Comparison of CBCT and panoramic radiography for the evaluation of opacification of the maxillary sinuses

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ABSTRACT | *Objective:* Thorough assessment of the maxillary sinus (MS) is very important. Panoramic radiography (PR) is an accessible and well-established imaging technique in dental practice; however, inherent inaccuracies are inevitable. Recently, cone beam computed tomography (CBCT) has emerged as an acceptable alternative. Thus, the aim of this study was to compare the diagnostic accuracy of panoramic and CBCT images for MS opacification evaluation. *Methods:* Panoramic and CBCT images of 51 patients were selected from a database. The images were randomly assessed for the presence or absence of MS opacification, by two calibrated evaluators (evaluators 1 and 2) in two reading sessions. A third oral radiologist evaluated the imaging findings provided by the CBCT (Evaluator 3). *Results:* Of the 51 evaluated cases, 33 patients—20 females and 13 males—presented MS opacification. The results showed significant disagreement between the diagnosis of evaluators 1 and 2 and Evaluator 3 (76.5% and 60.8%), and fair agreement between evaluators 1 and 2 (68.7%). *Conclusions:* CBCT images were more accurate in evaluating and locating opacification involving the MS. Panoramic images were able to identify it correctly but not to locate it.

DESCRIPTORS | Maxillary Sinus; Radiography, Panoramic; Cone Beam Computed Tomography; Paranasal Sinuses.

RESUMO | **Comparação de TCFC e radiografia panorâmica na avaliação de velamento em seio maxilar** • *Objetivo:* A avaliação completa do seio maxilar (SM) é muito importante. A radiografia panorâmica é uma técnica de imagem acessível e bem estabelecida na prática odontológica; no entanto, imprecisões estão sempre presentes. Recentemente, a tomografia computadorizada de feixe cônico (TCFC) está emergindo como uma alternativa aceitável. Assim, o objetivo deste estudo foi comparar a precisão de diagnóstico proporcionada por imagens panorâmicas e imagens de TCFC para a avaliação de velamentos no seio maxilar. *Métodos:* Imagens panorâmicas e de TCFC de 51 pacientes foram selecionadas a partir de uma base de dados. As imagens foram aleatoriamente observadas por dois avaliadores calibrados em duas sessões de leitura para a presença ou ausência de velamentos no SM. Um terceiro radiologista oral avaliou as imagens fornecidas pela TCFC. *Resultados:* Dos 51 casos avaliados, 33 pacientes – 20 do sexo feminino e 13 do masculino – apresentaram velamentos no SM. Os resultados mostraram discordância significativa entre o diagnóstico dos avaliadores 1 e 2 e o do Avaliador 3 (76,5% e 60,8%), e também uma concordância razoável entre os avaliadores 1 e 2 (68,7%). *Conclusões:* As imagens tomográficas foram mais precisas na avaliação e localização de velamentos envolvendo o SM. As imagens panorâmicas foram capazes de identificar corretamente os velamentos, mas não localizá-los.

DESCRITORES | Seio Maxilar; Radiografia Panorâmica; Tomografia Computadorizada de Feixe Cônico; Seios Paranasais.

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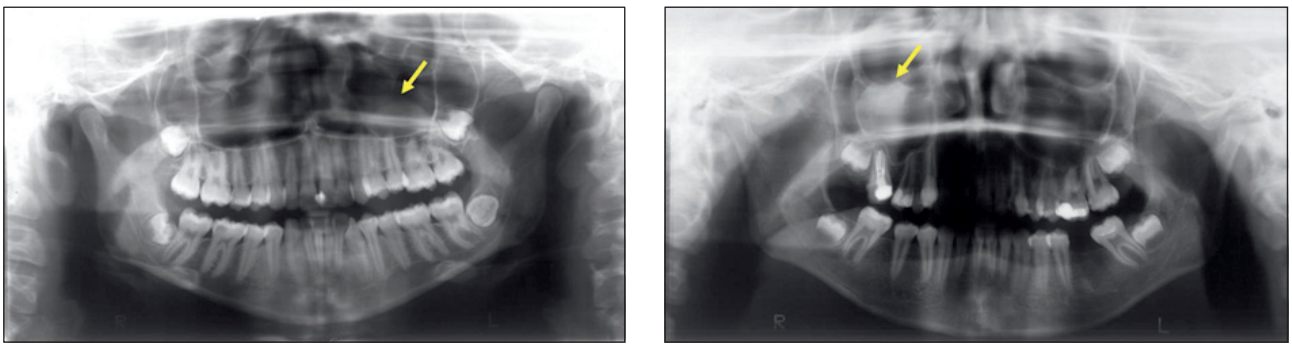

Figure 1 | Panoramic radiographs showing maxillary sinus opacification corresponding to antral pseudocyst.

INTRODUCTION

The maxillary sinuses (MSs) are frequently included in dental imaging exams (figures 1 through 3). The evaluation of these structures is essential in certain situations, for example, before placement of dental implants and assessment of odontogenic pathologies, including cases associated with patients that do not present classical clinical signs and symptoms of an inflammatory reaction (sinusitis).[1]

The MSs are included in panoramic images, and may be used to identify changes within these structures (Figure 1). In panoramic images, any mucosal reaction of bacterial, viral, fungal, allergic or neoplastic origin will appear as an ill-defined opacification, and an antral pseudocyst or mucous retention cyst, as a round-shaped opacification.[2] However, panoramic images commonly present distortions and an overlap of structures, which are inherent to the technique. These factors considerably limit the evaluation and diagnostic accuracy of the MS.[3]

Three-dimensional images have become more accessible to the dental community, with the greater availability of cone beam computed tomography (CBCT).[4] This imaging modality is able to provide reconstructed images not only in axial, coronal and sagittal planes, but in virtually any desired plane. Another advantage is associated with the amount of radiation delivered to the patient, a dose considerably lower than helical CT.[5] Therefore, the aim of this study was to compare the diagnostic accuracy of digital panoramic radiography (PR) and CBCT in evaluating opacification involving the MS.

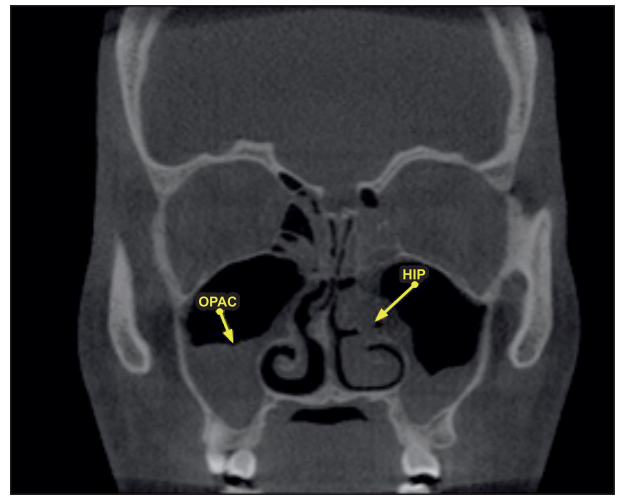

Figure 2 | Coronal view showing diffuse maxillary sinus opacification (OPAC) and hypertrophic ethmoidal cells and left nasal turbinate (HIP).

MATERIAL AND METHODS

Fifty-one patients age 18 to 72 years, of both genders, were selected for this study, in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and all subsequent revisions. They were imaged by the same digital panoramic machine (Orthophos CD, Siemens, Benshein, Germany) with imaging settings of 60 to 90 kVp, 9 to 12 mAs and 12 s of exposure. In the same visit, the patients were examined by a CBCT system

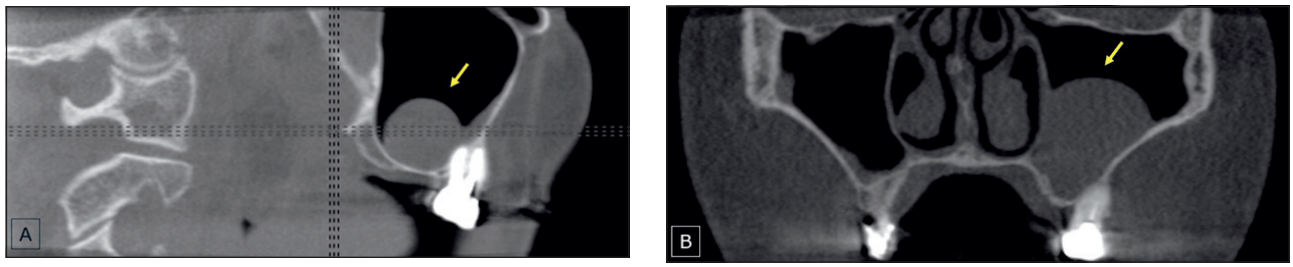

Figure 3 | A: Sagittal view showing maxillary sinus opacification corresponding to antral pseudocyst. B: Coronal view.

Table 1 | Sample features: gender and age.

Gender	n (%)	Age	
Female	31 (60.8%)	Average:	41.5
		Minimum:	18
		Maximum:	72
Male	20 (39. 2%)	Average:	31.1
		Minimum:	18
		Maximum:	54
Total	51 (100%)		

Table 2 | Field of view (FOV) protocols.

	FOV 6 cm	FOV 19 cm	Total
Sample	42	9	51

Table 3 | Opacification frequency according to gender.

	Frequency	%
Female	20	61%
Male	13	39%
Total	33	100%

(i-Cat® Classic, Imaging Sciences International, Hatfield, USA) in two field of view (FOV) protocols (Table 2), according to the specific patient-related radiographic needs. The CBCT images were evaluated with XoranCAT software (Xoran Technologies Inc, Ann Harbor, USA). Tables 1 and 3 describe the characteristics of the population studied.

Information regarding gender, age and presence or absence of opacification of one or both MSs was collected for each patient. All images were evaluated by two oral radiologists (evaluators 1 and 2) with experience in interpreting panoramic radiographs. The images were presented in two separate sessions within a one week period at least. A third oral radiologist (Evaluator 3) of notable expertise in maxillofacial radiology and computed tomography evaluated the imaging findings provided by the CBCT.

A statistical package (SPSS for Windows, version 11.0) was used to perform a descriptive analysis with absolute and relative frequencies of sinus opacification. The concordance between evaluators 1 and 2, and also between evaluators 1 and 2 and the gold standard (Evaluator 3) was obtained using kappa analysis. The significance level was set at $p < 0.05$. An age analysis was performed to obtain mean, standard deviation, maximum and minimum values for the study sample.

RESULTS

The mean age of the sample evaluated was 41 years for females (18 to 72 years, SD = 14) and 31 years for males (18 to 54 years, SD = 11). In regard to gender, the opacification frequency was 20 females (61%) and 13 males (39%). Table 4 describes the sinus-wall-associated opacification, and Table 5, the frequency of opacification cases with odontogenic etiology.

Of the 51 patients, Evaluator 3 diagnosed opacification in 33 patients (65% of the population). As regards the radiographic findings, Evaluator 1

Table 4 | Opacification distribution according to its location in MS walls.

MS walls	Frequency	%
Medial	25	49.0%
Lateral	24	47.1%
Anterior	21	41.2%
Posterior	11	21.6%

Table 5 | Frequency of opacification associated to odontogenic causes.

	Frequency	%
Yes	5	15%
No	28	85%
Total	33	100%

Table 6 | Presence of opacification: Evaluator 3 versus Evaluator 1.

Evaluator 1	Evaluator 3		Total
	Present	Absent	
Present	26 (51.0%)	5 (9.8%)	31 (60.8%)
Absent	7 (13.7%)	13 (25.5%)	20 (39.2%)
Total	33 (64.7%)	18 (35.3%)	51 (100.0%)

The underlined values represent the accordance observed.

Table 7 | Presence of opacification: Evaluator 3 versus Evaluator 2.

Evaluator 2	Evaluator 3		Total
	Present	Absent	
Present	15 (29.4%)	2 (3.9%)	17 (33.3%)
Absent	18 (35.3%)	16 (31.4%)	34 (66.7%)
Total	33 (64.7%)	18 (35.3%)	51 (100.0%)

The underlined values represent the accordance observed.

Table 8 | Presence of opacification: Evaluator 1 versus Evaluator 2.

Evaluator 1	Evaluator 2		Total
	Present	Absent	
Present	16 (31.4%)	15 (29.4%)	31 (60.8%)
Absent	1 (2.0%)	19 (37.3%)	20 (39.2%)
Total	17 (33.3%)	34 (66.7%)	51 (100.0%)

The underlined values represent the accordance observed.

Table 9 | Estimate of the Kappa coefficient between Evaluator 3 and evaluators 1 and 2.

	Kappa coefficient	Standard-error	*p*
Evaluator 3 versus Evaluator 1	0.498	0.125	< 0.001
Evaluator 3 versus Evaluator 2	0.286	0.104	0.103
Evaluator 1 versus Evaluator 2	0.415	0.105	0.001

0.41 and 0.498 = moderate; 0.286 = fair.

was able to correctly diagnose opacification in 26 cases (51%), and Evaluator 2 in 15 cases (30%). As regards the presence or absence of opacification, Evaluator 1 was able to provide a correct diagnosis in 39 cases (76.5%) and Evaluator 2 in 31 cases (60.8%; Table 6 and 7). Agreement between evaluators 1 and 2 was observed in 35 cases (68.6%), as shown in Table 8.

In regard to the agreement between Evaluator 3 and evaluators 1 and 2, moderate agreement was observed between Evaluator 3 and Evaluator 1 (k = 0.49), and between evaluators 1 and 2 (k = 0.41). The statistical analysis showed significant difference between Evaluator 3 and Evaluator 1 (p < 0.001) and between evaluators 1 and 2 (p = 0.001). Fair agreement was observed between Evaluator 3 and Evaluator 2 (k = *0*.28; Tabela 9). No significant difference was noted between Evaluator 3 and Evaluator 2 (p = 0.103). These results are presented in Table 10.

In regard to the location of the opacification (right, left or both sinuses), Evaluator 1 agreed with Evaluator 3 in 26 cases (51%) and with Evaluator 2 in 24 cases (48%), and evaluators 1 and 2 agreed in 27 cases (53%; Tables 10, 11 and 12). The kappa analysis showed fair agreement between Evaluator 3 and evaluators 1 and 2, as well as between evaluators 1 and 2 (Table 13), with positive statistical significance (p < 0.001)

Table 10 | Frequency of opacification on the affected side: Evaluator 3 versus Evaluator 2.

Evaluator 2	Evaluator 3				Total
	Present on both sides	Right	Left	Absent on both sides	
Present on both sides	1 (2.0%)	-	-	-	1 (2.0%)
Right	2 (3.9%)	3 (5.9%)	1 (2.0%)	-	6 (11.8%)
Left	3 (5.9%)	1 (2.0%)	4 (7.8%)	2 (3.9%)	10 (19.6%)
Absent on both sides	9 (17.6%)	6 (11.8%)	3 (5.9%)	16 (31.4%)	34 (66.7%)
Total	15 (29.4%)	10 (19.6%)	8 (15.7%)	18 (35.3%)	51 (100.0%)

The underlined values represent the accordance observed.

Table 11 | Frequency of opacification on the affected side: Evaluator 3 versus Evaluator 1.

Evaluator 1	Evaluator 3				Total
	Present on both sides	Right	Left	Absent on both sides	
Present on both sides	9 (17.6%)	5 (9.8%)	1 (2.0%)	3 (5.9%)	18 (35.3%)
Right	4 (7.8%)	1 (2.0%)	1 (2.0%)	1 (2.0%)	7 (13.7%)
Left	1 (2.0%)	1 (2.0%)	3 (5.9%)	1 (2.0%)	6 (11.8%)
Absent on both sides	1 (2.0%)	3 (5.9%)	3 (5.9%)	13 (25.5%)	20 (39.2%)
Total	15 (29.4%)	10 (19.6%)	8 (15.7%)	18 (35.3%)	51 (100.0%)

The underlined values represent the accordance observed.

Table 12 | Frequency of opacification on the affected side: Evaluator 1 versus Evaluator 2.

Evaluator 1	Evaluator 2				Total
	Present on both sides	Right	Left	Absent on both sides	
Present on both sides	1 (2.0%)	3 (5.9%)	4 (7.8%)	10 (19.6%)	18 (35.3%)
Right	-	3 (5.9%)	1 (2.0%)	3 (5.9%)	7 (13.7%)
Left	-	-	4 (7.8%)	2 (3.9%)	6 (11.8%)
Absent on both sides	-	-	1 (2.0%)	19 (37.3%)	20 (39.2%)
Total	1 (2.0%)	6 (11.8%)	10 (19.6%)	34 (66.7%)	51 (100.0%)

The underlined values represent the accordance observed.

DISCUSSION

Images of the head and neck frequently include several structures unfamiliar to general dentists. This clearly shows the importance of an oral and maxillofacial radiology report to identify any alterations involving structures like the MSs.[6]

Helical CT has been used to evaluate alterations in paranasal sinuses, including opacification and changes in the sinus walls, due to pathologies including malignant diseases.[7,8] In studies involving the MS, these images are frequently used to define the gold standard.[9] However, according to the studies by Pinsky *et al.*[10] (2006) and Lou *et al.*[11] (2007), CBCT images are able to produce images with high quality and resolution, and to provide accurate diagnosis of changes involving the MSs.[10,11] Thus, we used CBCT in our study to compare the diagnostic accuracy of two-dimensional panoramic radiography images with that of three-dimensional projection images in evaluating opacification and struc-

Table 13 | Estimate of the Kappa coefficient between Evaluator 3, and evaluators 1 and 2 on the affected side.

	Kappa coefficient	Standard error	*p*
Evaluator 3 versus Evaluator 1	0.312	0.091	< 0.001
Evaluator 3 versus Evaluator 2	0.249	0.080	< 0.001
Evaluator 1 versus Evaluator 2	0.320	0.079	< 0.001

tural alterations of the MSs.

Several studies have demonstrated the low specificity of panoramic images in detecting MS opacification. Ohba *et al.*[7] (1994) demonstrated that panoramic images were less accurate in detecting changes in the anterior and posterior walls of the sinuses, due to the overlap with the medial sinus wall. Ogawa[12] (1975) found that imaging artifacts from the contralateral mandibular ramus in the maxillary sinus also make the detection of sinus changes more difficult. Technical features of the panoramic images, such as the almost vertical x-ray projection over the medial sinus wall, also make the detection of changes in the MS more difficult.[13]

Our study observed a statistically significant difference between the assessment of evaluators 1 and 2 (Table 8 and 12). The agreement between these evaluators was fair (68.7%). In regard to the agreement between evaluators 1 and 2 and the gold standard, moderate agreement was observed between Evaluator 1 and the gold standard (76.5%), and fair between Evaluator 2 and the gold standard (60.8%). These results show the subjectivity associated with interpreting panoramic images (Table 9).

In regard to the location of the opacification in the MS, Ohba *et al.*[9] (1990) found that opacification detection was more efficient when it was located in the inferior and posterior regions of the sinuses. In our study, opacification was more frequent in the medial wall (49%), followed by the lateral (47.1%) and the anterior (41.2%) walls, respectively (Table 4). The difference among these locations may explain the low agreement between the panoramic and the CBCT images (Table 10 and 11).

Our study was limited to comparing the accuracy in identifying MS opacification using panoramic images and CBCT. No information was collected on the patient's chief complaints, symptoms or other alterations associated with the paranasal sinuses or upper airway. One study compared the findings of panoramic and CBCT images for the detection of changes in the sinus walls and MS opacification. It observed significant variance between the evaluators, depending on the location of the opacification.[14]

In the study by Soikkonen and Ainamo[15] (1995), no significant difference was observed in detecting MS opacification in the panoramic images of patients between the age of 76 and 86 years. In fact, there was a slight increase in the incidence of diffuse opacification with a decrease in age.[14] In our study, there was a higher incidence of diffuse opacification in patients between the age of 30 and 50 years. Our population was composed of 68.8% females and 39.4% males. The mean age among females was 41 years, versus 31 years for males. The difference in the number of individuals and the average age of our sample may have affected our results. Small variations in the incidence of MS alterations would be observed better if the study sample were more homogeneous.

In regard to the antral pseudocysts of the MS, Allard *et al.*[16] (1981) observed an incidence between 1.4% and 9.6%.[18] In our CBCT images, the incidence of circumscribed opacification, diagnosed as antral pseudocysts, was 5.8% and was higher in females (Table 14). In the study by MacDonald-Jankowski[10] (1993), the incidence of antral pseudocysts was 5.2%, and higher in males. As regards the symptoms associated with pseudocysts, all our patients were asymptomatic. In one study, 14% of the population evaluated presented symptoms, and, in an-

Table 14 | Frequency of well-defined MS opacification considered as antral pseudocysts.

Location	Age	Frequency	%
Right	50 – 59.9	1	1.9%
Left	60 – 69.9	2	3.9%
Total		3	5.8%

other study, the figure was 11%.[16,17] Similarly to the study by Soikkonen and Ainamo[15] (1995), a higher incidence of pseudocysts was observed with an increase in age (Table 14).

Our study was not designed to associate odontogenic etiologic factors with maxillary sinus opacification, but possible odontogenic etiology could be observed in 15% of our cases. Lee *et al.*[17] (1988) observed changes in the MSs due to the dental pathologies present in 10% of their patients.

CONCLUSION

In conclusion, in our study, even though panoramic radiography is widely available and exposes patients to a relatively low dose of radiation, the images they provide were not able to support acceptable evaluation of opacification involving the MSs. The MSs are frequently included in CBCT exams; it is therefore important for oral and maxillofacial radiologists to receive appropriate training so that they can identify any alterations in these structures.

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