Prevalence of calcified triticeous cartilage-compatible images on 2500 digital panoramic radiographs of a Brazilian population sample

Prevalência de imagens compatíveis com calcificação da cartilagem tritícea em 2500 radiografias panorâmicas de uma amostra populacional brasileira.

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Abstract

Objective: To investigate the prevalence of calcified triticeous cartilage (CTC)-compatible images on digital panoramic radiographs of a significant Brazilian population sample. **Methods:** In this retrospective study, 2500 digital panoramic radiographs were analyzed by a trained examiner using contrast and brightness adjustments of the Adobe® Photoshop® CC 2015 software. Data were collected and exported for statistical analysis (p-value <0.05 was considered statistically significant). **Results**: The prevalence of CTC-compatible images was 4.5% (61.1% in women and 38.9% in men). The most prevalent age ranged between 51 and 60 years (32.7%), and bilateral occurrence had a higher prevalence (46.9%). Women between the ages of 61 and 70 years showed a significantly higher prevalence of CTC-compatible images (p=0.027). **Conclusion**: This study showed a low prevalence of CTC-compatible images, which mainly occurred in women close to 70 years of age.

Keywords: Prevalence. Cartilage. Panoramic Radiography. Physiologic Calcification.

Resumo

Objetivo: Investigar a prevalência de imagens compatíveis com calcificação da cartilagem tritícea (CCT) em radiografias panorâmicas digitais de uma significante amostra populacional brasileira. **Métodos**: Neste estudo retrospectivo, 2500 radiografias panorâmicas digitais foram analisadas por um examinador treinado utilizando ajustes de contraste e brilho através do software Adobe® Photoshop® CC 2015. Os dados foram coletados e exportados para análise estatística (p<0,05 foi considerado como valor estatisticamente significante). **Resultados**: A prevalência de imagens compatíveis com CCT foi de 4,5% (61.1% em mulheres e 38.9% em homens). A idade mais prevalente variou entre 51 e 60 anos (32,7%), sendo a ocorrência bilateral a mais comum (46,9%). Mulheres com idade entre 61 e 70 anos apresentaram prevalência significativamente maior de imagens compatíveis com CCT (p=0,027). **Conclusão**: O presente estudo evidenciou uma baixa prevalência de imagens compatíveis com CCT, que ocorreram, principalmente, em mulheres com idade próxima aos 70 anos.

Palavras-chave: Prevalência. Cartilagem. Radiografia Panorâmica. Calcificação Fisiológica.

INTRODUCTION

The triticeous cartilage (TC) is an anatomical structure that is part of the laryngeal skeleton, with variable shapes (round, oval, spindle, etc.)[1], measuring approximately 2 to 4 mm in length and 7 to 9 mm in width. It is located bilaterally in the center of the free posterior extremity of the thyrohyoid ligament, which extends from the greater horn of the hyoid bone to the superior horn of the thyroid cartilage[1-6], however, this structure may be absent in some cases[1,6,7]. Studies investigating the function of this cartilage, which is still unknown, have pointed out that TC may serve to strengthen the thyrohyoid ligament[1-6] and muscle attachment[1,8]. Throughout life, like other cartilages, TC has a tendency to calcify because of physiological or pathological alterations[2,3], and panoramic radiography may be a useful complementary imaging exam for differentiating

calcified triticeous cartilage (CTC)-compatible images from other calcification processes, such as sialoliths, phleboliths, mineralization of the stylomandibular and stylohyoid ligaments, and calcified carotid atheromas[1-5,9-12].

Although TC has been poorly described in dental imaging studies, probably because of its small size and intimate location with other radiographically similar structures[4], its recognition in panoramic radiographs is necessary, especially as a differential diagnosis of calcified carotid atheromatous plaques. Additionally, the imaging recognition of the TC has been emphasized in emergency services where, in some cases, the differential diagnosis of TC with the hyoid bone and laryngeal

fractures is required[1,3].

CTC-compatible images can be visualized on panoramic radiographs as homogeneous, ovoid, and radiopaque bodies located in the C3 and C4 region, below the greater horn of the hyoid bone and above the superior horn of the thyroid cartilage[1-6]. However, studies that analyze its prevalence in panoramic radiography are scarce. Ahmad et al (2005) firstly reported epidemiological data on 847 panoramic radiographs in a survey in the United States[2]. Other studies evaluated the prevalence of CTC in computed tomography exams[4] and even in cadavers[1,6,13,14].

Given the limited number of imaging studies that have focused on CTC, and considering the clinical correlation and importance of this anatomical structure, the present study aimed to conduct an epidemiological investigation regarding the prevalence of the CTC-compatible images in a significant sample of 2500 digital panoramic radiographs.

MATERIALS AND METHODS

Study design and sample

It was performed an observational study with retrospective data. Firstly, 2940 digital panoramic radiographs obtained from a private dental radiology clinic in the state of Ceará, Brazil, were evaluated regarding the adopted image-selecting criteria. The inclusion criteria were digital panoramic radiographs of patients aged older than 18 years, from individuals of both sexes, which showed the cervical region. Exclusion criteria were imaging exams with poor visualization quality and duplicated radiographs. After the exclusion of 440 images, the final sample evaluated in this investigation amounted to 2500 digital panoramic radiographs. All images were obtained from the Cranex D teleradiography (Soredex, Orion Co, Espoo, Finland)
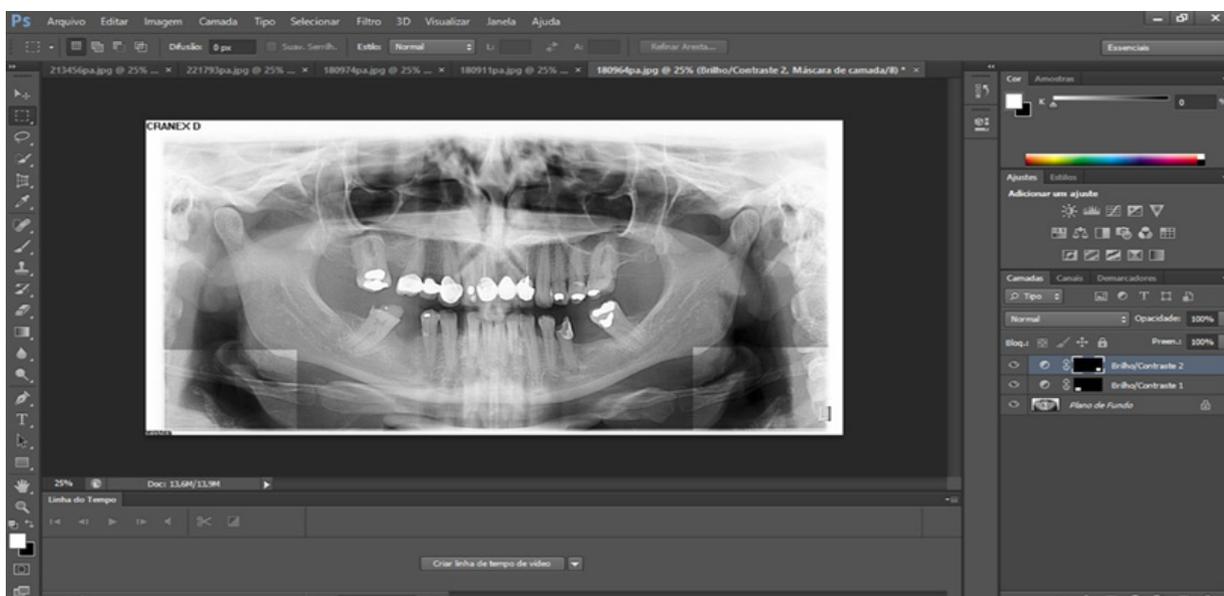
system.

Image analysis

The differential diagnosis of CTC-compatible images and other tissue calcifications in the cervical region was performed a dental student (examiner) who was trained by an oral and maxillofacial radiologist with more than 20 years of experience in the interpretation of panoramic radiographs and computed tomography of the head and neck ("reference standard"). CTC-compatible images were characterized as well defined, homogeneous, ovoid and radiopaque bodies located in the region of the C3 and C4 vertebrae, below the greater horn of the hyoid bone and above the superior horn of the thyroid cartilage, as described in the literature5. Examiner's agreement with the reference standard observer was verified with the independent evaluation of 100 randomly selected digital panoramic radiographs. The Kappa coefficient was used to measure the degree of agreement, and it was interpreted as being poor (0), slight (0.01-0.2), fair (0.21-0.4), moderate (0.41-0.6), substantial (0.61-0.8) or almost perfect (0.81-1)[15].

All digital panoramic radiographs selected for this study were analyzed by the trained examiner, and the oral and maxillofacial radiologist answered any questions. Finally, the diagnosis of CTC-compatible images was discussed and only images in agreement with the reference-standard examiner's diagnosis were considered positive. The software Adobe® Photoshop® CC 2015 (Adobe Systems Incorporated, California, USA) was used to detect CTC-compatible images, adjusting saturation and contrast parameters. A filter was created in the software and applied to all analyses, which provided better visualization and standardization during image evaluation (Figure 1). The data collected were: presence/absence of CTC-compatible images, gender, age, and laterality.

Figure 1

Legend: Saturation and contrast adjustment of a panoramic radiograph using the software Adobe® Photoshop® CC 2015 (Adobe Systems Incorporated, California, USA).

All imaging evaluations were completed after approximately 60 days. 40 radiographic assessments were performed daily (equally distributed between morning and afternoon shifts). The interval between shifts was at least 2 hours.

Statistical analysis

The data were tabulated in Microsoft Excel and exported to the Statistical Packing for Social Sciences (SPSS) version 20.0 for Windows software in which the analysis was performed considering a 95% confidence. Descriptive statistics were performed to obtain the absolute and percent frequency of each of the studied variables. Fisher's Exact / Chi-square tests were used to perform the univariate analysis of the frequencies, as well as the bivariate analysis, which included calcification prevalence-related risk factors and sex influence. The level of significance was set at 5%.

Ethical considerations

This study was approved by the Research Ethics Committee of the Federal University of Ceará (Fortaleza, Ceará, Brazil) under the approval protocol 285/11. The anonymity of the subjects during data processing was guaranteed, with no direct patient contact. Patient consent regarding the use of their panoramic radiographs for research purposes was obtained through a signed trustee form (translation for "Termo de Fiel Depositário" from the Portuguese language) provided at the private dental radiologic clinic.

RESULTS

Of a total of 2500 digital panoramic radiographs evaluated, 113 presented CTC-compatible images, resulting in a prevalence of 4.5%. Figure 2 shows two case examples. The value of the concordance analysis between the examiner and the reference standard observer using the Kappa coefficient was 0.831 (almost perfect).

According to Table 1, the age prevalence was found between 51-60 years. Gender prevalence was higher among females. CTC-compatible images showed a higher prevalence of a bilateral calcification pattern. Also, there was a statistically significant prevalence among female individuals aged between 61-70 years (p < 0.05; Figure 3).

Calcification site did not show a significant association with gender (p = 0.058) or age (p = 0.590). The distribution of patients was similar when correlating gender and age, with most female patients being independent of age since there was no statistically significant difference for the bivariate analysis (p = 0.246).

Although no statistically significant difference was found between laterality and age, similar percentage values were found between the right and left sides in individuals over 70 years of age, whereas radiographs of individuals aged under 50

years showed a higher percentage of CTC-compatible images on the left side.

When compared with the group of patients who did not exhibit calcifications (n = 2387; 95.5%), no statistically significant difference between the prevalence of calcification in men (n = 46; 4.4%) and women (n = 67; 4.6%) was observed. Regarding age, the prevalence of CTC-compatible images was significantly higher (p <0 .001) in age intervals of 41-50 (n = 27; 8.1%), 51-60 (n = 36; 9.2%), 61-70 (n = 23; 10.0%) and over 70 (n = 11; 7.3%) years than in patients under 40 years of age (n = 16; 1.1%).

Figure 2
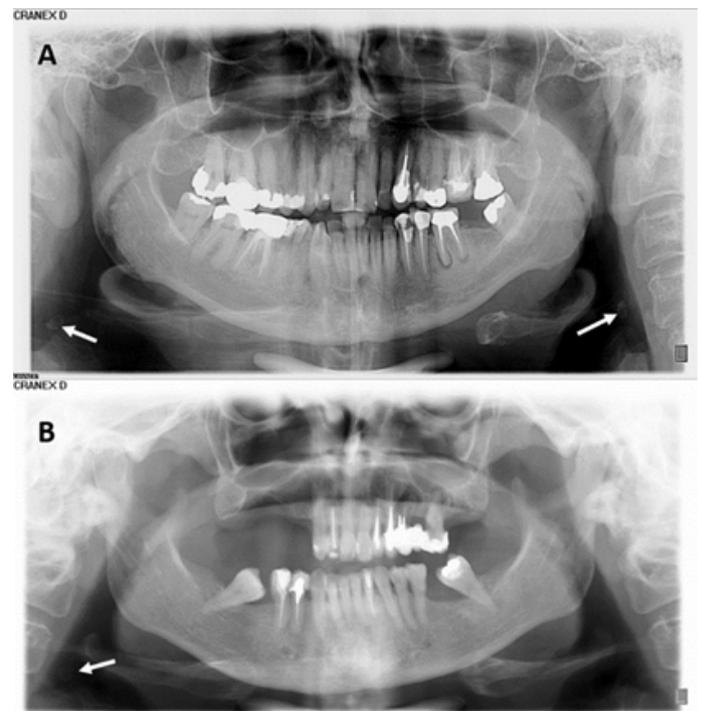
Legend: Case-example of CTC-compatible images. A. Bilateral. B. Unilateral Right Side.

Figure 3
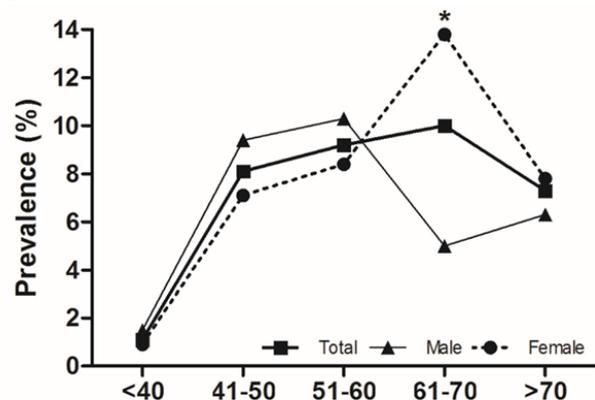
Legend: Influence of gender and age on the prevalence of CTC-compatible images in digital panoramic radiographs. * p <0.05, chi-square test versus male sex in the same age group. Data expressed in percentage frequency.

Table 1: Sample characterization

Age (years)	n	%	p-Value
≤ 40	15	13.3	
41-50	27	23.9	
51-60	37	32.7	0.051
61-70	23	20.4	
>70	11	9.7	
Gender			
Female	69	61.1	0.094
Male	44	38.9	
Site			
Right	24	21.2	
Left	36	31.9	0.058
Bilateral	53	46.9	

* p <0.05, chi-square test. Data expressed in absolute and percentage frequency.

Table 2: Influence of gender and age on the prevalence of cartilage calcification in digital panoramic radiographs.

Age	Calcification Prevalence				Female				Male				p-Value
	Absent		Present		Absent		Present		Absent		Present		
≤ 40	1376	98.9%	16	1.1%	792	99.1%	7	0.9%	583	98.5%	9	1.5%	0.313
41-50	307	91.9%	27	8.1%	182	92.9%	14	7.1%	125	90.6%	13	9.4%	0.542
51-60	357	90.8%	36	9.2%	217	91.6%	20	8.4%	140	89.7%	16	10.3%	0.593
61-70	208	90%	23	10%	112	86.2%	18	13.8%	96	95%	5	5%	0.027*
>70	139	92.7%	11	7.3%	94	92.2%	8	7.8%	45	93.8%	3	6.3%	1.000
p-Value	<0.001				<0.001				<0.001				

* p <0.05, chi-square test versus male sex in the same age group. Data expressed in absolute and percentage frequency.

DISCUSSION

CTC-compatible images is an important finding in panoramic radiographs, especially for the establishment of differential diagnosis with other anatomical or pathological structures that may be present in the cervical region[3,5]. In this context, the present study is important because it adds relevant results to the literature, which is relatively scarce, with a limited number of papers focusing on epidemiological data regarding the calcification of TC obtained from digital panoramic radiographs. Despite some recent studies performing investigations with computed tomography[1,4], this finding of this study is relevant because digital panoramic radiographs are complementary imaging exams routinely required in dental practice.

In this study, a relevant prevalence of 4.5% of CTC-compatible images was observed after a detailed evaluation of the radiographs. A previous study by Ahmad et al (2005), conducted in the United States, revealed the presence of calcification in 73 (8.6%) of a total of 847 radiographs[2]. Already Aoun and Nasseh (2018) identified a prevalence of 10.6% (53/500) in a study conducted in Lebanon[3]. Vatansever et al (2018) showed the prevalence of TC (68,1%) with the presence of variable calcification degrees, in a Turkish population, using computed

tomography angiography[1]. Similarly, a study by Alqahtani et al (2016) detected a prevalence of 53,1% of TC in an American population[4]. Wilson et al (2017) observed a prevalence of TC (33%) in dissected cadavers in a British population[6].

The age group between 51 and 60 years old showed a higher prevalence when compared to the other age groups (n = 37, 32.7%). This finding is following the report by Ahmad et al (2005), in which CTC was found in 12.8% of the patients in the same age group[2]. In a study by Aoun and Nasseh (2018), a similar result was found in patients, with an average age of 55.6 years[3]. In contrast, Hately et al (1965) suggested a higher prevalence at 23 years of age[16]. CTC-compatible images are more frequently found in panoramic radiographs of older individuals because they remain as hyaline cartilage throughout life. These types of cartilages, also represented by the cricoid and thyroid, show a greater tendency to calcify, or even to ossify, with advancing age[5,6,17].

Previous research has shown that CTC is more common in females, which is under our findings. Ajmani et al (1979, 1990) carried out studies with cadavers in India and Nigeria[13,14],

showing a higher prevalence of calcification in women (men = 7.3% and women = 9.5%, men = 13.2% and women = 16.7%, respectively). In the United States, Ahmad et al (2005) also reported a significantly higher prevalence in females (12%) compared to males (5%)[2]. Studies by O'bannon and Grunow (1954) also revealed the presence of CTC-compatible images to be more common in women[18]. However, Hately et al (1965) reported a higher prevalence in men (29%) than in women (22%)[16].

Although there is no plausible explanation for a higher prevalence in women, this finding can be considered similar to that observed with atheromatous plaques, which are a differential diagnosis of CTC-compatible images. Concerning atheromas, a higher prevalence in females has been attributed to the decrease in estrogen levels, a hormone that prevents the formation of atheromas because of its effects on lipoprotein metabolism, according to Friendlander and Altman (2001)[19]. Similarly, the authors of the present study also attribute this to the fact that a higher percentage was observed in females.
In our study, bilaterality had a higher prevalence (46.9%), similar to the findings of Aoun and Nasseh (2018) (37/53)[3]. In cases of unilateral calcification, the left side was more prevalent (31.9%) than the right side (21.2%).

One of the most relevant aspects of this study was the comparison between the variables of age, gender, and laterality, which was not established in previous investigations. It was observed that the group of patients aged between 61-70 years showed a significantly higher prevalence of calcification in females than in males.

The presence of anatomical structures and soft tissue calcifications may be observed in proximity to the TC, such as hyoid bone, superior horn of calcified thyroid cartilage, sialoliths, tonsilloliths, stylomandibular ligament, and stylohyoid ligament mineralization. Therefore, the identification of the radiographic differences in morphology and location of these structures is necessary[3].

Calcified carotid atheromas are an important differential diagnosis of CTC[2,5,20-23]. Studies have indicated that calcified carotid atheromas-compatible images are radiographically visualized as irregular, heterogeneous, vertical, irregular radiopacities, below the angle of the mandible, and adjacent to the images of the C3 and C4 vertebrae[24-29]. Whereas CTC-compatible images can be seen as well defined, oval, uniform radiopaque bodies below the greater horn of the hyoid bone and above the superior horn of the thyroid cartilage. These calcified atherosclerotic plaques are located laterally on the panoramic radiograph compared to TC[2,5,21,22], which was observed in this study during the selection process of eligible images.

The correct diagnosis of CTC is relevant, especially when investigating carotid artery calcifications. No treatment is necessary for CTC, however, patients with carotid artery atheromas need better evaluation because they are a risk factor for stroke.

Panoramic radiography is not recommended for the diagnosis of soft tissue calcifications because of superimposition of structures and limited distinction of low contrast tissues. However, panoramic radiography can assist in the early diagnosis of these processes, such as a routine examination. The clinician should refer the patient to a specialist or request more specific exams (ultrasonography, magnetic resonance, computed tomography) for diagnostic confirmation only in case of real need when atheroma is suspected for example[30].

Panoramic radiography may be used to detect CTC-compatible images in patients. However, it is not considered a standard diagnostic method because of the overlapping of images and the variety of differential diagnoses such as atheroma. Therefore, it could be considered a limitation of this study. Besides, sample size, absence of detailed clinical data, and inclusion of a single dental imaging clinic may not reflect the general population.

In conclusion, the present study evidenced a low prevalence of CTC-compatible images (about 5%) in a significant sample of digital panoramic radiographs, which is an important additional contribution to the scarce literature. Moreover, a significant prevalence of CTC-compatible images was observed in women between the ages of 61 and 70 years. The findings of this could help clinicians in differentiating CTC-compatible images from other radiopaque structures, such as calcified carotid atheromas, which represent a risk factor for systemic complications.

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