years; 768 between 18-59 years and 58 >59 years). The statistical analysis was performed with SPSS 20.0 software package (IBM Corp., Armonk, NY, USA) for Windows operating system (Microsoft Corp., Redmond, WA, USA). The significance level was set in 5% ($p<0.05$) during the statistical tests.

Results.

Most of the males (n: 308; 93.33%) and females (n: 539; 86.37%) investigated in this study revealed maxillary sinus findings through CBCT (Table №1). The association between sex and the prevalence of these findings was not statistically significant ($p>0.05$).

Maxillary sinus findings were bilateral in most of the cases (n: 671; 79.22%), followed by separate occurrences in the left (n: 94; 11.10%) and right sinuses, (n: 82; 9.68%) (Table №2).

The distribution of maxillary sinus findings showed a higher prevalence in patients aged between 12 and 18 years (95.74%), followed by the age group of patients between 18 and 59 years (88.8%). Statistically significant associations between the findings and the different age groups were observed ($p<0.05$) (Table №3).

The most prevalent maxillary sinus findings detected in this study through CBCT were the thickening of the sinus mucosa (Figure 1), the presence of sinus septa (Figure 2) and the presence of mucous retention (Figure 3), with prevalence rates of 62.3%, 22.1% and 7.2%, respectively. Thickening of the sinus mucosa and the presence of mucous retention were classified as pathologic conditions, while the presence of sinus septa was classified as anatomic variation (Table №4).

Discussion.

After complete development around the age of eighteen, the maxillary sinuses have a close anatomic relationship with the posterior teeth (6, 7). Clinically, knowing the topographic aspect of these sinuses is of the utmost importance to predict and avoid accidents and complications. CBCT scanning contributes to Dentistry and Medicine, especially in procedures that involve diagnosis and therapeutics of dentomaxillofacial structures, such as the maxillary sinuses (21). Specifically in the routine of Stomatology, imaging exams are often requested for optimal clinical approaches. The present study aimed to analyze CBCT scans of patients treated in routine of Stomatology and screen the prevalence of anatomic variations and pathologic conditions. For a better contribution to the clinical practice, the screened prevalence outcomes were associated with patients' sex and age group.

Compared to other studies in the previous scientific literature (22-24), this study used a considerably larger sample (n: 954). Additionally, CBCT scans were used because it is becoming gradually more popular over the time and more available worldwide (25). The present study benefited from both strategies used in the methodological design. While in one hand the larger sample enables a reliable overview of diagnostic prevalence rates, in the other hand the use of CBCT enables a more accurate analysis of the maxillary sinus itself (26) and the inherent image findings searched in this study – namely the anatomic variations and pathologic conditions.

Table №1. Sample distribution based on sex and the prevalence of maxillary sinus findings.

Sex	Maxillary sinus	
	Findings detected (n)	Findings not detected (n)
Male	308 (93.33%)	22 (6.67%)
Female	539 (86.37%)	85 (13.63%)

Absolute (n) and relative (%) values obtained from the prevalence of maxillary sinus findings in males and females observed through descriptive statistics. The association of maxillary sinus findings with sex were not statistically significant (p>0.05).

Moreover, images of patient that underwent dental treatment were sampled to highlight the importance of maxillary sinus findings in the routine of Stomatology.

Prevalence rates of maxillary sinus findings of over 93% and 86% were observed for males and females, respectively (Table 1). Despite the high prevalence of anatomic and pathologic findings, statistically significant associations with sex were not observed (p>0.05). These outcomes corroborate the study of Drumond et al. (27) that recently observed no association of sex and side of the occurrence of maxillary sinus findings. Regarding the last, the present study found a higher prevalence of bilateral findings instead of unilateral (Table №2) – the same was observed by Drumond et al. (27). Apart the similar outcomes, the authors (27) used spiral computed tomography (27). According to the scientific literature (26), computed tomography may provide important image details of the maxillary sinus that may not be found in panoramic radiographs. In this context, the present study was conducted with adequate methods towards optimal outcomes.

For a more detailed investigation, the sample was stratified in four age groups. Most of the patients were in the age group from 18 to 59 years (n: 768). However, the highest prevalence rate of maxillary sinus findings was not observed in this group (88.80%) but yet in the age group between 12 and 18 years (95.74%), in which 90 out of 94 patients expressed image findings. Statistically significant outcomes were observed by associating age and the prevalence of maxillary sinus findings

Table №2. Distribution of maxillary sinus findings as bilateral or unilateral.

Prevalence	Maxillary sinus findings		
	Bilateral (n)	Unilateral	
		Right (n)	Left (n)
M+F	671 (79.22%)	82 (9.68%)	94 (11.10%)

Absolute (n) and relative (%) values obtained from the prevalence of maxillary sinus findings in the total sample combining males (M) and females (F) observed through descriptive statistics.

(Table №3). With a prevalence rate of 63.20% of maxillary sinus abnormalities, Drumond et al. (27) observed more patients affected in the age range between 20 and 49 years. However, their outcomes were not statistically significant different between age groups [27]. The different outcomes between studies may rely in the methods. While Drumond et al. [27] analyzed more pathology-related abnormalities, the present study used a broader approach and analyzed also anatomic variations of the maxillary sinuses. Consequently, the combination of anatomic and pathologic findings resulted in the higher prevalence rates reported in the present study.

Finally, the top three most prevalent findings detected in the maxillary sinus through cone-beam computed tomography were reported (Table 4). Maxillary sinus septa figured as the only anatomic variations among the three most prevalent. The prevalence (22.1%) of this finding was compatible to that previously reported (nearly 26%) in the scientific literature [28]. The maxillary sinus septa are classified into primary and secondary. The first consists of bone projection inside the sinus that remained unabsorbed during the development of the maxilla [29], while the second may result from alveolar bone resorption and dental loss [30]. This variation has a fundamental role in the clinical practice because it may represent a potential risk factor for membrane perforation during sinus lifting surgeries for implant placement [31]. The septa may be detected in panoramic radiographs and (CB) CT scanning and must be considered in treatment planning prior to surgical interventions in the maxillary sinus.

Among the three most prevalent findings, two had a pathologic origin: the thickening of the sinus mucosa (62.3%) and the presence of mucous retention (7.2%). Clearly, the first reached a higher prevalence rate compared to the second. Pathologic conditions of the maxillary sinus may arise from therapeutic interventions [32] or as a biological response to odontogenic or systemic diseases [21]. Therapeutic interventions that affect the maxillary sinuses may be related to malpractice or not, such as oroantral communication during dental extraction and the surgical access to the sinus for retrieving foreign bodies, respectively. Oppositely, pathologic conditions that emerge as biological responses affect the sinus structure, especially the inner soft tissue. Thickening of the sinus mucosa and mucous retention are often associated with biological responses. While the occurrence of mucous retention phenomenon was less common, thickening of the sinus mucosa entered the spotlight of attention due to the high prevalence (62.3%). This finding also figures as the most prevalent and with high rates (66%) in the study of Rege et al. [33]. The authors used a similar approach with CBCT scanning and high

Table №3. Distribution of maxillary sinus findings, their prevalence and association with the different age groups.

Age group	Sample (n)	Maxillary sinus		Prevalence*
		Findings detected (n)	Findings not detected (n)	
<12 years	34	29 (3.42%)	5 (4.68%)	85.29%
12-18 years	94	90 (10.63%)	4 (3.73%)	95.74%
18-59 years	768	682 (80.52%)	86 (80.38%)	88.80%
>59 years	58	46 (5.43%)	12 (11.21%)	79.31%

*Absolute (n) and relative (%) values obtained from the prevalence of maxillary sinus findings and their prevalence in the different age groups. *Statistically significant associations were observed for the prevalence of maxillary sinus findings within the age groups ($p<0.05$)*

Table №4. Most prevalent maxillary sinus findings detected in the present study through cone-beam computed tomography.

Findings	Prevalence	Type
Thickness of the sinus mucosa	62.3%	Pathologic condition
Presence of sinus septa	22.1%	Anatomic variation
Presence of mucous retention	7.2%	Pathologic condition

Prevalence of maxillary sinus findings and their description as anatomic variation or pathologic condition

lighted the importance of multiplanar navigation of the maxillary sinuses, especially in asymptomatic patients [33]. Clinically, thickening of the sinus mucosa raises a flag signaling potential odontogenic diseases, such as teeth with pulpal infection [33]. In this context, Endodontists play an essential part not only diagnosing the origin of mucosal thickening but also treating and maintaining the sinuses to optimal conditions.

The present study screened a large database of CBCT scans of the maxillary sinus in the search for prevalence rates of anatomic variations and pathologic conditions. Future studies are encouraged to systematically review the scientific literature in order to provide a larger overview of prevalence rates across different populations and with different imaging modalities, such as conventional panoramic radiographs, CBCT scanning and multi-slice CT scanning.

Conclusion.

Professionals in the field of Stomatology must be aware of the potential findings that may be detected through CBCT scanning in order to promote therapeutics with optimal performance in the clinical practice. Diagnosis and treatment planning must be conducted with evidence-based decisions in the routine of Dentistry and Medicine. For this reason, specific knowledge on the radiological anatomic and pathology of the maxillary sinuses is fundamental.

Authors declare the absence of potential conflict of interests.

Authors transmit editorial right to article publication, guarantee its originality and certify that neither the article nor the figures had not been published previously and sent for publication in other editions.

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