

# QUANTITATIVE ANALYSES OF MAXILLARY SINUS USING COMPUTED TOMOGRAPHY

## *ANÁLISE QUANTITATIVA DOS SEIOS MAXILARES POR MEIO DA TOMOGRAFIA COMPUTADORIZADA*

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**T**he aim of this study was to evaluate the precision and accuracy of linear measurements of maxillary sinus made in tomographic films, by comparing with 3D reconstructed images. Linear measurements of both maxillary sinus in computed tomography CT of 17 patients, with or without lesion by two calibrated examiners independently, on two occasions, with a single manual caliper. A third examiner has done the same measurements electronically in 3D-CT reconstruction. The statistical analysis was performed using ANOVA (analyses of variance). Intra-observer percentage error was little in both cases, with and without lesion; it ranged from 1.14% to 1.82%. The inter-observer error was a little higher reaching a 2.08% value. The accuracy presented a higher value. The perceptual accuracy error was higher in samples, which had lesion compared to that which had not. CT had provided adequate precision and accuracy for maxillary sinus analyses. The precision in cases with lesion was considered inferior when compared to that without lesion, but it can't affect the method efficacy.

**UNITERMS:** Tomography; X-ray computed; Maxillary sinus; Quantitative study.

## INTRODUCTION

The maxillary sinus is a pneumatic cavity of the facial skeleton within maxillary bone; it has a quadrangular pyramid form with an internal base<sup>6</sup>. The maxillary sinus fluids drain into the nasal cavity by a narrow osteomeatal complex, with the obstruction of the outflow causing sinusitis, mucosal thickening, and polyps or retention cyst formation<sup>14</sup>. Also it can be affected too by other lesions in the face, like tumors or fractures but its clinical access is difficult and radiographic examination is considered to be very helpful in the better clarification of those diseases.

Computed tomography (CT) proved to be the most accurate technique used in detection of simulated lesions of all surfaces of the maxillary sinus, allowing access to all the walls of the sinus and should be used when

there is definite evidence of maxillary sinus pathosis<sup>12</sup>. The defect can be exactly located by CT scans using three-dimensional reconstructed images.

Spiral CT is a fast scanning method, permitting improved contrast enhancement and decreased motion artifacts, so it enables the radiologist to visualize lesions quickly and manipulate volumetric data in three-dimensional reconstructed images (3D-CT). Quantitative studies have validated linear measurements of bone structures in the maxillofacial region, for treatment planning using 3D reconstructed spiral CT<sup>5</sup>.

Following those statements, the purpose of this study was to evaluate the precision and accuracy of linear measurements of maxillary sinus made in tomographic films, by comparing with 3D reconstructed images, in cases with and without maxillary sinus lesions.

**MATERIALS AND METHODS**

The study population consisted of 17 patients, with or without maxillary sinus lesion (17 sinuses with lesion and 17 without), who were submitted to a CT scan (Toshiba X/Press, Toshiba Medical System, Tustin, CA, EUA) with the following protocol: 3 mm axial slices, 3 mm table feed and 3 mm reconstructed slice interval, in 1 second, at 130 kVp and 200mA, and 512X512 matrix. The original CT data were transferred to a workstation (DELL hardware Precision 420 WINDOWS NT with Vitrea® 2.3 software, Vital Images Inc., Minneapolis, MN, USA). The data were archived in a standard computer workstation and on a CD-ROM in order to postprocess any study.

Linear measurements were done on the tomographic films in the antero-posterior and right-left largest diameters by two calibrated examiners independently, on two occasions, with a single manual caliper, which was previously calibrated. To perform these measurements it was used a scale, which vary from 5cm to 15cm, on the right side of the CT films (Figure 1). So we pointed on the caliper in a boundary of the region we wanted (each side of the large diameter A-P or R-L) and then we transferred this distance obtained to the scale to obtain the value of this distance.

The 3D-CT reconstructed images were used as a gold standard, to evaluate the accuracy of 2D-CT in films. To obtain the measurements in 3D-CT we used the crosshair tool, which allowed selecting the antero-posterior and right-left largest measurements of the maxillary sinus, in axial view and marked it with an arrow in order to guide the measurement in the 3D. Subsequently, we displayed the 3D-CT images with



**FIGURE 1-** 2D-CT axial view is demonstrating the largest diameter delimitation of maxillary sinuses (arrows). The scale, which was used to perform the measurements, is also shown on the right side of the figure (open arrow)

the arrows showing the exact localization of the measurements, and we have done it electronically with the ruler tool (Figures 2 and 3). In order to make easy this work, we have used other tools from the software, which allowed us to rotate and to section the skull. The statistical analysis was performed using ANOVA (analyses of variance).



**FIGURE 2-** 3D-CT supero-inferior view using bone protocol is demonstrating the electronically measurement of the left maxillary sinus' antero-posterior largest diameter (32.00 mm)



**FIGURE 3-** 3D-CT supero-inferior view using bone protocol is demonstrating the electronically measurement of right maxillary sinus' medio-lateral largest diameter (43.4mm)

## RESULTS

The Tables 1 and 2 showed the error percentage found in linear measurements of maxillary sinus with lesion and without lesion, respectively. The statistical evaluation displayed the data like the group means, standard deviations and 95% of confidence intervals for individual predicted values.

The intra-observer percentage error was little in both cases, with and without lesion; it ranged from 1.14% to 1.82%. The inter-observer error was higher reaching a 2.08% value. The accuracy presented a higher value.

The perceptual accuracy error was higher in samples, which had lesion compared to that which had not (8.08% and 5.19%, respectively), but this difference isn't significant because we have a small sample".

## DISCUSSION

Inaccurate measurements from conventional radiographs occurs due to superimposition of the other paranasal sinuses and craniofacial skeleton on the upper portion of the maxillary sinus. However, CT has the advantage of plainly demonstrating the components of the maxillary sinus<sup>1</sup>. CT and multiplanar reconstructed images (MPR) are considered standard images for detecting both bony and soft tissue lesions improving the accuracy in evaluation of the soft tissues and subtle changes in

bones and air- filled spaces <sup>12</sup>.

In general, the films are more available to the clinicians who don't need extra equipment to interpret them. In our paper, we used an independent workstation, where 3D-CT images were processed, becoming a more practical and faster tool to assess the images. We used the 3D-CT images as being the gold standard of this study, since many authors have already found accuracy of measurements in these images<sup>5,8,10,15</sup>. Matteson, et al.<sup>10</sup> (1989) found the 3D-CT images of the craniofacial region to be very accurate, and Waitzman, et al<sup>15</sup> in 1992 related excellent agreement between direct measurements made in dry skull and in CT images. Quantitative studies have validated linear measurements of bone structures in the maxillofacial region, for treatment planning using spiral 3D-CT<sup>5</sup>. In CT images there is no significant enlargement or distortion of the image, overlap of structures, or tracing error, so it is an accurate and reproducible means of recording quantitative information<sup>15</sup>. Simulated 3D-CT reformats conventional imaging data into series of images that closely resemble the original studied structure<sup>8</sup>. Cavalcanti, Ruprecht<sup>3</sup> in 2000, studying neoplastic lesions associated with the mandible concluded that spiral CT allowed accurate computer graphics and film-based measurements. They showed there was no statistically significant differences between computer graphics or film-based measurements and physical measurements or between inter and intra-observer measurements. These findings are in agreement with those we found in our results regarding to maxillary sinus.

**TABLE 1-** Statistical analysis of measurements in maxillary sinus without lesion

	Intra-observer 1	Intra-observer 2	Inter-observers	Accuracy
Mean difference	1.14%	1.82%	2.08%	5.19%
Standard deviation	1.63%	1.70%	1.88%	5.091%
M + 95%CI	0.54%	1.18%	1.39%	3.31%
M – 95%CI	1.75%	2.45%	2.78%	7.08%

**TABLE 2-** Statistical analysis of measurements in maxillary sinus with lesion

	Intra-observer 1	Intra-observer 2	Inter-observers	Accuracy
Mean difference	1.72%	1.66%	1.69%	8.08%
Standard deviation	1.65%	1.69%	1.39%	10.07%
M + 95%CI	0.61%	0.62%	0.51%	3.73%
M – 95%CI	1.11%	1.03%	1.18%	4.35%

Measurements of skeletal dimensions are essential for accurate diagnosis and planned reconstructive surgery<sup>10,15</sup>. An inaccurate localization of anatomical structures can lead to undesirable complications as a perforation of the maxillary sinus<sup>13</sup>. In our research, several factors were considered as potential errors when the measurements were made: 1. Lesions, which caused destruction or expansion on the sinus cortex, made more difficult to localize the landmarks (the internal walls of the maxillary sinuses in their largest diameter antero-posterior and right-left) to perform the measurements, especially in the 3D-CT. 2. Another point, which influenced on the results, was how the measurements on the tomographic films were done. In materials and methods section, we used the film's scale. However those scales were not millimetrically divided and each interval corresponds to a large value varying from 5 mm to 10 mm not in real distances (this 5 mm does not correspond to 5 mm in a ruler, but 5 mm in real image). Subsequently, our measurements presented values lower than these, so we may suppose the lower intervals and this perception varied from person to person making our measurements less precise than it could be if the scale were divide in lower intervals. This did not occur in 3D-CT images, because the measurements are made electronically with ruler tool software. The measurements in 3D-CT are made easier by the software tools like translation, rotation and segmentation, as was stated by Cavalcanti, Vannier<sup>4</sup> in 1998. The value of computer graphics in manipulating craniofacial images and the importance of 3D-CT images in quantitative and qualitative information about the craniofacial complex are clearly recognized. Computer graphics technology and current workstations allow better visualization and segmentation that enable assessment of volume, area, linear and angular measurements<sup>4</sup>.

3D –CT – based measurements are characterized by a number of features: spiral CT scanning, 3D-image reconstruction, image manipulation (translation, rotation, and segmentation) by computer graphics and interactive landmark identification. Ace contributes to the overall improvement in measurement accuracy<sup>4</sup>. Our results demonstrated that reproducibility of measurements was high, and the error intra and inter-observers were less than 2.0%. Similar results were already found by Christiansen, Thompson, Kopp<sup>7</sup>, 1989 when studying accuracy in linear and angular measurements in CT done in vitro in human mandible<sup>7</sup>, and by Cavalcanti, et al<sup>3</sup> in 2000 in their studies with simulated neoplastic lesions in mandible too. 2D-CT and 3D-CT images can be useful to the clinician in diagnosis and treatment planning. These methods

enhance the accuracy of diagnostic decisions and establishment of appropriate treatment plans<sup>2</sup>.

## CONCLUSIONS

The mean difference of measurements were higher in maxillary sinus with lesion when compared to that without lesion

The measurements of CT-based films provided adequate precision (reproducibility) and accuracy for maxillary sinus analyses.

CT-based films can be used in study and in attendance of clinical cases in all their phases as treatment planning and a follow up of cases.

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## RESUMO

O objetivo deste trabalho foi avaliar a precisão e acurácia de medidas lineares da região de seio maxilar realizadas em filmes tomográficos, por meio de comparação com a reconstrução da imagem em 3D. Medidas lineares de ambos os seios maxilares foram realizadas em tomografias computadorizadas (2D-TC) de 17 pacientes, normais e com lesão, por dois examinadores, calibrados, separadamente, duas vezes cada um, utilizando um compasso. Um terceiro observador realizou as mesmas medidas eletronicamente na reconstrução 3D-TC. ANOVA (análise de variância) foi utilizado para análise estatística. A porcentagem de erro intra-examinadores foi pequena em ambos os casos, com ou sem lesão, variando de 1,14% a 1,82%. O erro inter-examinadores foi maior alcançando o valor de 2,08%. O erro percentual de acurácia nas amostras com lesão foram maiores comparando-as às que não tinham lesão. A tomografia computadorizada em 2D-TC (Em filmes e estação de trabalho independente) proporcionou precisão e acurácia adequadas para análise dos seios maxilares. "O erro foi maior no caso de seios maxilares com lesão, comparando aos lados sem lesão, tanto inter

quanto intra-examinadores, sem alterar, porém, a eficácia do método.”

**UNITERMOS:** Tomografia; Raios x por computador; Seio maxilar; Estudo quantitativo.

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