Title page

Prevalence and imaging characteristics of palatine tonsilloliths evaluated on 2,244 pairs of panoramic radiographs and CT images

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Abstract

Objectives: Palatine tonsilloliths incidentally detected on diagnostic imaging should be differentiated from pathologic calcifications to enable correct diagnosis and treatment. The aim of this study is to clarify the prevalence and imaging characteristics of palatine tonsilloliths on panoramic radiographs.

Materials and Methods: We retrospectively reviewed 2,244 individuals who underwent pairs of consecutive panoramic radiography and computed tomography (CT) of the head and neck region. The imaging characteristics of palatine tonsilloliths on panoramic radiography were compared with the findings from CT, which was considered the gold standard.

Results: Tonsilloliths were detected in 300 (13.4%) and 914 (40.7%) of the 2,244 individuals on panoramic radiographs and CT, respectively. On panoramic radiographs, tonsilloliths were superimposed over the ramus of the mandible at the level coincident with and inferior to the soft palate in 176 (7.8%) and 90 (4.0%) individuals, respectively. Tonsilloliths were also superimposed over the surrounding soft tissue inferior to the body of the mandible, postero-inferior to the angle of the mandible, and posterior to the

ramus of the mandible in 33 (1.5%), 26 (1.2%), and 28 (1.3%) individuals, respectively. A significant correlation was observed between the detectability on panoramic radiographs and the size (Spearman r=1.000) and number (Spearman r=0.991) of tonsilloliths, as revealed by CT images.

Conclusions: The present results suggest that tonsilloliths are commonly detected on panoramic radiographs. Furthermore, they can be superimposed on both the mandible and the surrounding soft tissue.

Clinical Relevance: Clinicians should include tonsilloliths among the differential diagnoses when calcified bodies are detected on panoramic radiographs.

Keywords: tonsillolith, prevalence, panoramic radiograph, computed tomography

Introduction

Tonsilloliths (also known as tonsillar concretions or tonsillar calculi) are calcified structures that develop in enlarged tonsillar crypts. Most palatine tonsilloliths are asymptomatic and require no treatment [1]. However, large palatine tonsilloliths can cause recurrent or persistent throat irritation or discomfort, pain, dysphagia, bad taste, halitosis, otalgia, and foreign body sensation upon swallowing [2, 3]. Palatine tonsilloliths are also suspected to be a potential causative factor in orofacial pain or glossopharyngeal neuralgia [4].

Previous reports using computed tomography (CT) revealed that palatine tonsilloliths are common forms of calcification [5-9]. On panoramic radiographs, tonsilloliths may appear incidentally as multiple, small, poorly-defined radiopacities. It is important for clinicians to differentiate palatine tonsilloliths from pathologic calcified structures such as sialoliths of the parotid or submandibular salivary glands, and phleboliths. However, the variations in imaging characteristics of tonsilloliths on panoramic radiographs remain unclear.

Therefore, the purpose of this study was to clarify the prevalence and imaging

characteristics of palatine tonsilloliths on panoramic radiographs when compared with paired CT.

Methods

This study was based on 2,244 pairs of panoramic radiographs and CT images that were obtained in Tokushima University Hospital from patients with oral and maxillofacial diseases that were not related to tonsillar conditions between 2004 and 2012.

Panoramic radiographs were taken using Veraviewepocs (Morita, Osaka, Japan) with a standard locus. The CT devices used were either Somatom (Siemens, Erlangen, Germany) with a single-row detector or Aquilion (Toshiba, Tokyo, Japan) with 16-row multidetectors. The reconstruction thickness was 1 mm and the scanning plane was parallel to the occlusal plane and/or the inferior border of the mandible to minimize regions with dental metallic artifacts. All of the images were observed on display monitors used for medical purposes. CT images were obtained using both standard soft tissue and bone algorithms.

The presence or absence and location of palatine tonsilloliths were evaluated on

panoramic radiographs by a single, experienced dental radiologist (A. T.) who was unaware of the CT findings. The locations of the tonsilloliths on panoramic radiographs were classified into two categories and six regions (Fig. 1). Category 1 was defined as calcifications that were superimposed on the ramus of the mandible. These were divided into three regions as follows; superior to the soft palate (region 1), coincident with the soft palate (region 2), and inferior to the soft palate (region 3); according to the classification by Oda et al. [7]. Category 2 was defined as calcifications that were superimposed on the soft tissue. These were divided into three regions as follows: inferior to the body of the mandible (region 4), postero-inferior to the angle of the mandible (region 5), and posterior to the ramus of the mandible (region 6). If multiple tonsilloliths were detected in two or more regions, each region was classified individually. We did not consider the number of tonsilloliths in a single region on panoramic radiographs because the exact number of tonsilloliths was difficult to distinguish.

The number and size of the palatine tonsilloliths were evaluated using CT images. If the patient had multiple tonsilloliths, the largest concretion was measured.

Next, another experienced radiologist (C. S.) reviewed whether the calcifications on the panoramic radiographs were identical to those detected on CT images. If the calcifications on the panoramic radiographs differed from the palatine tonsilloliths noted on CT images, the causes for this difference were analyzed. These patients were considered to have no tonsilloliths present on their panoramic radiographs.

Categorical values were compared using the chi-square test, and the relationships between categorical values were assessed using Spearman's rank correlation coefficient. The results were considered significant if $p<0.05$.

This clinical investigation was approved by the Ethics Committee of the Tokushima University Hospital on November 26th, 2012 (No. 1580), and informed consent was obtained from all patients prior to review of the images.

Results

Of the 2,244 individuals, 914 (40.7%) were judged as having tonsilloliths on CT images (Table 1). These patients consisted of 468 males and 446 females. Of the 2,244 individuals, 300 (13.4%) were judged as having tonsilloliths on panoramic radiographs.

The detection rate of the panoramic radiographs was 32.8% when compared with CT. These patients consisted of 162 males and 138 females, with no sex difference being observed. One hundred and nineteen cases of tonsilloliths were located on the right side and 109 were located on the left side. Tonsilloliths were detected bilaterally in 72 patients (Table 2). There was no significant difference between the left and right sides. The prevalence of palatine tonsilloliths on panoramic radiographs gradually increased with age up to approximately 50 years of age. The prevalence of tonsilloliths in patients 30 years old and younger was significantly lower than in those who were 40 years old and above (Table 3) (p<0.01).

On panoramic radiographs, tonsilloliths were predominantly superimposed over the ramus of the mandible (category 1), and coincided with the soft palate (region 2) in 176 individuals (49.9%). This was followed by their presence inferior to the level of the soft palate (region 3) in 90 individuals (25.5%) (Table 4 and Fig. 2), with a prevalence of 7.8% and 4.0%, respectively, out of 2,244 individuals. Tonsilloliths were also superimposed over the soft tissue surrounding the mandible (category 2), and were located inferior to the body of the mandible (region 4) in 33 individuals (9.3%),

postero-inferior to the angle of the mandible (region 5) in 26 individuals (7.4%), and posterior to the ramus of the mandible (region 6) in 28 individuals (7.9%). The prevalence rates were 1.5%, 1.2%, and 1.3%, respectively, out of 2,244 individuals.

The sizes of the palatine tonsilloliths ranged from 1 to 10 mm as assessed by CT. With increasing tonsillolith size, the detection rate also increased on panoramic radiographs (Table 5) ($p<0.01$). Panoramic radiographs detected all cases of tonsilloliths larger than 6 mm, while the detection rate of tonsilloliths smaller than 2 mm was less than 8%. The number of palatine tonsilloliths detected in a single patient ranged from 1 to 18 as evaluated by CT. The detection rate increased on panoramic radiographs as the number of tonsilloliths increased (Table 6) ($p<0.01$).

Discussion

In the present study, palatine tonsilloliths were observed in 13.4% of the study population on panoramic radiographs, and the detection rate was 32.8% as compared with CT. The detectability depended on the size and number of tonsilloliths. Tonsilloliths were superimposed on the ramus of the mandible, surrounding soft tissue,

or both. To our knowledge, this is the first study to demonstrate that palatine tonsilloliths can be superimposed on the soft tissue in panoramic radiographs.

Tonsilloliths are thought to result from unresolved tonsillitis; with infectious agents such as fungi, bacteria, and actinomyces combining with pus cells to serve as an ideal location for stone formation [10]. Large palatine tonsilloliths are rare, and only approximately 50 cases have been reported in the literature [2-4, 10-18]. Tonsilloliths may vary in size and shape; for example, they may be round or rod-shaped. They may also arise as single or multiple calcifications, with either unilateral or bilateral formations.

The reported prevalence of palatine tonsilloliths on CT is 16% to 46.1% in previous literature [5-9]. This wide range of prevalence between investigations might be due to differences in slice thickness. The results from more recent studies using thin slice thicknesses will be more accurate, with prevalence rates of 39.9% [8] and 46.1% [7]. These high prevalence rates indicate that palatine tonsilloliths are one of the most common findings among the pathologic and physiologic calcifications in the head and neck region. In this study, panoramic radiographs detected palatine tonsilloliths in

13.4% of the study population, with a detectability approximately one-third that of CT. Therefore, it is important for clinicians to have accurate knowledge about the relatively high prevalence and imaging characteristics of palatine tonsilloliths during evaluation of panoramic radiographs. Should clinicians encounter patients with abnormal calcification incidentally detected on panoramic radiographs, the correct diagnosis should be made in the early stages to avoid further unnecessary diagnostic imaging. To our knowledge, only one previous report has investigated the detection rate of tonsilloliths on panoramic radiographs [7]. In that report, the tonsillolith detection rate on panoramic radiographs was 7.3%; approximately one-sixth of that found using CT when comparing 480 pairs of panoramic radiographs and CT images. This prevalence rate on panoramic radiographs was lower than that found in our present study. Although the reason is unclear, some possibilities exist to explain this difference; (i) the focal trough differed because of variations in the panoramic equipment or locus, which may have influenced the detectability of calcified bodies located medial to the mandible; (ii) differences in patient positioning during exposure of radiographs; (iii) different sample sizes; and (iv) variations in imaging systems, including digital and analog procedures. The tonsillolith

detection rate was significantly higher in participants over 40 years of age in the present study. In some previous reports, there were correlations between the tonsillolith detection rate and age of the participants [7, 8], while other reports showed no relationship between these factors [2, 11]. Although the reason for this discrepancy is unclear, it is possible that chronic oropharyngeal inflammation persists in older patients because of the higher rates of smoking and/or poor oral hygiene [19, 20]. However, the tonsillolith detection rate on panoramic radiographs was significantly related to the size and number of tonsilloliths, which coincided with the findings of a previous study [7]. There is a strong probability that tonsilloliths are positioned closer to the focal trough of the panoramic apparatus as they increase in size and number, which may contribute to the increased detection rate.

On panoramic radiographs, palatine tonsilloliths were most frequently superimposed over the ramus of the mandible (category 1). Of these, palatine tonsilloliths that coincided with the soft palate had the highest prevalence rate (region 2, 7.8%), whereas the prevalence was lower when tonsilloliths were located inferior to the soft palate (region 3, 4.0%) and superior to the soft palate (region 1, 0%). Anatomically,

as most of the palatine tonsillar structure is located inferior to the palate, this will not usually be observed superior to the soft palate on panoramic radiographs. When calcified bodies are detected on the mandibular ramus, clinicians should consider tonsilloliths as a differential diagnosis in addition to intra-mandibular lesions.

In this study, palatine tonsilloliths were also superimposed on the soft tissue surrounding the mandible (category 2). This was consistent with the observations of previous case reports [1, 3, 16]. However, these reports did not comment on the location and imaging characteristics of the tonsilloliths. When palatine tonsilloliths are superimposed on the soft tissue, differentiation between submandibular and parotid sialoliths is most important during routine clinical diagnosis, especially for patients with symptoms of obstructive sialadenitis. Furthermore, other conditions involving calcification should be considered in the differential diagnosis, such as calcification of the stylohyoid ligament and thyroid or triticeal cartilage. In addition, anatomical variants such as an enlarged maxillary tuberosity and prominent hamulus of the pterygoid process should also be considered. The following pathologic conditions should also be considered: calcification of the lymph nodes, calcified carotid or facial

arteries, phleboliths, loose bodies from the vertebrae, cysticercosis, calcified acne, osteoma cutis (miliary osteoma of the skin), myositis ossificans, dense bone islands (enostosis), displaced teeth, and foreign bodies [1, 5, 10, 12, 15, 21-23]. The imaging characteristics of the palatine tonsilloliths that were revealed by the present study will aid differentiation among these aforementioned conditions.

Conclusions

Palatine tonsilloliths are common forms of calcification, and are detected incidentally with high prevalence; 13.4% on panoramic radiographs and 40.7% on CT imaging. The detection rate of the panoramic radiographs was 32.8% as compared with CT. On panoramic radiographs, palatine tonsilloliths were superimposed both on the mandible and the surrounding soft tissue. Clinicians should be aware that palatine tonsilloliths emerge frequently, and they should be included among the diagnostic possibilities when panoramic radiographs detect calcified bodies around the mandible.

Conflict of interest

The authors declare that they have no conflict of interest.

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Figure Legends

Fig. 1. Locations of palatine tonsilloliths on panoramic radiographs.

Category 1: Tonsilloliths superimposed over the ramus of the mandible

Region 1: superior to the soft palate

Region 2: coincident with the soft palate

Region 3: inferior to the soft palate

Category 2: Tonsilloliths superimposed over the soft tissue surrounding the mandible

Region 4: inferior to the body of the mandible

Region 5: postero-inferior to the angle of the mandible

Region 6: posterior to the ramus of the mandible

Fig. 2. Panoramic radiographs and axial CT images of tonsilloliths superimposed over the ramus of the mandible on panoramic radiographs (category 1).

a) Calcified nodular masses (arrowheads) at the level of the soft palate (region 2). **b)** Tonsilloliths (arrowheads) on a CT image of the same patient. **c)** Calcified nodular masses (arrowheads) inferior to the level of the soft palate (region 3). **d)** Tonsilloliths (arrowheads) on a CT image of the same patient. A tonsillolith on the contralateral side is also observed (arrow).

Fig. 3. Panoramic radiographs and axial CT images of tonsilloliths superimposed over the soft tissue surrounding the mandible on panoramic radiographs (category 2).

a) Calcified nodular masses (arrowheads) inferior to the body of the mandible (region 4). **b)** Multiple tonsilloliths (arrowheads) on a CT image of the same patient. A tonsillolith on the contralateral side is also observed (arrow). **c)** Calcified nodular mass (arrowhead) postero-inferior to the angle of the mandible (region 5). **d)** Tonsillolith (arrowhead) on a CT image of the same patient. A tonsillolith on the contralateral side is also observed (arrow). **e)** Calcified small nodular mass (arrowhead) posterior to the ramus of the mandible (region 6). **f)** Tonsillolith (arrowhead) on a CT image of the same patient.

Figure

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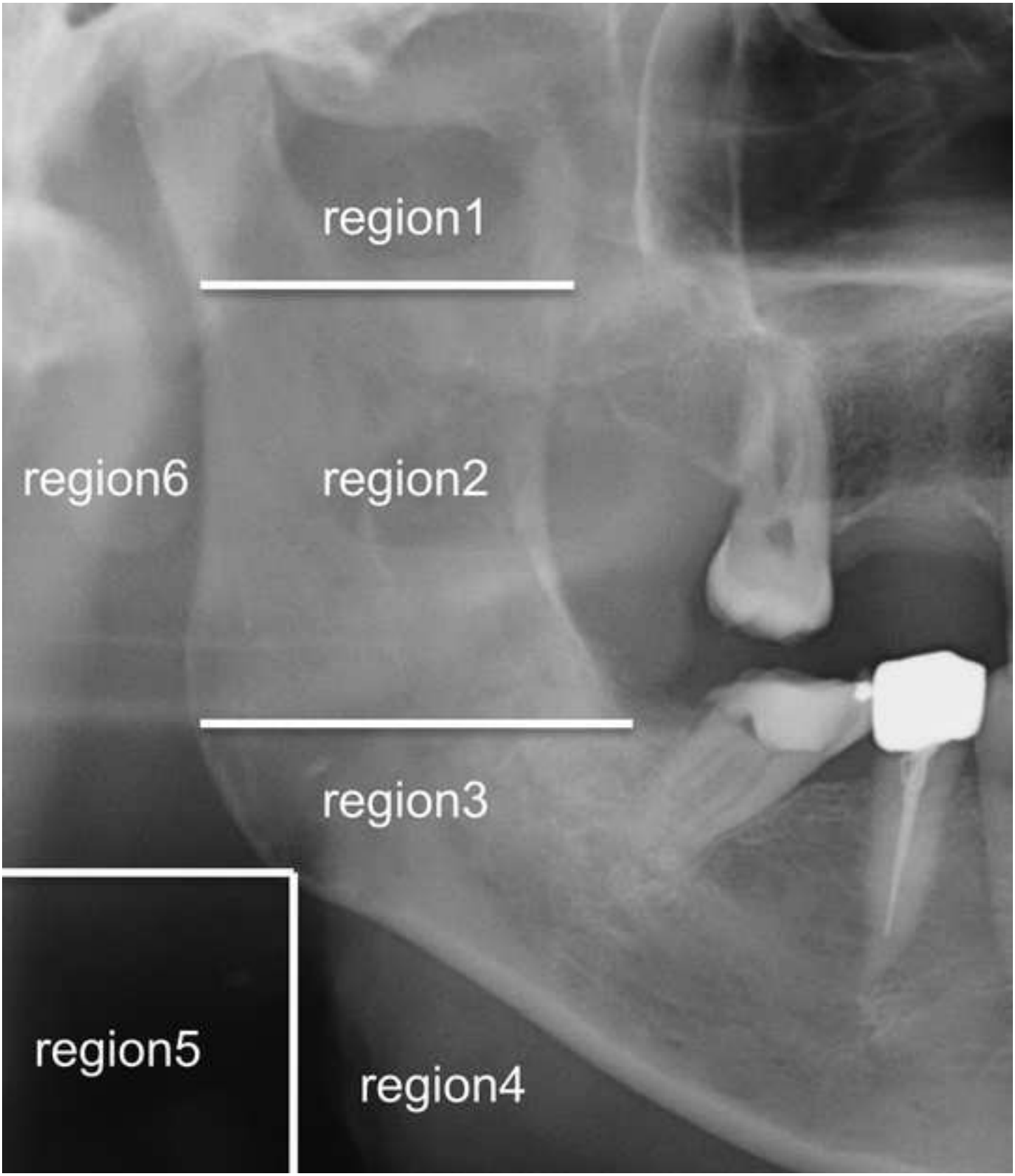

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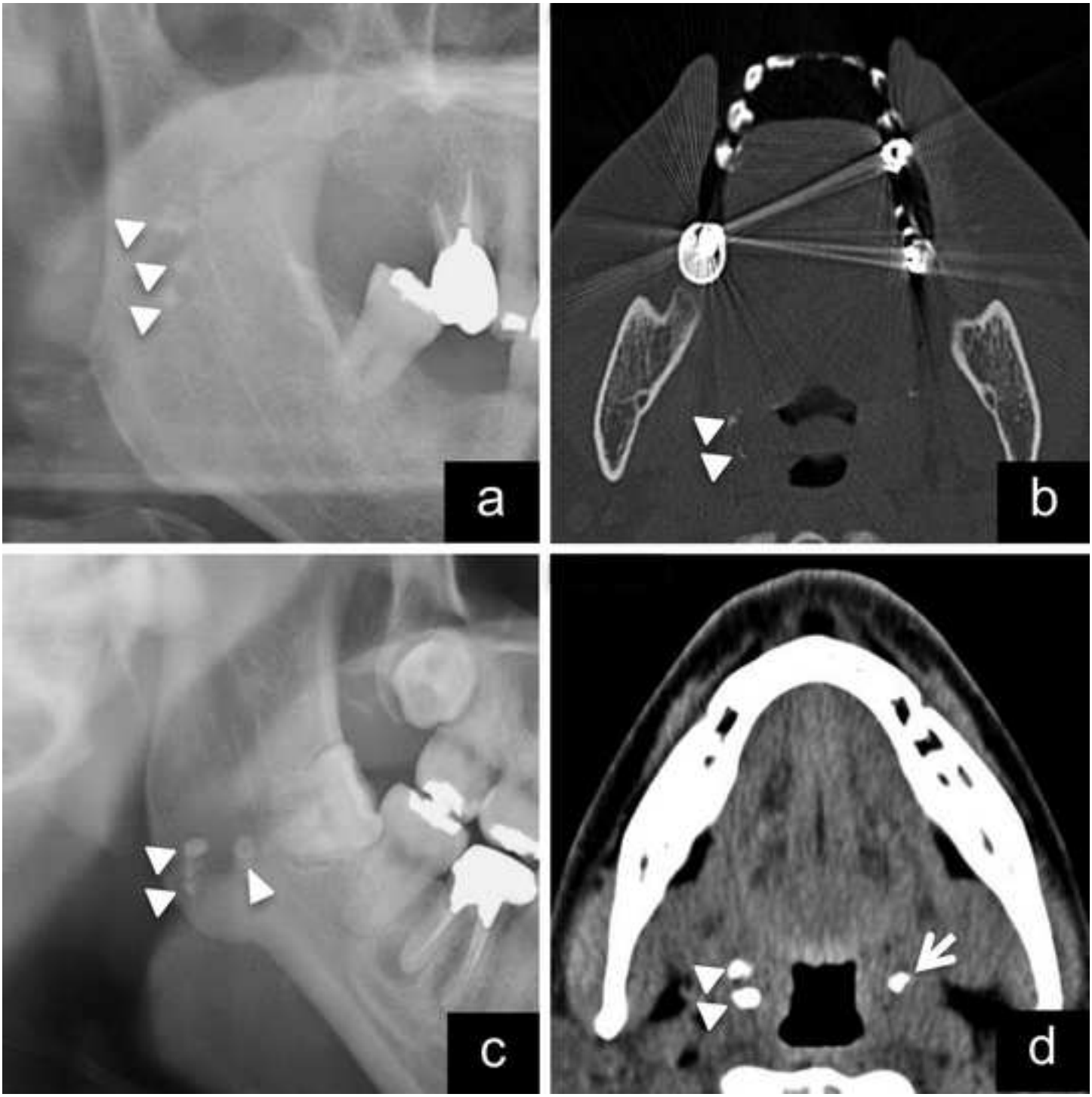

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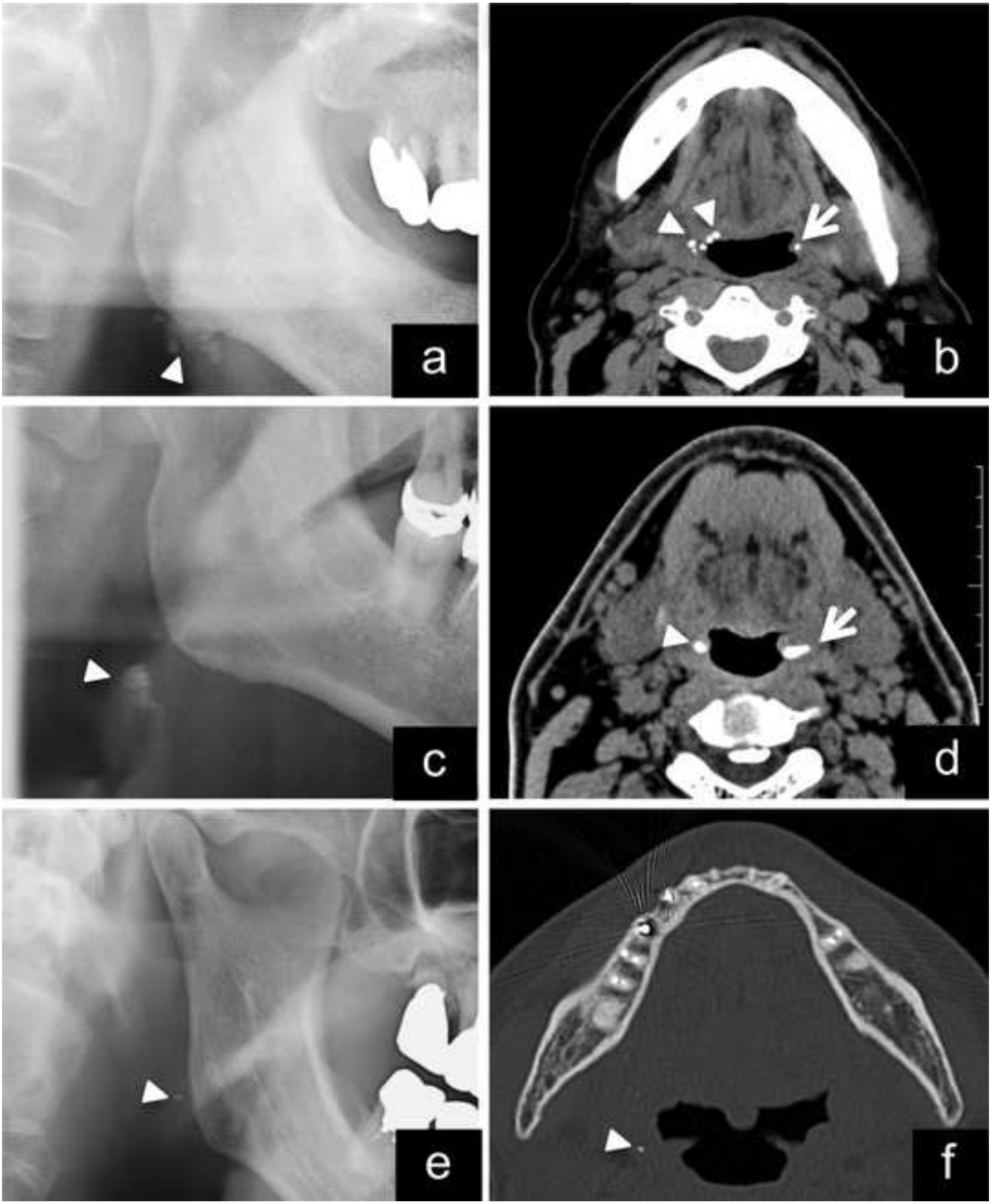

Table

Table 1. Sex differences in the detection rate of palatine tonsilloliths on panoramic radiographs and CT

Sex	Panoramic radiographs		CT		Detection rate of panoramic radiographs
	Presence / Total		Presence / Total		
Male	162 / 1060	(15.3%)	468 / 1060	(44.2%)	34.6%
Female	138 / 1184	(11.7%)	446 / 1184	(37.7%)	30.9%
Total	300 / 2244	(13.4%)	914 / 2244	(40.7%)	32.8%

CT: computed tomography

Table 2. Distribution of palatine tonsilloliths on the right and left sides on panoramic radiographs

Sex	Patients	Case number of tonsilloliths on panoramic radiographs					
		Right		Left		Bilateral	
Male	1060	70	(6.6%)	56	(5.3%)	36	(3.4%)
Female	1184	49	(4.1%)	53	(4.5%)	36	(3.0%)
Total	2244	119	(5.3%)	109	(4.9%)	72	(3.2%)

Table 3. Age distribution of palatine tonsilloliths on panoramic radiographs and CT

Ages	Panoramic radiographs				CT			
	Presence / Total				Presence / Total			
<9	0	/ 25	(0.0%)		2	/ 25	(8.0%)	
10–19	8	/ 182	(2.7%)		42	/ 182	(23.1%)	
20–29	9	/ 182	(3.3%)		59	/ 182	(32.4%)	
30–39	16	/ 182	(5.7%)		59	/ 182	(32.4%)	
40–49	36	/ 257	(11.3%)	*	105	/ 257	(40.9%)	*
50–59	83	/ 433	(13.6%)		212	/ 433	(49.0%)	
60–69	84	/ 446	(14.1%)		223	/ 446	(50.0%)	
70–79	47	/ 322	(12.1%)		153	/ 322	(47.5%)	
80–89	17	/ 126	(8.7%)		55	/ 126	(43.6%)	
>90	2	/ 14	(14.3%)		4	/ 14	(28.6%)	
Total	300	/ 2244	(13.4%)		914	/ 2244	(40.7%)	

CT: computed tomography

*Prevalence of palatine tonsilloliths in patients 30 years old and younger was significantly lower than those 40 years old and above ($p<0.01$)

Table 4. Location and prevalence of palatine tonsilloliths on panoramic radiographs

Location	Number of patients	Distribution by location	Prevalence on panoramic radiographs
Category 1: ramus of mandible			
region 1: superior to soft palate	0	0.0%	0.0%
region 2: coincident with soft palate	176	49.9%	7.6%
region 3: inferior to soft palate	90	25.5%	4.0%
Category 2: soft tissue			
region 4: inferior to body of mandible	33	9.3%	1.5%
region 5: postero-inferior to angle of mandible	26	7.4%	1.2%
region 6: posterior to ramus of mandible	28	7.9%	1.3%

Table 5. Size of palatine tonsilloliths on CT and detectability on panoramic radiographs

Size (mm) on CT	Number of sides detected by panoramic radiographs	Number of sides detected by CT	Detection rate by panoramic radiographs when compared with CT
1	41	525	7.8%
2	119	405	29.4%
3	110	187	58.8%
4	55	75	73.3%
5	26	29	89.7%
6	10	11	90.9%
>6	11	11	100.0%
Total	372	1243	29.9%

(Spearman $r = 1.000$, $p<0.01$)

CT: computed tomography

Table 6. Number of palatine tonsilloliths on CT and detectability on panoramic radiographs

Number on CT	Number of sides detected by panoramic radiographs	Number of sides detected by CT	Detection rate by panoramic radiographs when compared with CT
1	120	675	17.8%
2	82	262	31.3%
3	55	129	42.6%
4	36	71	50.7%
5	32	48	66.7%
6	20	30	66.7%
7	11	12	91.7%
>7	16	16	100.0%
Total	372	1243	29.9%

(Spearman $r = 0.991$, $p<0.01$)

CT: computed tomography