Revista ARACÊ
ISSN: 2358-2472

ANALYSIS OF PATHOLOGICAL CHANGES IN THE PARANASAL SINUSES USING CONE BEAM COMPUTED TOMOGRAPHY

https://doi.org/10.56238/arev7n3-169

Date of submission: 18/02/2025 **Date of publication:** 18/03/2025

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ABSTRACT
This prospective study aims to evaluate the prevalence of alterations in the paranasal sinuses using total cranial CBCT scans. A total of 100 CBCT scans were analyzed for the presence of mucoperiosteal thickening, sinusopathies, rhinosinusitis, polyps, bone lesions, and neoplasms in the maxillary sinuses, sphenoid sinus, and frontal sinus. The most frequent comorbidities were analyzed, as well as the most affected paranasal sinuses. Data were collected and evaluated for their normality patterns. The statistical test used was the Kruskal-Wallis ANOVA with Dunn's post-test, followed by a descriptive analysis of the data, using the BioEstat 5.0 program. The most frequent pathologies were mucoperiosteal thickening (41.0%), sinusopathy (31.0%), odontogenic sinusopathy (23.0%), and polyp formation (5.0%). The sinuses that showed the most alterations were the left maxillary, right maxillary, sphenoid, and frontal sinuses, respectively. Additionally, it was observed that, when evaluating the differences between the maxillary and frontal sinuses, there was a

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ISSN: 2358-2472

significant difference between them ($p<0.05$); however, no significant difference was found between the right maxillary, left maxillary, and sphenoid sinuses. This study concluded that mucoperiosteal thickening and sinusopathies are the most prevalent pathological findings, with cone beam computed tomography being a useful tool in assisting diagnosis, and the sphenoid sinuses showed the highest frequency of involvement.

Keywords: Maxillary sinus. Frontal sinus. Sphenoid sinus. Diagnosis. Cone beam computed tomography.

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ISSN: 2358-2472

INTRODUCTION

The paranasal sinuses are composed of the maxillary, sphenoid, ethmoid, and frontal sinuses, which are complex anatomical structures characterized by highly variable size and morphology. The maxillary sinuses are located above the upper premolars and molars, with the largest volume, and have walls adjacent to the infratemporal fossa, nasal cavity, orbit, and alveolar process [19]. The frontal sinus generally has irregular shapes [6] and connects with the maxillary sinuses almost perpendicularly to the airflow of the nasal passage [31]. The sphenoid sinus extends posteriorly to the pre-sellar area [22], surrounded by important neural and vascular structures, which may or may not be exposed depending on the degree of pneumatization [33].

Among the pathological alterations, mucoperiosteal thickening can be mentioned, which consists of a 2 mm increase in the total thickness of the lining mucosa [20]. Sinusopathy, more commonly known as sinusitis, is the most common disease of the paranasal sinuses, which can present as acute (up to 4 weeks), subacute (more than 4 and less than 12 weeks), and chronic (more than 12 weeks); rhinosinusitis is an inflammatory process of the nasal cavity that is also classified according to the duration of symptom evolution [12,24].

Nasosinusal polyposis develops from the thickening of chronically inflamed mucosa and can occur either as a single polyp or in multiple forms [32]. Bone lesions (midface fractures, surgical iatrogenesis, osteoma, and central ossifying fibroma) and neoplasms (cysts, tumors, among others) [11] are also common pathologies. Odontogenic sinusopathy presents as a rupture of the sinus membrane, usually related to periodontal infections, dental abscesses, surgical iatrogenesis, among others [23].

The diagnosis of sinus pathologies can be aided by imaging exams and corroborated by clinical findings. Periapical and panoramic radiographs are not ideal for this purpose, as they provide a two-dimensional view, leading to image overlap and underdiagnosis [2]. The use of cone beam computed tomography (CBCT) allows for the visualization of morphological and anatomical changes in the sinuses, the relationship between lesions and adjacent tissues, as well as the degree of infiltration and depth, reducing pathological underidentifications [24].

The application of more accurate investigative methods assists in early diagnosis, immediate dental referral, and appropriate treatment, reducing future complications and their severity [1]. Therefore, the aim of this study is to determine the prevalence of the most

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ISSN: 2358-2472

common alterations in the paranasal sinuses using total cranial CBCT, by linearly measuring the dimensions of the alterations and identifying the most frequently affected sinuses.

METHODOLOGY

ETHICAL ASPECTS

This research was submitted to the Ethics Committee of the FIBRA University Center and approved under opinion 5.069.745. The scans used were from image archives provided by a dental clinic specialized in radiology in the city of Belém do Pará. The scans were performed between 2011 and 2020.

SAMPLE IDENTIFICATION AND SELECTION

The number of CBCT scans was determined by a sample size calculation, through a pilot study, using the GPower 3.1 program (Heinrich-Heine-Universität Düsseldorf, Germany). The required sample for analysis included 100 scans (with a statistical power of 80% and an α error of 5%). Among the 100 scans used, 200 analyses were of the maxillary sinuses (100 on the right side and 100 on the left side), 100 analyses of the frontal sinuses, and 100 analyses of the sphenoid sinuses. The sample consisted of CBCT scans from both genders (male and female).

The selection of the scans from the archive adhered to inclusion and exclusion criteria, such as patients over 18 years old (maturation of the paranasal sinuses) up to the third decade of life (when they reach maximum pneumatization), complete upper dental arch, absence of previous surgeries, and absence of craniofacial deformities. In this study, the ethmoid sinus was not analyzed due to its high anatomical variability among individuals, making precise verification of this structure difficult.

STRUCTURE ANALYSIS

The image analyses were conducted by three researchers who were properly trained, qualified, and calibrated to identify the anatomical structures and pathological changes related to the maxillary, sphenoid, and frontal sinuses. The evaluations were carried out at two distinct times, with a fifteen-day interval between analyses to verify the reliability of the data and the reproducibility of the study.

Since this study was based on the analysis of image archives, without new exposure to radiation and with a significant sample size, it was exempted from requiring the Informed Consent Form (ICF), based on CNS Resolution 466/12.

The research utilized tools from the CS 3D Imaging Software 3.2.9 (Eastman Kodak, Rochester, USA), which allows extensive projections in various planes (axial, coronal, and sagittal), enabling the identification of the craniofacial complex in DICOM format files (Digital Imaging Communications in Medicine). The sample evaluations focused on the maxillary sinuses (both right and left), sphenoid sinus, and frontal sinus.

The identification of pathological changes in the sinuses was evaluated based on the following criteria: Mucoperiosteal Thickening (mild, discrete, or focal thickening with a thickness greater than 2 mm, observed radiographically as a non-cortical hyperdense band parallel to the bony walls of the sinus); Sinusopathy (a partially or totally hyperdense area of the sinus, or circumferential mucoperiosteal thickening); Odontogenic Sinusopathy (a partially or totally hyperdense area near the roots of teeth); Acute Rhinosinusitis (mucosal thickening with fluid level or presence of air bubbles within the hyperdense nasal cavity); Polyps (hyperdense dome-shaped appearance with the base adhered to the antral wall); Bone Lesions (images with loss of bone continuity or presence of intense calcification in the region, such as bone cysts and midface fractures); and Benign or Malignant Neoplasms (ameloblastic carcinoma, squamous cell carcinoma, among others).

The images were identified based on the presence or absence of changes in the sinuses (Presence: Score 01; Absence: Score 0). In cases involving multiple sinuses, the right and left sides were specified.

Fig. 01: Sagittal section showing the complete structure of the sphenoid and frontal sinuses

Source: authors.

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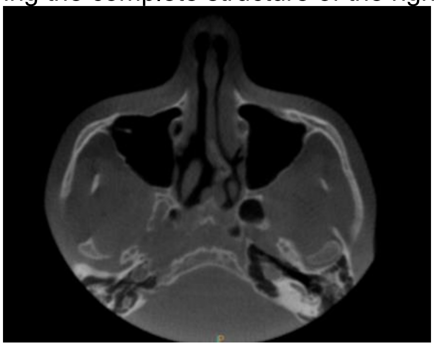
ISSN: 2358-2472

Fig. 02: Frontal section showing the complete structure of the right and left maxillary sinuses.

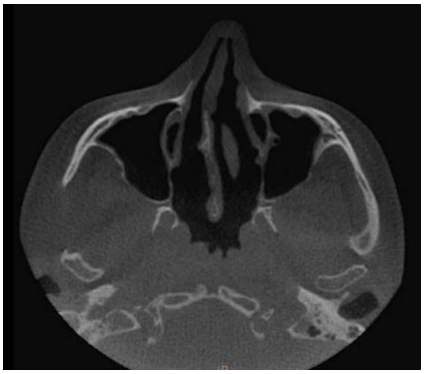
Source: authors.

Fig. 03: Axial section showing the complete structure of the right and left maxillary sinuses



Source: authors.

Fig. 04: Axial section of the maxillary sinuses showing mucoperiosteal thickening



Source: authors.

Fig. 05: Frontal section of the left maxillary sinus showing a sinonasal polyp**.**

Source: authors.

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Fig. 06: Sagittal section of the maxillary sinuses showing odontogenic sinusopathy.

Source: authors.

Fig. 07: Axial section of the right maxillary sinus showing sinus disease**.**

Source: authors.

The evaluation identified the presence (score 1) or absence (score 0) of alterations in the sinuses. The volume of the lesions was estimated by comparing the anteroposterior and laterolateral measurements of the sinus with and without the lesion. The data were statistically analyzed, using the kappa test to verify reliability among evaluators. Statistical analysis was performed with the Bioestat 5.0 program, using ANOVA of Kruskal-Wallis and Dunn's post-test, with a significance level of α=5%.

RESULTS

The data analysis showed that the most frequent pathologies were mucoperiosteal thickening (41.0%), followed by sinusopathy (31.0%), odontogenic sinusopathy (23.0%), and polyp formation (5.0%). No cases of neoplasms, bone lesions, or acute rhinosinusitis were reported in this study. Mucoperiosteal thickening had higher mean values (0.93)

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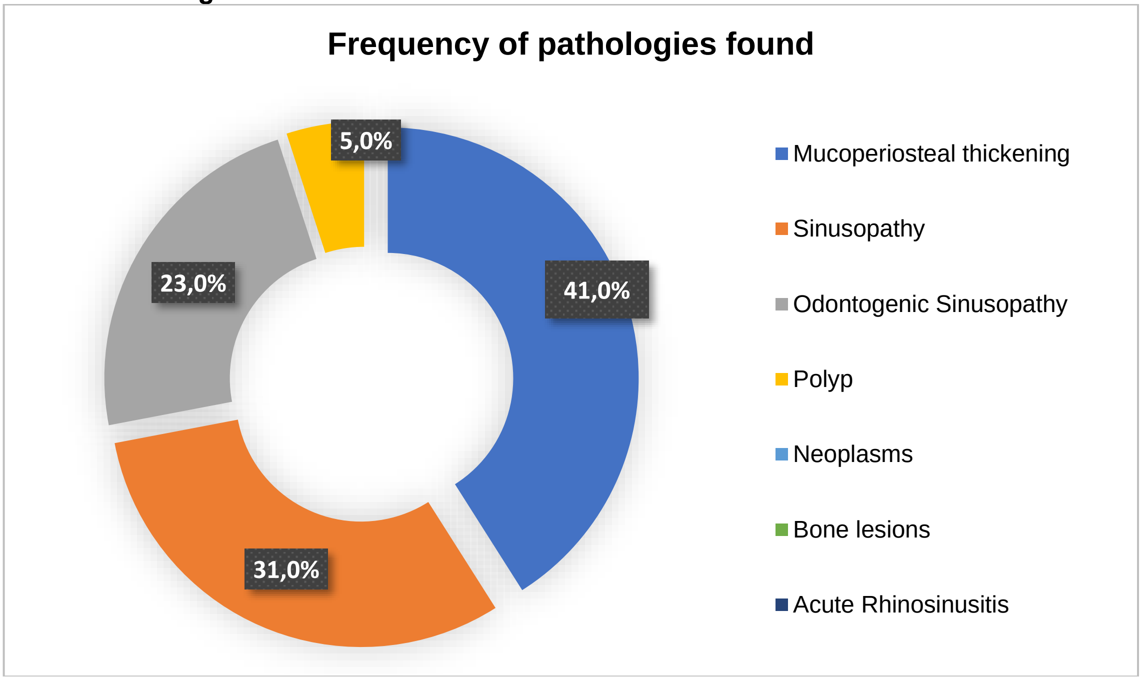
compared to the other pathologies. For a better understanding of the data, see Fig. 10 and Table 01.

Fig. 8: Demonstrative Chart of Alterations in the Paranasal Sinuses



Source: authors

Mucoperiosteal thickening, followed by sinusopathy and odontogenic sinusopathy, showed significant differences between them ($p<0.05$) and in relation to polyp formation, neoplasms, bone lesions and acute rhinosinusitis, there were no findings.

Table 01: Description of the frequency of changes in the sinuses.

	EM	S	SO	P	RA	LO	N
Mín./Max	0.3-1	0-1	0-1	0-1	0-0	0-0	0-0
Average	0.9317	0.4851	0.2277	0.0505	0.0000	0.0000	0.0000
Variance	0.0292	0.1311	0.0522	0.0217	0.0000	0.0000	0.0000
DeviationP.	0.1708	0.3620	0.2285	0.1474	0.0000	0.0000	0.0000

The sinuses that presented the most alterations were the left and right maxillary sinuses, the sphenoid sinus and the frontal sinus, respectively. In addition, it was possible

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to observe that the right maxillary sinus presented a statistically significant difference compared to the frontal sinus ($p<0.05$). However, there was no significance between the left maxillary sinus and the sphenoid sinus.

The left maxillary sinus presented a statistical difference compared to the frontal sinus ($p<0.05$), however, it did not present a difference compared to the sphenoid sinus. When analyzing the frontal sinus with the sphenoid sinus, we can observe a statistical difference ($p<0.05$).

The sinus that presented the highest average of alterations was the left maxillary sinus (0.95) and the lowest standard deviation of the data (0.21). These data can be seen in tables 02 and 03.

Table 02: Frequency of affected sinuses.

	Seio maxilar direito	Seio maxilar esquerdo	Seio frontal	Seio esfenoidal
Mín./Max	0-1	0-1	0-1	0-1
Average	0.9400	0.9500	0.5030	0.9330
Variance	0.0570	0.0480	0.2225	0.0489
Standard deviation	0.2387	0.2190	0.4717	0.2211

To assess the estimation of agreement between the evaluators, the kappa test was performed, in which the analysis demonstrated a kappa of 0.57, demonstrating a moderate estimate, with data in agreement.

Table 03: Description of measurements of the paranasal sinuses.

	SMD - AP	SMD - LL	SME - AP	SME - LL	F- AP	F - LL	E - AP	E - LL
Mín./Max	0-21.7	0-16.8	0-19.9	0-15.9	0-24.5	0-4.90	0-4.90	0-21.7
Average	9.7940	4.5700	8.5040	4.9820	4.1980	0.8540	6.5180	8.7570
Variance	48.7816	21.5985	56.7079	28.2512	47.1158	2.1318	24.8015	53.5970
Standard deviation	6.9844	4.6474	7.5305	5.3152	6.8641	1.4601	4.9801	7.3210

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When evaluating the anteroposterior and laterolateral volumes of each sinus, only the right maxillary sinus showed a difference, the others did not.

In the analysis of the anteroposterior and laterolateral measurements, the maxillary sinuses did not show any statistical difference between them, but when compared to the frontal sinus and the sphenoid sinus, significant differences were found, as well as between the frontal sinus and the sphenoid sinus ($p<0.05$).

In laterolateral measurements, we can observe a difference between the right and left maxillary sinuses and the frontal sinus and the sphenoid sinus.

DISCUSSION

Paranasal sinuses are pneumatic cavities with physiological and structural functions. External influences such as viruses, bacteria, and allergic processes can cause inflammatory reactions in the sinus membrane [6,20,26]. When present, an increase in the total thickness of the mucosa can be observed, which is the most common pathology with a prevalence ranging from 8% to 29% [20]. This finding is consistent with the present study, where mucoperiosteal thickening was found in 41.0% of the analyzed cases, compared to other pathologies.

Some studies suggest that mucosal thickening greater than 2 mm is indicative of nasosinusal inflammation, while others classify any thickening as sinusitis. This variation, though small, can introduce bias in diagnosing sinusitis, potentially overestimating or underestimating its prevalence [17,3]. In this study, 31.0% of findings presented hyperdense areas greater than 2 mm, suggesting possible sinusopathy.

For the maxillary sinus, the likelihood of inflammatory conditions is approximately three times higher when a dental root is in contact with the sinus floor, as seen in the area of the upper first molars, where root length and pneumatization are greater [20]. Literature reports that odontogenic sinusitis accounts for 10% to 12% of sinus infections [23], while Lima et al. (2017) states that this prevalence can reach up to 40.0%. In this analysis, 23.0% of findings were odontogenic sinusopathy, making it the third most prevalent pathological finding, highlighting the importance of understanding this condition.

Common causes include dental abscesses, periodontal diseases, secondary infections from foreign bodies, and iatrogenic factors from surgical procedures. Accurate diagnosis requires thorough evaluation through clinical and appropriate imaging exams [23].

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Misdiagnosis can result in ineffective treatments and worsening of the disease, potentially spreading to adjacent areas such as the periorbital and cavernous regions [34].

Inflammations and infections associated with these sinuses often involve bilateral manifestations, even when clinical symptoms are unilateral. In the analysis of anteroposterior and laterolateral measurements, the maxillary sinuses did not show statistical differences [30].

The sphenoid sinus is one of the most morphologically variable structures, with asymmetric cavities located within the sphenoid body, separated by a frequently laterally deviated bony septum [22]. In this study, when measured in the anteroposterior and laterolateral directions, the sphenoid sinus showed numerically higher median values along with the maxillary sinuses.

Nasosinusal polyposis is a chronic inflammatory disease of the nasal mucosa and paranasal sinuses, leading to varying degrees of upper respiratory tract obstruction [34], causing blockage, congestion, and nasal discharge [15]. Several authors consider nasal polyps a subdivision of chronic rhinosinusitis [11,32], affecting more than 10% of the Western population [4]. In this study, 5.0% of the analyzed scans showed polyp formation, and no cases of acute rhinosinusitis were found, suggesting a chronic state. However, this assertion can only be definitive when correlated with clinical and endoscopic data [18].

The exact pathogenic mechanisms and etiological agents of rhinosinusitis are not fully discerned. Typical tomographic and radiological characteristics include air levels or complete opacification in one or more sinuses [9].

Regarding bone lesions and benign or malignant neoplasms, literature indicates that they are more common in the lower face regions compared to the upper regions [5,29], which aligns with the results found in this study, which showed 0% occurrence. Despite their low frequency, when affecting the paranasal sinuses, bone lesions and neoplasms can be more aggressive, potentially involving the zygomatic bone, maxillary sinus, and even the orbit [13,14].

CONCLUSION

This study concluded that mucoperiosteal thickening and sinusopathies are the most prevalent pathological findings. The left and right maxillary sinuses showed the highest frequency of involvement. The use of cone beam computed tomography (CBCT) is a crucial tool in aiding diagnosis.

ISSN: 2358-2472

ACKNOWLEDGMENTS

We would like to thank the researchers and collaborators who contributed to the completion of this study, as well as the Centro Universitário Fibra and the Federal University of Pará for their institutional support. We express our special gratitude to Dr. and Professor Fabrício Mesquita Tuji for providing the database of tomographic exams, which was essential for the development of this work.

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