

Evaluation of Maxillary Sinus Septa Prior to Dental Implant Therapy: A Cone Beam Computed Tomography Study

Evaluación del Septo del Seno Maxilar Antes del Tratamiento con Implantes Dentales:
Un Estudio con Tomografía Computarizada de Haz Cónico

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SUMMARY: The objective of this study was to investigate the prevalence and location of maxillary sinus septa prior to dental implant therapy in different age groups by cone beam computed tomography (CBCT) and identify the most helpful orthogonal plane for this purpose. CBCT scans of 200 patients were selected. The final sample was divided into four groups according to age: (1) 30-39 y.o.; (2) 40-49 y.o.; (3) 50-59 y.o.; (4) +60 y.o. Three calibrated examiners assessed the presence and location (anterior, middle, posterior) of sinus septa using all orthogonal slices. The prevalence of septa per region and plane was compared by chi-square test. Among 359 maxillary sinuses evaluated, it was observed at least one septum in 163 sinuses (45.4 %). Overall, the anterior region was the most prevalent. However, when the age groups were considered, the anterior region was only the most prevalent in groups 2 and 3. The middle and posterior regions were more prevalent in groups 4 and 1, respectively. In conclusion, the prevalence of maxillary sinus septa in patients who were candidate to dental implant therapy was notably high. It was observed that the anterior region of the sinus was the most prevalent and the axial slice was the most representative.

KEY WORDS: anatomy, cone beam computed tomography, diagnosis, maxillary sinus.

INTRODUCTION

Paranasal sinus septum is defined as a fin-shaped projection of bone that may exist in the sinus in any size, location and orientation. The sinus septa can be classified according to its origin into primary and secondary. Primary septa arise from the development of the maxilla, whereas the secondary septa originate from an irregular pneumatization (Lee *et al.*, 2010; Ilgüy *et al.*, 2013; von Arx *et al.*, 2014). The prevalence of these projections may vary depending on the ethnic group, diagnostic method

used, and dentition status of the patient (i.e., dentulous, partially edentulous or edentulous patients) (Shen *et al.*, 2012; Ilgüy *et al.*; von Arx *et al.*).

The increasing demand for osseointegrated dental implants and, consequently, the need for maxillary sinus floor augmentation surgery highlighted the necessity of an accurate identification of the presence of sinus septa. When septa are neglected, the chance of surgical complications increases, mainly because

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of the risk of membrane perforation during the procedure, oroantral fistulas and sinusitis (Kim *et al.*, 2006; Rosano *et al.*, 2010; Vogiatzi *et al.*, 2014).

Conventional extraoral radiographs do not allow a good evaluation of the maxillary sinuses. Once it is a two-dimensional image of three-dimensional structures, invariably superimposition of structures will typically happen. Nowadays, cone beam computed tomography (CBCT) is the main choice in Dentistry when bone structures need to be evaluated in detail (Vogiatzi *et al.*). Uncountable studies have been proven the advantages of this technique in most different situations including the diagnosis of septa in the maxillary sinuses (Kim *et al.*; Naitoh *et al.*, 2009; Orhan *et al.*, 2012), but most of them evaluated septa in Computed Tomography (CT) (Krennmair *et al.*, 1999; Koymen *et al.*, 2009; van Zyl & van Heerden, 2009; Lee *et al.*; Shen *et al.*).

The aim of this study was to investigate the prevalence and location of maxillary sinus septa in different age groups by CBCT images, and identify the most helpful orthogonal plane for this purpose.

MATERIAL AND METHOD

This study was approved by the Ethics Committee in Research of the Piracicaba Dental School at the University of Campinas, Piracicaba, São Paulo, Brazil (register number 077/2012) and complied with the recommendations of the National Health Council Ministry of Health of Brazil for research in human patients.

A sample of CBCT scans was selected from a dental school database. To be included on the study,

the CBCT volume should completely cover at least one of the maxillary sinuses. Besides that the patient needed to be totally or partially edentulous. Partially edentulous individuals were considered, when at least two consecutive premolars and/or molars were missing. On the other hand, patients whose maxillary sinuses presented with pathological changes or it could not be observed in its full extension, as well as totally edentulous patient were not selected. In the study 200 consecutive patients were analyzed, but only 359 maxillary sinus were selected. The final sample was divided into six groups according to age of the patients: group 1: 30-39 y.o.; group 2: 40-49 y.o.; group 3: 50-59 y.o.; group 4: +60 y.o.

All scans were part of a preoperative planning for implant placement in the maxilla and were acquired on the same device (i-CAT Next Generation; Imaging Sciences International, Hatfield, PA, USA), according to the protocol recommended by the manufacturer for 0.25 mm voxel resolution covering the maxilla (6 x 8 cm field of view, 120 kVp, 8mA, 26.9 s for acquisition). Images were processed and reconstructed on the proprietary software (Xoran CAT v. 3.0.34; Xoran Technologies, Ann Arbor, MI, USA). All resulting images were coded and randomly displayed on a 21-inch LCD monitor with a matrix resolution of 1280 x 1024, under dim-light conditions, in sets of 20 images. Each set was viewed separately by three examiners, who identified the presence and location of sinus septa by performed a dynamic evaluation, using all orthogonal slices (axial, coronal and sagittal). They could adjust brightness and contrast and use the zoom tool, but task-specific filters were not permitted.

Once identified, the septa were classified according to its location, following the classification suggested by Lee *et al.*: anterior septum (from the anterior wall of the sinus to the distal aspect of the second

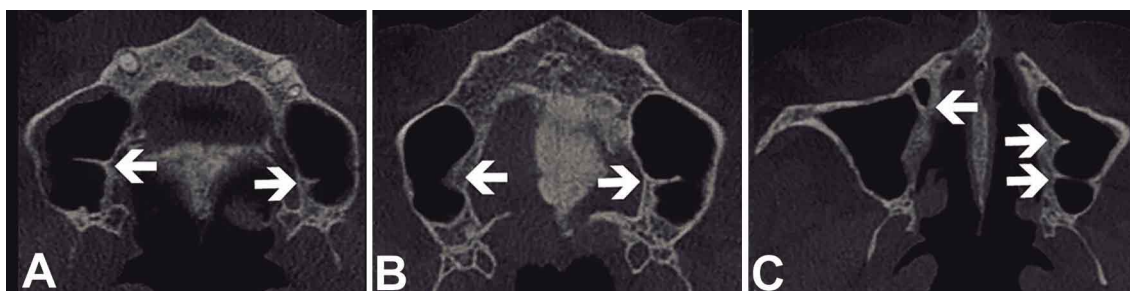


Fig. 1. Cone beam computed tomography (CBCT) axial sections showing examples of the maxillary sinus septa classification according to its location (arrows). A – Middle (right sinus) and posterior (left sinus) septa; B – Posterior septa (both sinuses); C – Anterior (right sinus), middle and posterior (left sinus) septa.

premolar, or its equivalent region), middle septum (from the distal aspect of the second premolar to the distal aspect of the second molar, or its equivalent regions), and posterior septum (from the distal aspect of the second molar, or its equivalent region, to the posterior wall of the sinus) (Fig. 1). The examiners were also asked to indicate the most representative orthogonal slice (axial, coronal and sagittal) for the visualization of each particular septum (Fig. 2).

A second evaluation was performed after 30 days, under the same conditions, to assess the reproducibility of the method. The examiners were previously calibrated by two oral and maxillofacial radiologists. The calibration consisted of written and verbal instructions about CBCT image interpretation

and the usage of the software, with examples of maxillary sinus septa in CBCT scans. Cohen's kappa was used to calculate intra- and interobserver agreement, and interpreted as follows: poor agreement (< 0.40), moderate agreement (0.40-0.59), good agreement (0.60-0.74), and excellent agreement (0.75-1.00). The prevalence of septa per age group (30-39 y.o., 40-49 y.o., 50-59 y.o. and +60 y.o.), region (anterior, middle and posterior) and slice (axial, sagittal and coronal) was compared by chi-square test. The level of significance was set at $p < 0.05$. Data analyses were performed using Graphpad Prism for Windows (version 5.0; GraphPad Software Inc, La Jolla, CA, USA) and the Statistical Package for Social Sciences (SPSS) for Windows (version 13.0; Chicago, IL, USA).

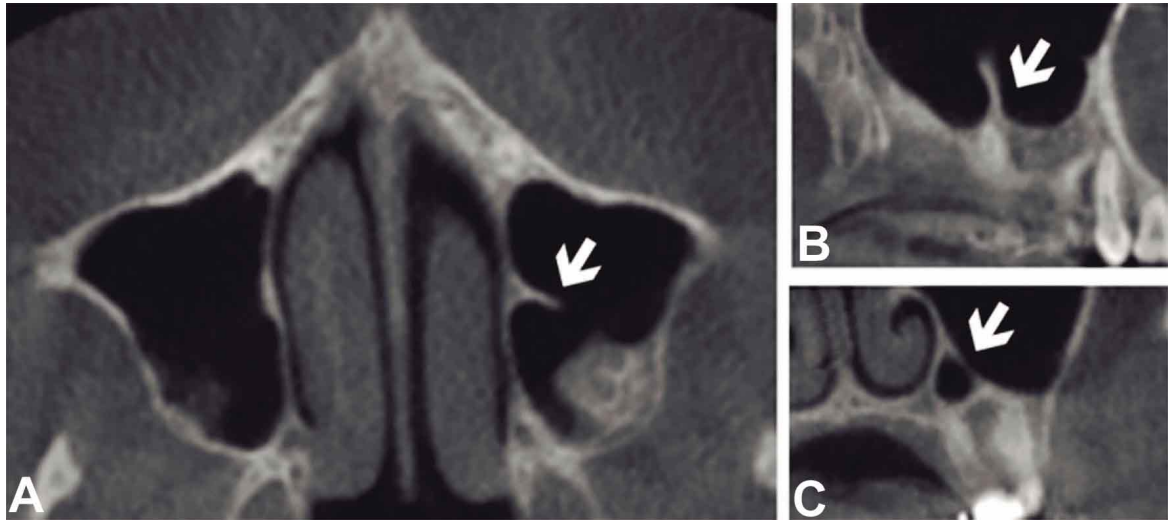


Fig. 2. Cone beam computed tomography (CBCT) axial (A), sagittal (B) and coronal (C) sections of the same patient showing the location of a middle septum in the left maxillary sinus (arrow).

RESULTS

Overall, the reproducibility of the examiners was considered excellent. The intraobserver agreement ranged from 78.88 % to 88.2 %, while the interobserver agreement ranged from 74.53 % to 82.61 %.

After establishing the inclusion criteria, 359 maxillary sinuses were evaluated. It was observed the prevalence of at least one septum in 163 sinuses (45.4 %), and a total of 179 septa. The prevalence of septa was higher in patients younger than 40 years, but there was no statistically significant difference ($p > 0.05$) (Table I).

The prevalence of septa was also distributed according to the region of the sinus. Overall, it was found that the anterior region was the most prevalent, followed by posterior and middle regions. However, when the age groups were considered, it was observed that the anterior region was only the most prevalent in group 2. Septa in the posterior region were more prevalent in subjects of group 4 (Table II).

According to the examiners, the most representative CT plan to evaluate the presence of maxillary sinus septa was the axial view, followed by sagittal and coronal, independent of age group ($p = 0.34$) (Table III).

Table I. Distribution n (%) of maxillary sinuses according to different age groups.

Age group*	Sinus septa		Total
	Yes	No	
1	26 (7.2)	22 (6.1)	48 (13.4)
2	48 (13.4)	61 (17.0)	109 (30.4)
3	41 (11.4)	61 (17.0)	102 (28.4)
4	48 (13.4)	52 (14.5)	100 (27.8)
Overall	163 (45.4)	196 (54.6)	359 (100)

Table II. Prevalence n (%) of maxillary sinus septa according to sinus region.

Age group*	Sinus region		
	Anterior	Middle	Posterior
1	9 (12.9)	8 (14.8)	13 (23.6)
2	25 (35.7)	14 (25.9)	13 (23.6)
3	18 (25.7)	13 (24.1)	13 (23.6)
4	18 (25.7)	19 (35.2)	16 (29.2)
Total	70 (100)	54 (100)	55 (100)
<i>p value</i>	0.19	0.82	0.34

Table III. Distribution n (%) of the 179 diagnosed maxillary sinus septa according to its most representative CBCT plan.

Age group*	CBCT plan		
	Axial	Sagittal	Coronal
1	13 (7.3)	9 (5.0)	1 (0.6)
2	32 (17.9)	19 (10.7)	1 (0.6)
3	30 (16.7)	17 (9.5)	1 (0.6)
4	35 (19.4)	21 (11.7)	0 (0.0)
Total	110 (61.3)	66 (36.9)	3 (1.8)

DISCUSSION

Maxillary sinus septa are thin cortical bone projections that vary in number, thickness and length (Lee *et al.*; Baciut *et al.*, 2013; Kang *et al.*, 2013; von Arx *et al.*). Its presence cannot be neglected in edentulous and partially edentulous patients undergoing maxillary sinus floor augmentation prior to implant placement, due to the risk of sinus membrane perforation during surgery (Koymen *et al.*; van Zyl & van Heerden; Lana *et al.*, 2012; Baciut *et al.*; Kang *et al.*; Vogiatzi *et al.*). Since there is a lack of studies that addressed the possible influence tridimensional images may have on the identification of septa, the aim of this study was to evaluate the prevalence and location of maxillary sinus septa in total or partial edentulous patients, potential candidates for oral rehabilitation by osseointegrated dental implants, by CBCT images.

It is well-known that two-dimensional extraoral radiographies, e.g. panoramic radiographic and Waters projection, do not allow a complete and accurate examination of morphological or pathological changes involving the maxillary sinus (Koymen *et al.*; Naitoh *et al.*; Lana *et al.*; Orhan *et al.*; van Zyl & van Heerden; Vogiatzi *et al.*; Santos Junior *et al.*, 2015). Computed tomography images, on the other hand, are more appropriated for that evaluation considering the possibility of visualization of the whole volume in different planes and without superimposition of structures (Kim *et al.*; Naitoh *et al.*; Lee *et al.*; Maestre-Ferrín *et al.*, 2010; Lana *et al.*; Orhan *et al.*; Baciut *et al.*; Kang *et al.*; Shiki *et al.*, 2014; Vogiatzi *et al.*; von Arx *et al.*; Santos Junior *et al.*). On this study, 359 maxillary sinuses were evaluated by CBCT images, in which the examiners were asked to verify the entire volume in all multiplanar reconstructions available.

Several authors have studied the prevalence of maxillary sinus septa (Krennmair *et al.*; Kim *et al.*; Koymen *et al.*; Naitoh *et al.*; Lee *et al.*; Maestre-Ferrín *et al.*; Orhan *et al.*; Pommer *et al.*, 2012; Shen *et al.*; Ilgüy *et al.*; von Arx *et al.*). Lee *et al.* found a prevalence of 51.6 % of septa in the maxillary sinus, whereas in the study conducted by Shen *et al.* the prevalence was only of 29.3 %. A systematic review from 2010 has indicated that this prevalence may vary from 21.6 to 66.7 %, depending on the number of patients analyzed (Maestre-Ferrín *et al.*). In the present study of 359 maxillary sinuses, 163 (45.4 %) had at least one bone septa inside.

When the presence of septa was evaluated by age, a higher prevalence was found in patients younger than 40 years. The younger the patient the greater the tendency to present more pronounced bone loss in edentulous areas. Conversely, many authors stated that the highest presence of maxillary sinus septa in elderly edentulous patients with resorbed alveolar ridge (Krennmair *et al.*; Kim *et al.*; Lee *et al.*; Orhan *et al.*; Pommer *et al.*; von Arx *et al.*).

The maxillary sinus septa can be found in the anterior, middle and/or posterior regions (Naitoh *et al.*). In this study, the highest number of septa was observed in the anterior region (39.1 %, $p = 0.19$). However, when the distribution was analyzed by patients' age, it was observed that in groups 4 the posterior region was statistically more frequent ($p = 0.34$). A previous study also found a higher prevalence of maxillary sinus septa in the anterior region (70 %) (Naitoh *et al.*). They suggested that the difference in distribution is related to the growth pattern of the maxilla, however they

concluded that further studies were needed. On the other hand, Orhan *et al.* found a higher prevalence of sinus septa in the middle region (70 %), followed by the posterior (18.6 %) and anterior (12.2 %) regions. Van Zyl *et al.* also found a higher prevalence in the middle region (49 %), followed by the anterior and posterior regions. The prevalence of septa on the region is widely discussed but little understood (Naitoh *et al.*; Orhan *et al.*).

The identification of septa was performed by analyzing all three plans (axial, sagittal and coronal) of the CBCT volume (Vogiatzi *et al.*). The results showed that the axial section, regardless of patients' age, was the most representative for identification of septa ($p = 0.34$).

The analysis was performed on a sample of the Brazilian population; these results may be specific to a particular population. More studies should be conducted with other ethnic groups and with a larger sample.

The prevalence of maxillary sinus septa in patients who were candidate to dental implant therapy was notably high. It was observed that the anterior region of the sinus was the most prevalent and the axial slice was the most representative for diagnosis.

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RESUMEN: El objetivo de este estudio fue investigar la prevalencia y localización del septo del seno maxilar antes del tratamiento con implantes dentales en diferentes grupos etarios, por medio de la Tomografía Computarizada de Haz Cónico (TCHC). Fueron seleccionadas TCHC de 200 pacientes. La muestra final fue dividida en cuatro grupos de acuerdo con la edad: (1) 30-39 años; (2) 40-49 años; (3) 50-59 años y (4) +60 años. Tres examinadores calibrados evaluaron la presencia y localización (anterior, media o posterior) del septo del seno maxilar usando todas las secciones ortogonales. La prevalencia del septo por región y

plano fue comparada mediante el test x-cuadrado. Entre los 359 senos maxilares evaluados, fue observado por lo menos un septo en 163 senos (45,4 %). Generalmente la región anterior fue la más prevalente. Sin embargo, cuando fueron considerados los grupos etarios, solamente la región anterior fue la más prevalente en los grupos 2 y 3. Las regiones media y posterior fueron las más prevalente en los grupos 4 y 1, respectivamente. La prevalencia del septo del seno maxilar en pacientes que son candidatos a tratamiento con implantes dentales fue notablemente alta. Se observó que la región anterior fue la más prevalente siendo las secciones axiales las más representativas.

PALABRAS CLAVE: anatomía, tomografía computarizada de haz cónico, diagnóstico, seno maxilar.

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