ORIGINAL PAPER

EXAMINATION OF INCIDENTAL INTRA-CRANIAL AND EXTRA-CRANIAL HEAD AND NECK CALCIFICATIONS USING CONE-BEAM COMPUTED TOMOGRAPHY

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ABSTRACT

Introduction: Increasing use of cone-beam computed tomography (CBCT) has improved the likelihood for all physicians, including dentists, to detect incidental findings (IFs) on scans.

Objectives: This study aimed to evaluate the incidence and clinical significance of incidental calcifications in the head and neck region as well as vital calcifications, such as ponticulus posticus and carotid artery calcifications, on CBCT images with large field of view (FOV).

Material and methods: CBCT of 171 patients, including 95 men and 76 women, with FOV of 230 mm × 170 mm and FOV of 230 mm × 270 mm, who met the inclusion and exclusion criteria, were included in the current study. Calcifications unrelated to the purpose of CBCT request and detected in analyzed images calcifications were recorded as IFs.

Results: Incidental calcifications were found in 75.4% of the analyzed images. The incidence of calcifications in the head and neck region was 17%. The most common type of calcification was intra-cranial calcification with 69%, and ponticulus posticus calcification with 19.3%. Carotid artery calcification was found in 1.2%. Although not statistically significant, our study found that the rate of calcification was higher in men above 60 years of age ($p > 0.05$).

Conclusions: In our study, more than one calcification finding in the same patient's CBCT was recorded as a common finding. The clinical significance of calcifications, especially carotid calcifications, increases with age. Therefore, this finding should be considered while performing CBCT examinations.

Key words: cone beam computed tomography, calcification, ponticulus posticus, carotid, incidental.

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INTRODUCTION

Following the development of three-dimensional (3D) cone-beam computed tomography (CBCT) in 1990s [1], in recent years, this method has been established in dentistry due to high resolution and detail [2], offered by CBCT in imaging the maxilla and mandible. In addition, multiplane images produced by CBCT provide a different perspective in assessing patient's needs compared with two-dimensional images produced by conventional radiographs. In addition to examining dental structures, CBCT allows the evaluation of anatomical formations, including temporomandibular joints (TMJ), paranasal sinuses, and pathological formations, such as soft-tissue calcifications of the neck and ponticulus posticus [3-5]. CBCT reveals not only anatomy, but also hidden pathology, reducing the risk of neglecting a clinically significant disease [6]. Additionally, the high resolution and

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detail imaging of CBCT increase the chances of discovering incidental findings (IFs). IF can be defined as a radiographic or tomographic image with any discovery unrelated to the original purpose of examination, which can range from anatomical variations to benign and malignant lesions [7]. CBCT examinations with a large field of view (FOV) can reveal incidental findings, such as anatomic variants of the cervical spine and calcifications of the carotid artery in the neck. These findings' location and radiologic features can be critical [3-5]. Failure to diagnose and follow-up with IFs can have negative consequences for the patient, and cause dentists to neglect their legal responsibilities. Although often overlooked, evaluation of all structures included in the examination is required according to the guidelines of the American Academy of Oral and Maxillofacial Radiology. Therefore, the dentist evaluating a CBCT image should be aware of all the structures included in the image, except the dento-maxillary complex [4]. Most dentists, who are not radiologists, are not qualified to interpret anatomical structures and/or pathologies other than teeth and jaws [8]. In the current literature, no study examined calcifications in the head and neck region, including carotid artery calcifications (CAC), ponticulus posticus, and intra-cranial calcifications at large FOV in CBCT images used in examination of the head and neck region.

OBJECTIVES

The aim of this study was to determine the occurrence of incidental calcifications and vital calcifications, such as ponticulus posticus and CAC as well as age and gender prevalence in large FOV CBCT images, and to indicate the clinical significance of these calcifications.

MATERIAL AND METHODS

Ethical approval was obtained from the Ethics Committee of the Faculty of Medicine, Ankara University (dated June, 7, 2021, with. approval No of 2021/143). The study was conducted in full compliance with the Declaration of Helsinki.

In this study, CBCT records of patients admitted for various diagnostic reasons between 2013 and 2018 derived from the archives of Ankara University, Faculty of Dentistry (AUDF) and Department of Oral, Dental, and Maxillofacial Radiology, were retrospectively analyzed. All indications for CBCT examination are specified in the official signed referral request at the AUDF Oral Radiology Unit. Demographic characteristics of the patients included in the study are shown in Table 1.

All of CBCT images used in the study were obtained with Planmeca ProMax 3D Max (Planmeca, Promax, Finland) device. Images with 230 mm × 270 mm and 230 mm × 170 mm FOV, 96 kVp, 5.6/7/8 mA, 9-12 seconds irradiation time, and 0.2 mm or 0.4 mm voxel sizes, were examined. Original software of the device, Planmeca Romexis (3.7; Planmeca, Helsinki, Finland), was applied for CBCT evaluations. All images were viewed and evaluated on a 21.3 inch flat panel, color active matrix, and thin-film transistor (TFT) medical monitor (NEC MultiSync MD215MG München, Germany) with 2,048 × 2,560 resolution at 75 Hz and 0.17 mm dot pitch at 11.9 bit. Any calcification finding unrelated to the purpose of CBCT request was recorded as an incidental finding. Patients' age, gender, and CBCT imaging areas were recorded. Incidental calcification findings were grouped according to their location: complete ponticulus posticus (Figure 1A), partial ponticulus posticus (Figure 1B), intra-cranial calcification (Figure 1C), carotid artery calcification (Figure 1D), osteoma cutis (Figure 2A), nasal cavity calcification (Figure 2B), tonsillolith calcification (Figure 2C), sialolith (Figure 2D), styloid ligament calcification (Figure 2E-F), and lymph node calcification. Radiographic criteria for review of incidental findings were applied according to the specifications for differential diagnosis by White and Pharoah (7th edition) [9]. Radiopaque images, such as teeth, intra-oral prostheses, root remnants, and implants that presented with similar appearance to the calcification, were identified and excluded from the examination. In addition, findings of calcifications that were directly related to the primary indication for CBCT scans were excluded. Scans without 230 mm × 170 mm FOV and 230 mm × 270 mm FOV fields were excluded as well as CBCT scans with motion artifacts, poor diagnostic image quality, and positioning artifacts. Each volume was viewed in three orthogonal planes (axial, coronal, and sagittal views). Oblique sections were examined when a variation or pathology was found. Panoramic images were created to view the maxillary and mandibular teeth. Sections were viewed perpendicular to the created panoramic images to visualize the details. All scans were independently reviewed by a professor, oral and maxillofacial radiologist, and a resident with 3 years of training in oral and maxillofacial radiology. At the time of interpretation, all working conditions were similar and standardized, and any inconsistencies in assessments were unanimously resolved.

TABLE 1. Distribution of demographics and image size characteristics

Factor	n (%)
Age	
< 35	80 (46.8)
35-60	71 (41.5)
> 60	20 (11.7)
Gender	
Male	95 (55.6)
Female	76 (44.4)

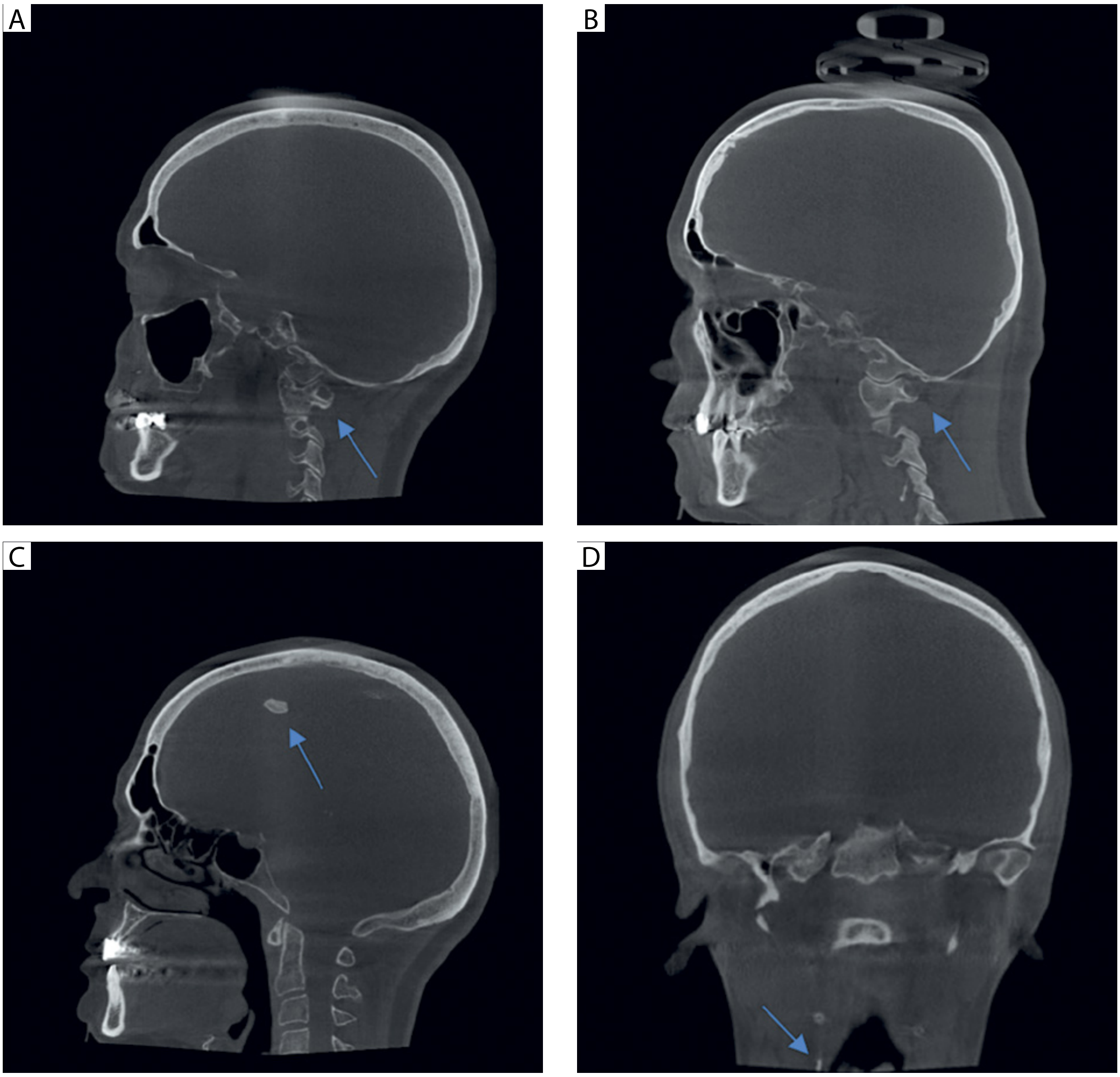

FIGURE 1. A) Cone-beam computed tomography (CBCT) image of right complete ponticulus posticus. **B**) CBCT image of right partial ponticulus posticus. **C**) CBCT image of intra-cranial calcification. **D**) CBCT of right carotid artery calcification

STATISTICAL ANALYSIS

Data analysis was done with SPSS version 26.0 program, and it was analyzed with a 95% confidence level. Frequency (*n*) and percentage (%) statistics were given for categorical (qualitative) variables. In the study, χ^2 test was applied to determine the relationships between the variables. χ^2 is a test technique used to determine the relationship between two categorical variables. Pearson's χ^2 test is applied, when the percentage of cells with an expected value less than 5 is 20% or less, while the test is considered invalid if it is greater than 20%. For this reason, Fisher's exact test was used for such variables. In the study, χ^2 test was applied in the relationship between calcification status and types, gender, age, and image size.

RESULTS

Of the patients in our study, 46.8% were under 35 years of age, 41.5% were between 35 and 60 years of age, and 11.7% were over 60 years of age. The gender ratio was 55.6% in men, and 44.4% in women. The image size was 230 mm × 170 mm FOV in 58.5% of the analyzed images, and 230 mm × 270 mm FOV in 41.6%.

Calcification was observed in 75.4% of the patients, and not seen in 24.6%. Calcification was noted in the head in 53.2%, in the neck in 5.3%, and both the head and neck in 17.0% of the patients. Incidence rates by calcification type were as follows: complete ponticulus, posticus 8.81%; partial ponticulus posticus, 10.51%; intra-cranial calcification, 69.0%; carotid artery calcification,

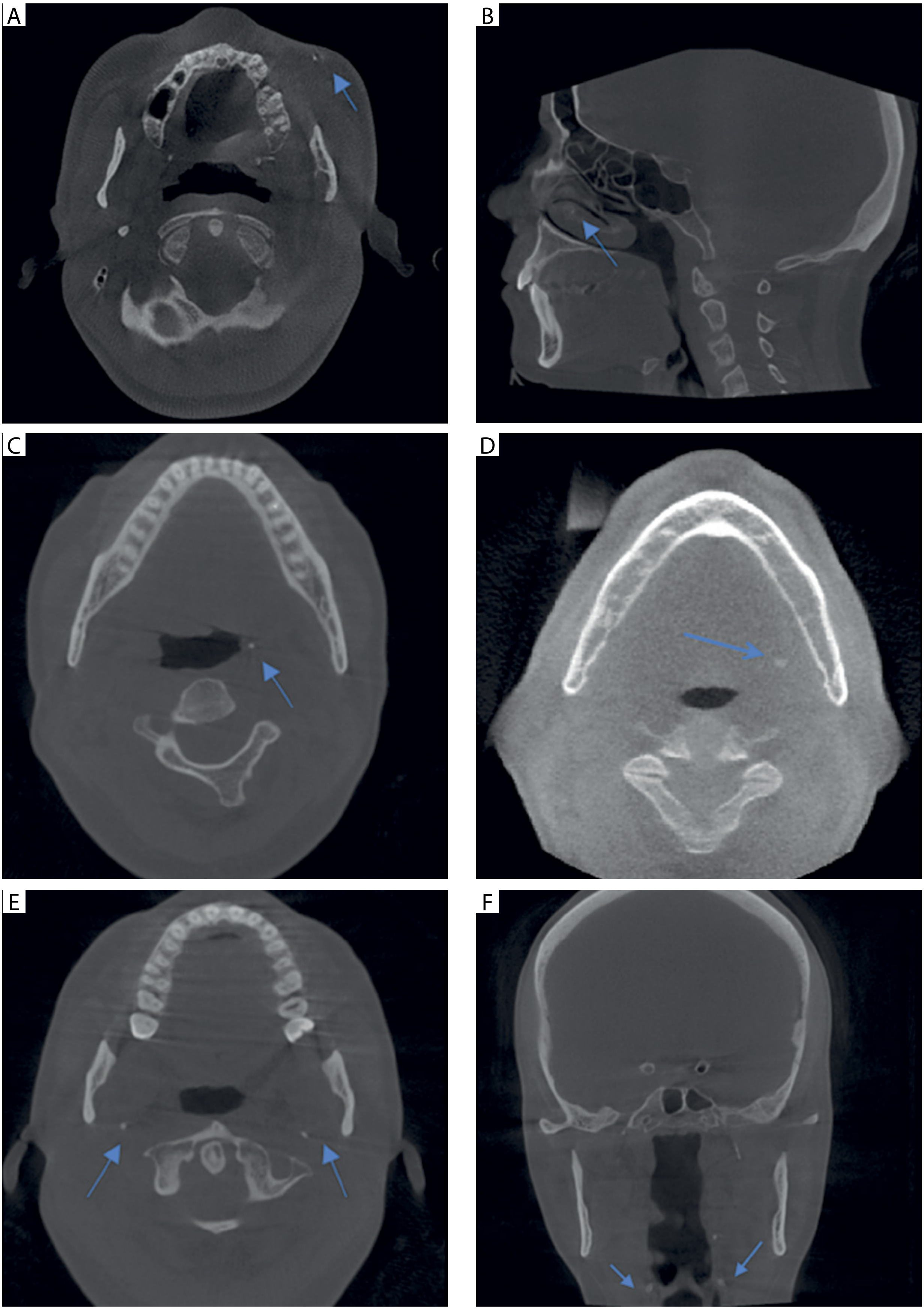

FIGURE 2. A) Cone-beam computed tomography (CBCT) image of osteoma cutis. **B**) CBCT image of nasal cavity calcification. **C**) CBCT image of tonsilloliths. **D**) CBCT image of sialolith. **E**) CBCT image of calcification of styloid ligament. **F**) CBCT image of calcification of styloid ligament

TABLE 2. Distribution of calcification characteristics

Factor		n (%)
Calcification		
	–*	42 (24.6)
	+**	129 (75.4)
Calcification zone		
	–	42 (24.6)
	Head	91 (53.2)
	Neck	9 (5.3)
	Head and neck	29 (17.0)
Intra-cranial calcification		
	–	53 (31.0)
	+	118 (69.0)
Carotid artery calcification		
	–	169 (98.8)
	+	2 (1.2)
Osteoma cutis		
	–	169 (98.8)
	+	2 (1.2)
Complete ponticulus posticus		
	–	156 (91.19)
	+	15 (8.81)
Partial ponticulus posticus		
	–	153 (89.49)
	+	18 (10.51)
Tonsillolith		
	–	163 (95.3)
	+	8 (4.7)
Sialolith		
	–	167 (97.7)
	+	4 (2.3)
Lymph node calcifications		
	–	171 (100.0)
	+	0 (0.0)
Calcification of stylohyoid ligament		
	–	167 (97.7)
	+	4 (2.3)
Nasal cavity calcification		
	–	170 (99.42)
	+	1 (0.58)

***Presence of calcification. *Absence of calcification.*

1.2%; osteoma cutis, 1.2%; nasal cavity calcification, 0.58%; tonsillolith calcification, 4.7%; sialolith, 2.3%; styloid ligament calcification, 2.3%; and lymph node calcification, 0.0%.

Although there was no significant correlation, the rate of calcification was higher in patients with ages older than 60 years. While calcifications of the head and neck were more common in individuals under 35 years of age, the incidence of calcifications over 60 years of age was simultaneously higher on the right and left sides.

Intra-cranial calcification and complete ponticulus posticus were more common in patients over 60 years of age, carotid artery calcification, partial ponticulus posticus, and tonsilloliths were more common in the 35-60 age group, while osteoma cutis and calcification of stylohyoid ligament were more common under 35 years of age (Table 3).

When the incidence of calcification in all regions was examined, it was observed that it was generally higher in men, but there was no significant relationship between these two. Carotid artery calcification, osteoma cutis, complete ponticulus posticus, and partial ponticulus posticus were more commonly seen in women (Table 4).

DISCUSSION

In the current study examining incidental calcifications not directly related to the indication in large FOV CBCT scans, the rate of intra-cranial calcifications (Figure 1) was 69.0% (Table 2). In studies investigating intra-cranial calcifications with CBCT conducted by Sedghizadeh *et al.* [10], Bayrak *et al.* [11], and Yalcin *et al.* [12], the intra-cranial calcifications were determined as 35.2%, 33.1%, and 3.9%, respectively. In other study, Daghighi *et al.* [13] examined the rate of intra-cranial calcifications with medical CT, and the rates of intra-cranial calcifications were 71.0% and 69.3%, respectively. Researchers attributed the detection of more intra-cranial calcifications than CBCT in CT studies to the better soft-tissue contrast and less noise of CT, which allows clearer identification and differentiation of lesions in the brain [10, 11]. In our study using CBCT, the rate of intra-cranial calcification was found consistent with studies using CT [13]. In addition to these superior features of medical CT, one of the most striking features of CBCT imaging is that it has a high geometric resolution that produces a sufficient image for detailed examination of small tooth and bone structures, that is, it can distinguish objects with different attenuation values that are adjacent to each other [14, 15]. This difference may be related to the specificity of different devices used in other studies and, in particular, to differences in FOV parameters used. In addition, ethnic differences in the studied populations may be an important criterion for the rate of intra-cranial calcification.

Carotid artery calcification (CAC) occurs when fatty deposits are formed in blood vessels of the carotid artery. This was found to effectively slow blood flow to the brain [3, 16]. Although the current literature on this topic is extensive and controversial, calcifications generally cause atherosclerosis and can lead to conditions, such as stroke

TABLE 3. Relationship between age and calcification characteristics

Factor		Age, *n* (%)			χ^2	*p*-value
		< 35 years	35-60 years	> 60 years		
Calcification						
	–	22 (27.5)	16 (22.5)	4 (20.0)	0.685	0.721
	+	58 (72.5)	55 (77.5)	16 (80.0)		
Classification zone						
	–	22 (27.5)	16 (22.5)	4 (20.0)	5.585	0.452
	Head	41 (51.3)	39 (54.9)	11 (55.0)		
	Neck	7 (8.8)	2 (2.8)	0 (0.0)		
	Head and neck	10 (12.5)	14 (19.7)	5 (25.0)		
Intra-cranial calcification						
	–	31 (38.8)	18 (25.4)	4 (20.0)	4.437	0.109
	+	49 (61.3)	53 (74.6)	16 (80.0)		
Carotid artery calcification						
	–	79 (98.8)	70 (98.6)	20 (100.0)	0.625	0.999
	+	1 (1.3)	1 (1.4)	0 (0.0)		
Nasal cavity calcification						
	–	80 (100.0)	70 (98.6)	20 (100.0)	1.878	0.532
	+	0 (0.0)	1 (1.4)	0 (0.0)		
Osteoma cutis						
	–	78 (97.5)	71 (100.0)	20 (100.0)	1.798	0.609
	+	2 (2.5)	0 (0.0)	0 (0.0)		
Ponticulus posticus						
	–	72 (90.0)	66 (93.0)	18 (90.0)	0.625	0.740
	+	8 (10.0)	5 (7.0)	2 (10.0)		
Partial ponticulus posticus						
	–	73 (91.3)	63 (88.7)	17 (85.0)	0.994	0.599
	+	7 (8.7)	8 (11.3)	3 (15.0)		
Tonsillolith						
	–	79 (98.8)	66 (93.0)	18 (90.0)	4.749	0.058
	+	1 (1.3)	5 (7.0)	2 (10.0)		
Sialolith						
	–	78 (97.5)	70 (98.6)	19 (95.0)	1.457	0.469
	+	2 (2.5)	1 (1.4)	1 (5.0)		
Calcification of stylohyoid ligament						
	–	79 (98.8)	69 (97.2)	19 (95.0)	1.699	0.339
	+	1 (1.3)	2 (2.8)	1 (5.0)		

[3, 17, 18]. In 2014, Selwaness *et al.* [19] observed that although most people have bilateral carotid disease, the presence of unilateral plaques is mostly found on the left side, and plaques on the left side are thicker than those on the right side. The plaques on the right side are predominantly calcified and considered more stable, leading to less thrombo-embolic complications. As a result of their study, it was shown that atherosclerotic plaques on the left side are more vulnerable than those on the right-side [19]. Previous studies have reported that atherosclerotic plaque calcification was ranging from 2.0% to 11.6% [7, 13, 15]. According to the results of our study, carotid artery calcification (Figure 1D) was 1.2% lower than in other studies (Table 2). This difference may be because the carotid artery does not extend to the FOV area or the population studied in our study was under 35 years of age.

TABLE 4. Relationship between gender and calcification characteristics

Factor	Gender, *n* (%) Male	Gender, *n* (%) Female	χ^2	*p*-value
Calcification				
–	20 (21.1)	22 (28.9)	1.420	0.284
+	75 (78.9)	54 (71.1)		
Classification zone				
–	20 (21.1)	22 (28.9)	2.991	0.393
Head	51 (53.7)	40 (52.6)		
Neck	7 (7.4)	2 (2.6)		
Head and neck	17 (17.9)	12 (15.8)		
Intra-cranial calcification				
–	29 (30.5)	24 (31.6)	0.001	0.999
+	66 (69.5)	52 (68.4)		
Carotid artery calcification				
–	94 (98.9)	75 (98.7)	0.001	0.999
+	1 (1.1)	1 (1.3)		
Nasal cavity calcification				
–	95 (100.0)	75 (98.7)	1.257	0.444
+	0 (0.0)	1 (1.3)		
Osteoma cutis				
–	94 (98.9)	75 (98.7)	0.001	0.999
+	1 (1.1)	1 (1.3)		
Ponticulus posticus				
–	84 (88.4)	72 (94.7)	1.389	0.239
+	11 (11.6)	4 (5.3)		
Partial ponticulus posticus				
–	87 (91.6)	66 (86.8)	0.566	0.452
+	8 (8.4)	10 (13.2)		
Tonsillolith				
–	89 (93.7)	74 (97.4)	1.360	0.302
+	6 (6.3)	2 (2.6)		
Sialolith				
–	92 (96.8)	75 (98.7)	0.665	0.630
+	3 (3.2)	1 (1.3)		
Calcification of stylohyoid ligament				
–	91 (95.8)	76 (100.0)	4.779	0.130
+	4 (4.2)	0 (0.0)		

CAC can be visualized on panoramic radiographs at a level of C3 and C4 under the mandibular angle proximal to the cervical vertebra [20]. De Weert *et al.* [21] found a highly significant correlation between carotid artery calcifications on panoramic radiographs and percentage of periodontal disease. This finding draws attention to the need to examine the images of patients, who have undergone CBCT with various indications in dentistry, taking into account their systemic status and detailed medical history. One limitation of using CBCT images to detect carotid artery calcifications is that, although most atherosclerotic lesions are calcified, some atheromas are not calcified and cannot be visualized on CBCT images. In other words, patients with CBCT image without carotid artery calcification may have atherosclerotic lesions [22, 23].

Incidental detection of carotid artery calcifications and reporting of these findings are very important. This diagnosis can be lifesaving, especially for people who are unaware of their cardiovascular disease. Studies have also shown that carotid artery calcifications correlate significantly with internal carotid artery stenosis when detected on CT angiography [24]. Therefore, it is recommended that the patient be referred to his/her physician for additional imaging procedures, such as CTA (computed tomography angiography), to evaluate intra-cranial atherosclerosis and other vascular abnormalities.

Ponticulus posticus (PP) is a bony bridge formed by the posterior portion of superior articular process of the atlas and the postero-lateral portion of superior border of the posterior arch of the atlas, enclosing all or part of the vertebral artery. Developmental anomalies of the atlas are of concern not only for anatomists, but also for clinicians, radiologists, surgeons, and chiropractors. Ponticulus posticus is generally considered a simple anatomic variant. However, compression of the neural and vascular structures, including vertebral artery, periarterial plexus, and sub-occipital nerve passing through the foramen, can cause a combination of symptoms, such as cervical migraine [23] and neuro-sensory hearing loss [25]. In some cases, neck pain, vertigo, shoulder/arm pain, postural muscle tone, and loss of consciousness [26] are the result of vertebrobasilar insufficiency. Those who have calcification of the ponticulus posticus, suffer from severe headaches in 56-90.0% of cases.

The retrospective nature of our study limited the evaluation of patients in terms of their clinical manifestations in the presence of ponticulus posticus. In a study conducted in Turkey in 2017, Buyuk *et al.* [27] determined the prevalence of ponticulus posticus as 43.04% in the adolescent population. Hong *et al.* [28] and Elliot *et al.* [29] found the overall prevalence of ponticulus posticus as 15.6% and 16.7%, respectively. In our study, the general prevalence of ponticulus posticus was 19.3% (Figure 1A).

As in other studies [27, 28], the high prevalence of ponticulus posticus in our study made it important to understand the unexplained clinical symptoms. The prevalence of ponticulus posticus has been investigated in radiological studies using cadavers, lateral radiographs, or computed tomography scans (CT) [27, 30]. Most of these studies were based on lateral radiographs, and it was not possible to determine whether ponticulus posticus was unilateral or bilateral on these radiographs. Therefore, our study examined total and partial ponticulus posticus separately (Figures 1A, 1B), and no difference was found between the right and left sides. As in previous CT and cadaver studies [29, 31, 32], no difference was observed between the right and left ponticulus posticus. In our study, the incidence of sialoliths was determined as 2.3%. Garay *et al.* [33] found a sialolith rate of 11.0% in their study with panoramic radiographs, while Yalcin *et al.* [12] observed a sialolith rate of 0.7% in their study with CBCT. These different results may be due to ethnic differences, sample characteristics, and FOV size of images. The rates of calcification of tonsilloliths and styloid ligament in CT images of 357 trauma patients were 32.2% and 24.3%, respectively [34]. In our study, these calcification types were 4.7% and 2.3%, respectively. This difference may be due to different working principles of CT and CBCT, ethnicity of the included population, and different sample sizes. Yalcin *et al.* [12] determined a rate of 1% for osteoma cutis in CBCT images analyzed. In this study, the rate was almost 1.2%. Additionally, more than one calcification was commonly seen in an image of the same patient. Although this finding was not clinically significant, it may be indicative of underlying pathology, and can pose a risk of arterial calcification at another time.

One of the limitations of this study is that the radiological evaluations of CBCT images were performed retrospectively. Therefore, no information was available about the medical history of the subjects other than age, sex, date of examination, and type of examination. Another limitation was the lack of clinical data and equipment that could be used in the differential diagnosis of calcifications. In addition, this study was conducted in a single-center, and the incidence of calcifications and associated risk factors may be different in other populations. In future studies, each type of calcification can be studied by relating it to age distribution and medical history of patients. Because the rate of incidental calcifications was found quite high, and particularly CAC and ponticulus posticus calcifications were critical, any finding in CBCTs should be carefully investigated and reported.

CONCLUSIONS

Calcification was found in 75.4% of the analyzed images in this study. In the images, it was found that all calcification rates were higher in men. The rate of calcification was also found to be higher, although not significant, over 60 years of age. Due to the high calcification rates in our study and the presence of critical calcifications, such as CAC and ponticulus posticus, all findings in CBCTs should be carefully investigated and reported.

CONFLICT OF INTEREST

The authors declare no potential conflicts of interest concerning the research, authorship, and/ or publication of this article.

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