The Comparison of Panoramic Radiography and Cone-Beam Computed Tomography for Detection of Tonsilloliths

Melih Ozdede\textsuperscript{a,}*\textsuperscript{*}, Gulsun Akay\textsuperscript{b}, Ozge Karadag\textsuperscript{c}, Ilkay Peker\textsuperscript{b}

\textsuperscript{a}Department of Dentomaxillofacial Radiology, Faculty of Dentistry, Pamukkale University, Denizli, \textsuperscript{b}Department of Dentomaxillofacial Radiology, Faculty of Dentistry, Gazi University, Ankara, \textsuperscript{c}Department of Statistics, Faculty of Science, Hacettepe University, Ankara, Turkey

\textbf{Address all correspondence to:}

Melih Ozdede
Pamukkale University,
Faculty of Dentistry, Kinikli Campus,
Denizli, Turkey

E-mail: melihozdede@gmail.com

\textbf{Short title:} Panoramic Radiography versus CBCT for Detection of Tonsilloliths

\textbf{Key words:} Cone Beam Computed Tomography \textbullet{} Dentistry \textbullet{} Otolaryngology \textbullet{} Diagnosis \textbullet{} Diagnostic imaging \textbullet{} Radiography \textbullet{} Panoramic \textbullet{} Palatine Tonsil \textbullet{} Calcinoses \textbullet{} Halitosis
Highlights of the study:

- The aim of this study was to compare cone-beam computed tomography and panoramic radiography for the detection of tonsilloliths.
- The detection rate of tonsillolith was 33.2% on cone-beam computed tomography.
- Only 51.4% of the tonsilloliths detected on cone-beam computed tomography were identified in panoramic radiography.
- Panoramic radiography was not adequate to detect tonsilloliths 1 mm or smaller in size.
Abstract

**Objective:** A tonsillolith is a concretion of the tonsillar crypt. The aim of this retrospective study was to compare panoramic radiography (PR) and cone-beam computed tomography (CBCT) for the detection of tonsilloliths. **Materials and methods:** The CBCT images of 527 patients with maxillofacial volume were evaluated retrospectively. 175 of these patients (81 females, 94 males; mean age, 51.05 years) had unilateral or bilateral tonsilloliths. 151 of them (67 females, 84 males; mean age, 51.03 years) had PR images performed in the same period and were included in the study. The PR images were examined to ascertain whether known tonsilloliths (from CBCT images) could be detected. The location (unilateral; left or right and bilateral), size and number of the tonsilloliths were examined on both CBCT and PR images. Descriptive analysis, Spearman’s rho correlation coefficient and chi-square tests were used for the statistical analysis. **Results:** The detection rate of tonsillolith was 33.2% on CBCT images. Only 51.4% of the tonsilloliths detected in CBCT were evaluated in the PR; the correlation between CBCT and PR was found significant (Spearman’s \( r = 0.399, p = 0.000 \)). PR was not adequate to detect tonsilloliths one mm or smaller in size. All the calcifications larger than five mm were detected on PR images. **Conclusion:** The results of this study showed that more than half of the tonsilloliths observed in CBCT were also detected in PR. Tonsilloliths larger than two millimetres were more likely to be detected on PR images.
Introduction

A tonsillolith is a calcified structure that occurs as a result of chronic and recurrent inflammation in enlarged tonsillar crypts. On clinical examination, tonsilloliths are generally seen as white or yellow plaques in tonsil crypts, especially in palatine tonsils. Tonsilloliths can be as hard as stone when they have been present for a long time. Small-sized tonsilloliths are usually asymptomatic, but large ones may present several symptoms such as irritation, pain, discomfort and foreign body sensation, swallowing and eating difficulties, bad breath, bad taste, ear pain and ulceration [1, 2]. Palatine tonsilloliths may cause orofacial pain and glossopharyngeal neuralgia [3]. They may be single or multiple and unilateral or bilateral [4]. The size of the lesions may vary from a few millimetres to several centimetres [5].

The differential diagnosis of tonsilloliths can be made by various lesions in the mandibular ramus region, such as odontoma, osteoma, idiopathic osteosclerosis, sialolithiasis, phlebolith, cysticercosis, calcified lymph nodes, carotid calcification, long hamular process, stylohyoid ligament calcification or osteoma cutis and foreign body [2, 3, 6]. Tonsilloliths can be detected by routine panoramic radiographic images [5].

Panoramic radiography (PR) is a technique that allows the viewing of the maxilla, mandible and facial structures in a single image. This radiographic technique lets us examine fractures, pathologies, developmental anomalies, development of the teeth, temporomandibular joint, maxillary sinuses, etc. Whether a lesion is in soft or hard tissue is indistinguishable on PR images. In these cases, postero-anterior skull radiographs or Reverse Towne projections may be useful. Tonsilloliths appear as single or multiple radiopacities that overlap the mid-portion of the mandibular ramus on PR images [1].

Recently, three-dimensional imaging by cone-beam computed tomography (CBCT) has been recommended for the imaging of tonsilloliths [2]. CBCT images allow us to examine a three-dimensional image of the maxillofacial region [1]. Palatine tonsilloliths can be detected with CBCT.
as small radiopacities in the medial part of the ramus mandible and the lateral wall of the oropharyngeal airway. The density of these calcifications is similar to cortical bone [1, 2].

The aim of this retrospective study was to compare CBCT and PR images for the detection of tonsilloliths. We hypothesized that the detectability of tonsilloliths in PR would be lower than that in CBCT. Our null hypothesis was that the detection rate of tonsilloliths would be similar in PR and CBCT images.

**Materials and Methods**

Ethical Approval was received from Pamukkale University Ethics Committee (60116787-020/8903). A priori power analysis with a significance level of 5% and an effect size of 0.30 indicated that the minimum number of patients required was 150.

Inclusion criteria were patients aged over 18 years old who had both face-scanned (field of view: 20 cm × 17 cm) CBCT and PR images in the radiology records. The exclusion criteria were the presence of prominent artefacts on CBCT and PR images, paediatric patients and individuals who had maxillofacial trauma. For this cross-sectional descriptive study, we examined CBCT images in the records of our radiology department between January 2018 and March 2019. Next, CBCT images with tonsilloliths were selected. Finally, the images of the patients who had both CBCT and PR records (simultaneously) were included in the study.

The CBCT images had been obtained by a standing patient positioning device (Promax 3D Mid; Planmeca Oy, Helsinki, Finland). The exposure parameters were 90 kVp, 12 mA, total scanning time of 27.7 seconds and 0.4 mm voxel size. In the axial sections, the radiopaque calcifications were scanned between the medial part of the mandibular ramus and the lateral wall of the oropharyngeal airway. The lesions were confirmed in sagittal and coronal planes. Evaluations were made with the original software program of the CBCT device (Romexis 2.7.0.; Planmeca Oy, Helsinki, Finland).
The PR images had been obtained by a digital panoramic x-ray unit (Orthophos XG-5; Sirona, Bensheim, Germany), operating at 66 kVp, 8 mA, 14 seconds of exposure time, a 0.5 mm focal spot and a magnification ratio of 1.25. Radiologically-visible radiopacities in the mid-portion of the mandibular ramus region were evaluated as a tonsillolith by the radiologists. All radiographic evaluations were made on 24-inch Philips medical monitor with NVIDIA Quadro FX 380 graphics card and 1920×1080-pixel resolution.

All blinded images were retrospectively evaluated by consensus of two experienced dentomaxillofacial radiologists (M.O. and G.A.), in a quiet room with subdued ambient lighting and sufficient distance from the screen. The PR images were examined for the presence of tonsilloliths, location (left, right or bilateral), size and number of the lesions. Both CBCT and PR images were compared regarding detection of tonsilloliths and their symmetry, size and number.

The data obtained were statistically analyzed by non-parametric correlation methods, using SPSS version 23.0 (IBM; Armonk, NY, USA). Statistical analysis was performed using the descriptive statistics, Spearman’s rho correlation coefficient and the chi-square test. The significance level was set to 0.05. The examples of tonsilloliths on both CBCT and PR images are shown in Figure 1 and Figure 2.

Results

CBCT images of 527 patients were examined retrospectively, and tonsilloliths were determined on 175 images (33.2%). Then, 151 patients with both CBCT and PR images were identified. At least one tonsillolith was observed on 96 PR images. The relationship between gender and the detection rates of tonsilloliths were analysed by Chi-square test. Tonsilloliths were found in 84 males (55.6%) and in 67 females (44.4%) on CBCT images ($p = 0.923$). On PR images, these calcifications were observed in 55 males (57.3%) and in 41 females (42.7%) ($p = 0.572$).

The mean age for females was $51.52 \pm 12.71$ and $50.64 \pm 14.46$ for males. The minimum and maximum ages for females were 21 and 80, respectively, whereas the ages were ranged between 18
and 77 for males. The overall mean age was 51.03 ± 13.67. The tonsilloliths were commonly observed in patients who were between 55 and 64 years of age, while fewer patients between 25 and 34 years showed evidence of tonsilloliths on both CBCT and PR images. According to the results of the chi-square test, there were no statistically significant differences between age groups in CBCT ($p = 0.736$) and PR ($p = 0.680$). The detailed distribution of tonsilloliths according to age groups is shown in Table 1.

The most common location of tonsilloliths were the right side (39.7%), bilateral (37.7%) and left side (22.5%) in CBCT. Using PR, tonsilloliths were detected on the right side (52.1%), left side (27.1%) and bilaterally (20.8%).

The correlation between CBCT and PR in the detection of tonsilloliths was analyzed by Spearman’s correlation coefficient (Table 2). A statistically significant moderate relationship was found between CBCT and PR ($p = 0.000$) and the value of correlation was found to be moderate, $\sim 0.40$ ($p = 0.000$). The detection rate of tonsillolith by PR was found to be 51.4%.

The sizes of tonsilloliths on CBCT and PR images, and detection rate by PR, are stated in Table 3. In the results for CBCT, more than half of the detected lesions were one millimetre or smaller size. In PR, 34.1% of the tonsilloliths were two millimetres in size, and 26.0% were three millimetres in size. The Chi-square test was used to compare the different levels of sizes, and the levels were reorganized to combine the largest tonsilloliths sized between 5 to 7 millimetres into one category. A significant difference was detected between six different levels of sizes ($p = 0.000<0.05$). Two millimetres and larger tonsilloliths were found to be more detectable on PR, and the detection rate of two millimetres lesions was approximately 60%. The detectability of tonsilloliths sized 3 millimetres and larger were found to be statistically the same using both methods. The correlation between size and detectability of PR analyzed by the Gamma correlation coefficient and according to the value of 0.794 ($p = 0.000$), size and detectability using PR were found to be highly correlated.
Table 4 shows the number of tonsilloliths on CBCT and PR images and detectability by PR. The detection rate of single tonsilloliths was high in both imaging techniques, 51.0% for CBCT and 75.9% for PR. The number of tonsilloliths detected by CBCT and the number of tonsilloliths detected by PR were strongly correlated to each other (r = 0.68; p = 0.000).

**Discussion**

Detection of tonsilloliths is important for patients. Clinically, these calcifications may be associated with halitosis, odynophagia, otalgia and upper airway obstruction. Symptomatic or larger tonsillar calcifications should be removed [1, 7 - 11].

Tonsilloliths may be incidentally identified in PR, but they may not be diagnosed because of some disadvantages such as superimpositions, distortion and magnification [1, 3, 8]. These calcifications are easily observed with three-dimensional images and distinguished from other soft tissue calcifications [8, 12]. The accurate radiographic diagnosis of palatine tonsilloliths can be made by medical computed tomography (CT) between the palatopharyngeus and palatoglossus muscles [6, 13]. However, CBCT uses a significantly smaller radiation dose, slices images more thinly, and is less expensive, compared to CT [13, 14]. Although CBCT has limited soft tissue imaging capacity, tonsilloliths can be determined on three-dimensional CBCT images [15 - 17]. Ultrasonography also can be used for the detection of soft tissue calcifications [18]. In the literature, it was reported that tonsilloliths could be diagnosed by an intraoral transducer [19]. Ultrasonography has some limitations such as patient discomfort and difficulty in use [19].

In the literature, the prevalence of tonsilloliths was evaluated using PR, CT and CBCT. The prevalence of tonsilloliths in PR was found to be 5.7 to 13% in the previous studies [4, 6, 20, 21]. Retrospective three-dimensional radiographic studies showed that the prevalence of tonsilloliths was found 16 to 46% in CT [3, 7, 8, 12, 22 - 24] and 5 to 34% in CBCT [15, 17, 25 - 27]. These differences may be due to differences in the demographics of the patients in these studies [3]. In addition, results may vary according to health conditions such as poor oral hygiene and smoking habits of examined...
individuals [12]. The higher rate of tonsilloliths in our study may be associated with a larger field of view, compared with other CBCT studies [25 - 27].

No significant difference between genders was reported in the previous studies [6, 7, 16, 20, 23, 28, 29]. The rate of tonsilloliths in males was found to be 41% - 51.2% in CT studies [3, 7, 8, 12], 41 - 50.5% in CBCT studies [15 - 17] and 50.9 - 60.4% in PR studies [3, 20, 30]. The results of our study for both imaging techniques were in accordance with previous studies. Tonsilloliths may be identified at any age; they are most frequently seen in the fourth decade [20, 28, 29]. Likewise, in our study, more than half of the lesions were detected in patients between 45 - 64 years of age. This result was compatible with previous studies [6, 20]. Oda et al. reported that when as patients aged, the detection rate increased [7]. Otherwise, similar to our study, Fauroux et al. stated that no correlation was found between age and prevalence of tonsilloliths [23]. Previous studies reported that unilateral tonsilloliths were more common than bilateral tonsilloliths, and no significant differences were found between the prevalence of calcifications in the right and left side [7, 12]. Our results were similar to the rates reported by other authors.

Two previous studies have reported the detection rate of tonsilloliths by PR and CT [3, 7]. Oda et al. reported that the detection rate of tonsilloliths was 46.1% and 7.7% on CT and PR images, respectively [7]. Thus, only one-sixth of the calcifications were detected in PR according to that study [7]. The authors emphasized that the main causes for the discrepancy of two imaging techniques were the calcification levels and the size of the tonsilloliths [7]. In another study, Takahashi et al. evaluated the prevalence and imaging characteristics of tonsilloliths by PR and CT images [3]. Their study showed that the tonsilloliths were observed in 40.7% of CT images and the detection rate was 13.4% in PR. Thus, the rate of detection in PR was 32.8%, compared with CT. In our study, the detection rate of PR was higher than previous CT-compared studies [3, 7]. Nevertheless, we found that the detection rate of tonsilloliths by PR was lower than that by CBCT. This result confirmed our hypothesis. The differences may be explained by soft tissue contrast and slice thickness between these imaging techniques [1].
The results of our study showed that the detection rate of PR increased as the size of the tonsilloliths increased. Tonsilloliths larger than six millimetres were detected by PR in a previous CT study [3]. Similarly, all the five millimetre or larger tonsilloliths were detected by PR in our study. Furthermore, as the number of the tonsilloliths increased, the incidence of the tonsilloliths increased in our study. The calcification degree, number, size and localization of the tonsilloliths, and individual anatomical differences like bone density may affect the detection of these calcifications on PR images [7].

**Conclusion**

The results of this study showed that more than half of the tonsilloliths observed in CBCT were also detected in PR. Tonsilloliths larger than two millimetres were more likely to be detected on PR images.
References


<table>
<thead>
<tr>
<th>Age Groups (n; %)</th>
<th>CBCT</th>
<th>PR</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-24</td>
<td>13; 8.6%</td>
<td>6; 6.3%</td>
</tr>
<tr>
<td>25-34</td>
<td>7; 4.6%</td>
<td>5; 5.2%</td>
</tr>
<tr>
<td>35-44</td>
<td>22; 14.6%</td>
<td>10; 10.4%</td>
</tr>
<tr>
<td>45-54</td>
<td>39; 25.8%</td>
<td>26; 27.1%</td>
</tr>
<tr>
<td>55-64</td>
<td>50; 33.1%</td>
<td>35; 36.5%</td>
</tr>
<tr>
<td>65-80</td>
<td>20; 13.2%</td>
<td>14; 14.6%</td>
</tr>
</tbody>
</table>

| p value | 0.736 | 0.613 |

Table 1. Distribution of the tonsilloliths by age groups.
Table 2. Correlation between CBCT and PR in the detection of the tonsilloliths

<table>
<thead>
<tr>
<th>CBCT (n; %)</th>
<th>PR (n; %)</th>
<th>Total (n)</th>
<th>Spearman’s Rho Correlation Coefficient</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not-detected</td>
<td>85; 90.4%</td>
<td>94</td>
<td>0.399</td>
</tr>
<tr>
<td></td>
<td>Detected</td>
<td>101; 48.6%</td>
<td>107; 51.4%</td>
<td>0.000*</td>
</tr>
<tr>
<td>Total (n)</td>
<td></td>
<td>186</td>
<td>116</td>
<td>302</td>
</tr>
</tbody>
</table>

In total, 302 sides were analysed in 151 patients, *: significant at 0.05
Table 3. Sizes of the tonsilloliths in CBCT and PR and detection rate via PR (Multiple lesions were classified separately)

<table>
<thead>
<tr>
<th>Sizes</th>
<th>CBCT (n; %)</th>
<th>PR (n; %)</th>
<th>Detection Rate via PR</th>
<th>Pearson Chi-Square Asymptotic Significance (2-sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1 mm</td>
<td>176; 39.8%</td>
<td>16; 9.3%</td>
<td>9.1%</td>
<td></td>
</tr>
<tr>
<td>1 mm</td>
<td>70; 15.8%</td>
<td>20; 11.6%</td>
<td>28.6%</td>
<td></td>
</tr>
<tr>
<td>2 mm</td>
<td>101; 22.9%</td>
<td>59; 34.1%</td>
<td>58.4%</td>
<td></td>
</tr>
<tr>
<td>3 mm</td>
<td>58; 13.1%</td>
<td>45; 26.0%</td>
<td>77.6%</td>
<td></td>
</tr>
<tr>
<td>4 mm</td>
<td>22; 5.0%</td>
<td>18; 10.4%</td>
<td>81.8%</td>
<td>0.000*</td>
</tr>
<tr>
<td>5 mm</td>
<td>9; 2.0%</td>
<td>9; 5.2%</td>
<td>100.0%</td>
<td></td>
</tr>
<tr>
<td>6 mm</td>
<td>4; 0.9%</td>
<td>4; 2.3%</td>
<td>100.0%</td>
<td></td>
</tr>
<tr>
<td>7 mm</td>
<td>2; 0.5%</td>
<td>2; 1.2%</td>
<td>100.0%</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>442; 100%</td>
<td>173; 100%</td>
<td>39.1%</td>
<td></td>
</tr>
</tbody>
</table>

*: significant at 0.05
**Table 4. Number of the tonsilloliths in CBCT and PR and detection rate via PR**

<table>
<thead>
<tr>
<th>Number</th>
<th>CBCT (n; %)</th>
<th>PR (n; %)</th>
<th>Detection Rate via PR</th>
<th>Pearson Chi-Square Asymptotic Significance (2-sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>106; 51.0%</td>
<td>88; 75.9%</td>
<td>83.0%</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>33; 15.9%</td>
<td>14; 12.1%</td>
<td>42.4%</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>38; 18.3%</td>
<td>9; 7.8%</td>
<td>23.7%</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>17; 8.2%</td>
<td>2; 1.7%</td>
<td>11.8%</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>4; 1.9%</td>
<td>2; 1.7%</td>
<td>50.0%</td>
<td>0.000*</td>
</tr>
<tr>
<td>6</td>
<td>4; 1.9%</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>5; 2.4%</td>
<td>1; 0.9%</td>
<td>20.0%</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>1; 0.5%</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>208; 100.0%</td>
<td>116; 100.0%</td>
<td>55.8%</td>
<td></td>
</tr>
</tbody>
</table>

*: significant at 0.05
Figure legends

**Figure 1.** Bilateral tonsilloliths are not visible on the PR image (A), while they are seen (arrows) on the axial section of CBCT (B).

**Figure 2.** Right tonsillolith (arrow) is visible on the PR image (A) and on the axial section of CBCT (B).
Figure 1. Bilateral tonsilloliths are not visible on the PR image (A), while they are seen (arrows) on the axial section of CBCT (B).
Figure 2. Right tonsillolith (arrow) is visible on the PR image (A) and on the axial section of CBCT (B).