Prevalence of pathologic findings in the maxillary sinus in cone-beam computerized tomography

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Objective. The aim of this study was to assess the prevalence of pathologic findings in the maxillary sinus by using cone-beam computerized tomography (CBCT).

Study design. One thousand twenty-nine consecutive CBCT scans were retrospectively inspected for pathologic findings in the maxillary sinus by 3 observers. Findings were differentiated by mucosal thickening, partial opacification with liquid accumulation, total opacification, and polypoidal mucosal thickening. Position and diameter of the maxillary sinus ostium were assessed. Correlations for pathologic findings and the factors of age and gender were calculated. Patients with clinical manifestations of sinusitis or total opacification in either sinus were reevaluated.

Results. A total prevalence for pathologies in the maxillary sinus of 56.3% was found in this study. The most frequent pathology was mucosal thickening. Patients >60 years of age showed significantly more pathologies in the maxillary sinus (P = .02), and male patients showed significantly more pathologies than female patients (P = .01). Clinical signs of sinusitis could be confirmed on CBCT images for all patients.

Conclusions. Pathologies in the maxillary sinus are frequently found in CBCT imaging and have to be treated or followed-up accordingly. CBCT is applicable for diagnosis and treatment planning of clinically present sinusitis. (Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011;111:634-640)

Cone-beam computerized tomography (CBCT), introduced in 1998, is increasingly used for 3-dimensional imaging in maxillofacial radiology.1 Available CBCT scanners generate image volumes of a field of view from (height × width) 4 × 4 cm to 23 × 17 cm. Spatial resolution of isotropic voxel size of available scanners ranges from 0.08 to 0.4 mm.1,2 Larger scans provide a comprehensive radiologic view of the maxillofacial skeleton and partly of the soft tissue therein.

Dental implant site assessment, maxillofacial trauma, and orthodontics are frequent indications for CBCT wherein the area of the nose and the maxillary sinus can be within the imaging field. This frequently confronts the operator with incidental findings in the area of the maxillary sinus. The increase in use of CBCT by dentists and maxillofacial surgeons suggested an assessment of the prevalence of incidental findings relevant for further evaluation. These can be either of direct significance to the treatment or incidental. Signs of inflammation in the maxillary sinus are relevant for planning bone augmentations procedures as sinus elevation. Here complications are related to anatomic and pathologic variations of the maxillary sinus.3 Moreover, sinusitis can be caused by a dental focus also urging for dental treatment. Oroantral fistulas caused after extraction can also be detected.4

Incidental findings of the maxillary sinus also have to be followed-up. Here the comprehensive radiologic examination of the maxillary sinus includes assessment of the maxillary mucosa, fluid levels, bone alterations, and position, size, and patency of the ostium. Staging of chronic sinusitis based on CT imaging evaluates the level of opacification, the ostiomeatal complex, and further abnormalities.5,6 Combined with the clinical examination, further treatment options or referral to a specialist can be considered also for findings not directly linked to the field of dentistry.

Earlier studies have addressed radiologic assessment of sinus alterations and incidental findings by analysis of CT7-9 and CBCT.10 One of the most frequent incidental findings are pathologies in the maxillary sinus. Visualization quality of the maxillary sinus and bony structures in CBCT appears similar to CT; however, CBCT generates high-resolution isotropic volume data and could therefore
show benefits for evaluating the bony aspects of the maxillary sinus by using a lower dose. On the other hand, CT provides higher-contrast images compared with CBCT, presenting more information on soft tissues. Studies using CBCT for evaluation of the maxillary sinus so far have focused on preoperative planning for implants and augmentative procedures.

Based on the established staging systems, the prevalence of mucosa thickening, opacification with liquid accumulation, polypoidal mucosal thickening, and size and position of the maxillary sinus ostium by CBCT in a larger cohort is presented herein. The aim of the present study was to provide data about the prevalence of pathologic findings in the maxillary sinus shown on CBCT scans now frequently applied in the field of dental medicine.

**MATERIAL AND METHODS**

This retrospective study included 1,029 consecutive patients of whom individual factors of gender, age, and indication for scanning had been recorded. The study was approved by the Ethics Committee of the Medical Faculty of the University of Cologne (approval no. 05-111).

The mean age of the patients was 44.19 ± 20.3 years, the youngest patient was 8 years old, and the oldest patient was 107 years old at the time of the investigation (Fig. 1). For statistical analysis, patients were separated into the following age groups: 1) 0-18; 2) 19-25; 3) 26-40; 4) 41-60; and 5) >60 years of age.

The CBCT scanner used in this study was a Galileos (Sirona Dental Systems, Bensheim, Germany). Technical parameters of the CBCT system used in this study are summarized in Table II.

Obtained CBCT images were viewed using the proprietary software (Galaxis, Sirona Dental Systems) giving a

![Fig. 1. Distribution of age in the study population. Solid line shows normal.](image-url)
panoramic reconstruction view module and the multiplanar reformations module, i.e., axial, sagittal, and coronal slices. All images were assessed under standardized conditions at the same examination workplace. Computer equipment at the examination station consisted of 2 LCD monitors with a brightness of 500 cd/m² and a resolution of 1,280 x 1,024 (Captiva E1701; Ecom Electronic Components Trading, Bergkirchen-Feldgeding, Germany). The computer was a 3.4 GHz Pentium IV HT Unit (Intel, Santa Clara, CA, USA) with 1 GB RAM and a 256-MB memory, 400 MHz clock speed, and 128-bit memory interface graphic accelerator card (Radeon 9600 series; ATI Technologies, Markham, Ontario, Canada). All hardware components were technically approved for radiologic diagnostics. The room containing the examination workplace was equipped with window shades and dimmable light for standardized low-lit ambience illumination.

Three observers experienced in oral radiology (1 oral surgeon, 2 general dentists) analyzed the images separately. Each observer analyzed one-third of the datasets (i.e., 343). Observers were calibrated by using 5 example images for each finding (Fig. 2). Calibration of the observers took place in a group, and each finding was discussed. Pathologic findings were categorized as mucosal thickening, partial opacification with liquid accumulation, total opacification and polypoidal mucosal thickening, and no pathologic signs. Diameters of left and right maxillary sinus ostium were recorded as well as the distance of the lower border of the ostium to the osseous floor of the sinus. Here observers also were calibrated. To measure the diameter of the ostium, first the ostium was localized using the crosshair functionality of the software. Subsequently, the maximum diameter to be found in the coronal view was measured.

On exactly this slice also the distance of the lower border of the ostium to the osseous floor of the maxillary sinus of the same side was measured. Observers were allowed to adjust brightness and contrast of the images and to zoom. For the detection of pathologic findings, all available views within the given software were at hand to the user.

Treatment plan, diagnosis, and outcome for patients with clinical manifestations of sinusitis were recorded. For patients showing total opacification of either sinus, ethmoidal cells as well as the integrity of the medial wall of the maxillary sinus were evaluated.

Obtained patient data, scan data, and assigned scores were recorded in a Microsoft Access (2003) database (Microsoft, Redmond, WA, USA). Statistical analysis was performed using PASW 18.0 for Windows (SPSS, Chicago, IL, USA). The χ² test was used to compare groups. An error probability of <.05 was accepted as significant.

RESULTS

Pathologic findings in either I or both of their sinuses were found in 579 patients (56.3%). Two hundred eighty patients (27.2%) showed pathologic signs in both and 299 patients (29.1%) in either one of their sinus. Four hundred fifty (43.7%) of the 1,029 investigated patient scans showed no pathologic signs within either left or right maxillary sinus. Results separated for the left and right sinus are listed in Tables II and III.

Either one or both sinuses of 73 patients (7.1%) showed total opacification. For 65 patients (6.2%) one sinus and for 8 (0.7%) patients both sinuses showed total opacification. From 73 patients showing total opacification in either one or both sinuses, 21 (28.8%)
Thirty-seven patients with total opacification of either one or both sinuses showed a destruction of the medial wall of the maxillary sinus and were referred for further treatment.

The mean diameter of the maxillary sinus ostium was 1.797 mm on the left and 1.792 on the right side. The distance from the floor of the maxillary sinus to the

### Table III. Pathologic findings for both sinuses, unilateral and bilateral

<table>
<thead>
<tr>
<th>Pathological finding</th>
<th>Total (%)</th>
<th>Unilateral (%)</th>
<th>Bilateral (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mucosal thickening</td>
<td>392 (38.1%)</td>
<td>225 (21.9%)</td>
<td>167 (16.2%)</td>
</tr>
<tr>
<td>Partial calcification with liquid accumulation</td>
<td>123 (12%)</td>
<td>100 (9.7%)</td>
<td>23 (2.2%)</td>
</tr>
<tr>
<td>Total opacification</td>
<td>73 (7%)</td>
<td>65 (6.2%)</td>
<td>80 (7%)</td>
</tr>
<tr>
<td>Polypoidal mucosal thickening</td>
<td>67 (6.5%)</td>
<td>61 (5.9%)</td>
<td>6 (0.5%)</td>
</tr>
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</table>

showed additional opacification in the ethmoidal sinus.

Fig. 2. Cone-beam computerized tomographic scans with pathologic findings. First row: Mucosal thickening in the maxillary sinus. Second row: Polypoidal mucosal thickening in the maxillary sinus. Third row: Total opacification in the maxillary sinus. Fourth row: Partial opacification and liquid accumulation.
lower border of the ostium was 32.02 mm on the left and 31.91 on the right side. Details of all measurements can be found in Table IV.

From 536 male patients 326 (60.8%) had at least some pathology in either of the sinuses, whereas only 253 of the 493 investigated scans of female patients (51.3%) showed pathologic signs in either sinus. The difference between male and female patients was statistically significant for the sum of findings ($P = .02$), but not for any specific finding. Except for age group 4 ($P = .01$), no statistical significant difference could be found between genders. Most scans were indicated for Trauma and dental implant planning. Figure 3 shows the uni- and bilateral prevalence of patholgical findings.

In Fig. 4 the evaluated age groups are shown compared with the prevalence of uni- and bilateral pathologic findings. Patients ≥60 years old in this study showed the most pathologic signs, and there was a statistically significant difference between the investigated age groups ($P = .02$). Patients scanned for trauma or sinus complaints showed pathologic findings more frequently than other groups. The differences between groups were statistically significant ($P = .001$).

From 36 patients showing clinical signs of sinusitis, 12 showed an obstructed ostiomeatal complex and were treated surgically. Ten of these patients showed polypoidal mucosa and signs of chronic sinusitis in a histologic specimen taken during surgery. One patient showed a radicular cyst and one patient a chronic fibrous inflammation in the histologic specimen. Histologic diagnosis correlated with the radiologic picture in investigated cases.

**DISCUSSION**

In this study 1,029 CBCT datasets were retrospectively evaluated for pathologies in the maxillary sinus. The results of this study are in concordance with studies that have previously addressed the topic using different imaging technologies. The prevalence of inflammation in the maxillary sinus based on CT images was reported in the literature to be between 63% and 83.2%.

Studies based on magnetic resonance imaging (MRI) found a prevalence of 50%, even for children. Studies based on panoramic imaging found a prevalence of mucosal changes in the maxillary sinus of 12% for mucosal thickening and 7% for polypoidal mucosal thickening in 5,021 individuals.

Differences in prevalence found in this study compared with the known literature could be explained by several factors. First, different age and patient groups were investigated in the various studies. One study investigated 30 patients with paranasal problems determining a prevalence of up to 63%, and another study reported on 202 patients having different indications for CT scanning with a prevalence of 82.2% for mucosal abnormalities. Moreover, the definitions for pathologic changes and the applied classification systems vary among the studies. Another factor could be the visualization quality of the different imaging modalities: one study compared CT and MRI and concluded that CT is the better alternative for visualizing fine bone, although it is affected by metal artifacts and therefore MRI had a higher sensitivity in visualizing mucosal thickening. Still, CT is currently the preferred imaging technique to screen for maxillary sinus disease.

CBCT as a new 3D imaging modality could be of clinical value not only in screening but also in planning paranasal surgery. The first experimental studies compared the image quality of CBCT and CT regarding hard tissue and experimental measurements of length, volume, and dose. Other studies reported on the useful application of CBCT for intraoperative imaging of the paranasal sinus. However, further studies are required to expedite the clinical value of CBCT for assessing the paranasal sinuses. One of the benefits of applying CBCT for imaging of the paranasal sinuses could be the lower dose compared with CT imaging. Moreover, CBCT delivers an isotropic volume resolution facilitating diagnosis of delicate structures in multiplanar reconstructions.

From the perspective of a dentist or maxillofacial surgeon, the evaluation of the maxillary sinus in CBCT appears to be relevant for several reasons. First, for many procedures in dentistry and maxillofacial surgery, the condition of the maxillary sinus is relevant for planning. For dental implant site assessment in the maxilla, the configuration and status of the maxillary sinus is important to assess the available amount of bone. If a sinus lift is indicated, the visualization is useful, because the success rate of sinus lift procedures is crucially dependent on the configuration and status of the maxillary sinus. Moreover, a dental focus can cause maxillary sinus inflammation as well as oroantral fistulas, conditions that are in the focus of dental medicine and should be diagnosed in CBCT when present. When CBCT is applied for diagnosing fractures of the midface, it is mandatory to visualize the maxillary sinus.

Incidental findings in scans primarily taken for other indications are another aspect of visualizing the maxillary sinus. Here the operator of a CBCT has to care-
Fig. 3. Frequency of findings in the maxillary sinus sorted by indication for scan.

Fig. 4. Frequency of findings by age categories.
fully evaluate the maxillary sinus to rule out any significant pathologic changes. Most findings here are benign, because inflammation in the paranasal sinus is a frequent disease in Western society. However, malignancies have to be identified. Incidental findings were the main focus of our study and, within its limits, it provides information on the frequency of pathologic findings in the maxillary sinus in CBCT images.

The present study is limited by several factors. First, observers in this study were not trained radiologists and may have different experience in evaluating pathologic findings in the maxillary sinus in CT or CBCT. However, the observers were clinically experienced oral surgeons and dentists using CBCT in clinical routine. This study was undertaken retrospectively and only 1 observer saw each dataset only once. Therefore, no inter- or intraobserver reliability could be measured. Moreover, some findings cannot be discriminated, because different fluids (i.e., blood or pus) appear radiologically identical. Datasets recorded for the evaluation of maxillary sinus disease limit the value of the study for detecting the incidence of pathology findings, because these can be expected in such patients. Still, those scans were included to provide data on the relation of radiologic findings and clinical or histologic data.

CONCLUSIONS

The detection of pathologies in the maxillary sinus seems to be feasible using CBCT imaging. Further studies are required to prospectively compare CT and CBCT in detecting pathologic lesions in the maxillary sinus and planning maxillary sinus surgery. Pathologic changes observed as incidental findings are frequent in CBCT and have to be followed-up accordingly.

REFERENCES


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