Calcifications in the neck region of patients with carotid artery stenosis: a computed tomography angiography study of topographic anatomy

Oya Barut, DDS, PhD,[a] Jan Ahlqvist, DDS, PhD,[a] Maria Garoff, DDS, PhD,[a] Elias Johansson, MD, PhD,[b,c] Magnus Johansson, MSc,[a] Per Wester, MD, Prof.,[c,d] and Eva Levring Jäghagen, DDS, PhD[a]

Objectives. The aim of this study was to map the vertical locations of calcified carotid plaques (CCPs), osseous anatomic structures, and calcified soft tissues in the area of the carotid artery, determine to what extent CCPs are superimposed on the cervical spine in coronal images, and analyze the differences between men and women.

Study Design. Computed tomography angiography (CTA) scans of 79 patients were studied. CCPs were discovered in 152 of the total 158 neck sides. Evaluations were performed by using sagittal and coronal reformatted CTA images with maximum intensity projection.

Results. Most of the calcified anatomic structures studied, including the carotid bifurcation, were found in close relationship to the level of the third and fourth cervical vertebrae. In the coronal view, all or most of the areas of the CCPs were superimposed on the cervical spine in 22 of 44 (50%) neck sides with CCP in women and in 37 of 108 (34.2%) in men ($P = .070$).

Conclusions. The carotid bifurcation is in close proximity to various calcified anatomic structures. This should be taken into account when diagnosing CCPs in panoramic radiographs. In the coronal view, CCPs and the cervical spine are often superimposed; thus, coronal images are not recommended for confirmation of putative carotid calcifications diagnosed on the basis of panoramic radiographs. (Oral Surg Oral Med Oral Pathol Oral Radiol 2020;129:523−530)

Panoramic radiography is often utilized as a diagnostic tool in dentistry. Calcifications in the area of the carotid arteries are depicted in 3% to 15% of panoramic radiographs (PRs) exposed in different populations.[1-3] One study reported that 99% of carotid calcifications depicted on PRs coincide with ultrasound-verified calcified carotid plaques (CCPs) of various sizes.[1] Carotid artery plaques, which typically develop in the area of the carotid bifurcation, with or without calcification, indicate the presence of atherosclerotic disease.[4] Individuals with carotid artery calcifications, as seen on PRs, have a higher rate of cardiovascular risk factors compared with those without these calcifications.[1] Furthermore, the former have an increased risk of vascular events (e.g., stroke, myocardial infarction) of 5.6% per year, compared with 2.4% per year for individuals without carotid calcifications and, therefore, should visit health care units for further examination of potential cardiovascular-associated risk factors.[5] Early identification and medical intervention reduces the risk of future events in individuals with untreated cardiovascular risk factors.[6]

It is crucial that dentists differentiate carotid calcifications from other calcified structures that often appear in the same area on PRs before referral for health care. Carotid calcifications have to be differentiated from, for example, the tip of the greater cornu of the hyoid bone, calcifications in the triticeous cartilage, the superior cornu of the thyroid cartilage, tonsils, parotid glands, submandibular glands, and the epiglottic cartilage, as well as calcifications in the stylohyoid chain and cervical lymph nodes[7-9] (Figure 1). Thorough knowledge of the positions of these calcified structures in relation to carotid calcifications improves the differential diagnosis and patient selection, resulting in fewer false-positive diagnoses. However, to the best of our knowledge, no anatomic studies have provided a detailed map of these calcified structures and their relationship to carotid calcifications.

To verify the presence of a potential carotid artery calcification, conventional anteroposterior projections (APPs) of the neck have been used to complement PRs.[1,10,11] However, carotid calcifications in APPs may be missed because of superimposition on the cervical

Statement of Clinical Relevance

Knowledge of the relationships among calcifications in the area of the carotid arteries is crucial for accurate interpretation of panoramic radiographs in patients with increased risk of cardiovascular events. Anteroposterior projections are not recommended for confirmation of carotid artery calcification.

[a]Oral and Maxillofacial Radiology, Department of Odontology, Umeå University, Sweden.
[b]Department of Pharmacology and Clinical Neuroscience, Umeå University, Sweden.
[c]Department of Public Health and Clinical Medicine, Umeå University, Sweden.
[d]Department of Clinical Sciences, Karolinska Institutet, Danderyds Hospital, Stockholm, Sweden.

Received for publication Apr 18, 2019; returned for revision Sep 15, 2019; accepted for publication Sep 28, 2019.

2212-4403/$-see front matter
https://doi.org/10.1016/j.oooo.2019.09.018

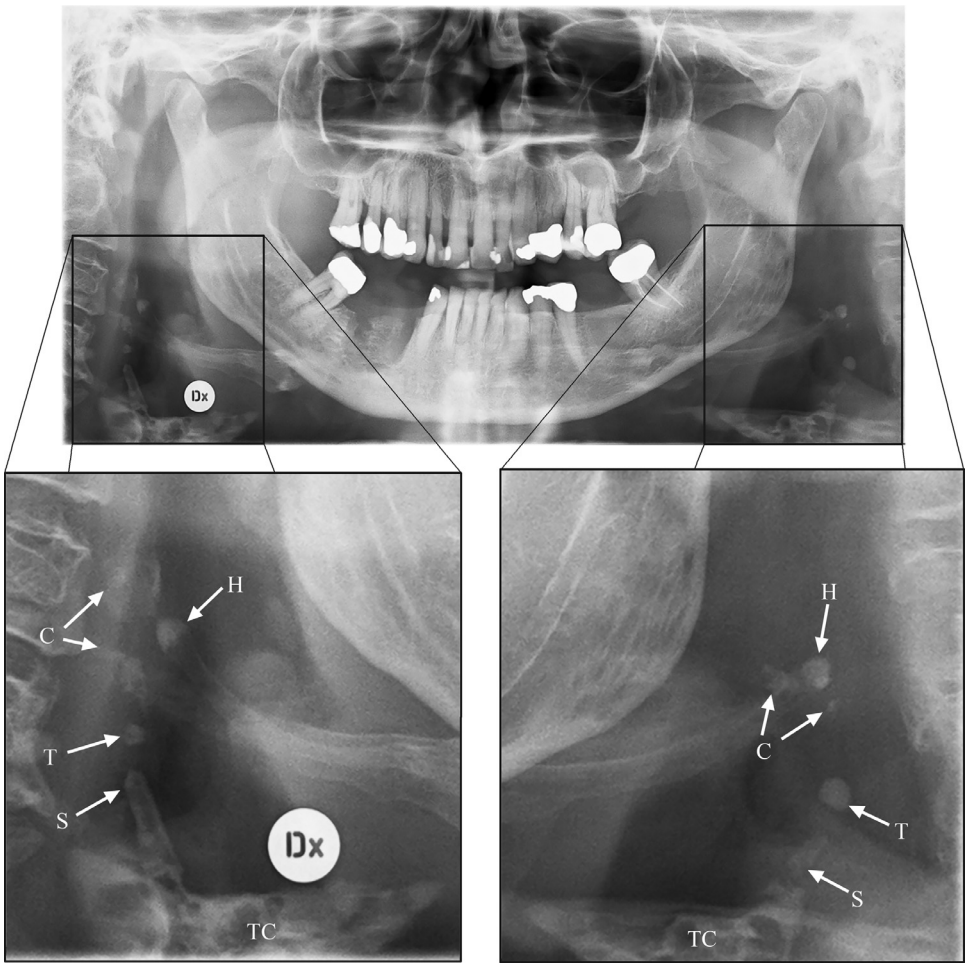

Fig. 1. Panoramic radiograph illustrating examples of the calcified anatomic structures in close relationship to calcified carotid plaques. H: Tip of the greater cornu of the hyoid bone; C: Calcified carotid plaque; T: Triticeous cartilage; S: Superior cornu of the thyroid cartilage; TC: Thyroid cartilage.

spine.[1] One study demonstrated that 12% of patients with carotid calcifications on PRs do not have ipsilateral carotid calcifications visualized on APPs.[12] Thus, the aims of the present study were to map the osseous anatomy and calcified soft tissues in the area of the carotid artery in the neck, determine the extent to which calcifications in the carotid arteries are superimposed on the cervical spine in coronal reformatted images, and analyze possible differences between men and women.

MATERIALS AND METHODS

Study population

The study population comprised 79 consecutive patients (55 men and 24 women), for a total of 158 neck sides (110 in men and 48 in women). The mean age of the patients was 69 years (range 54−83 years), and all were residents of the northern region of Sweden and referred to the Umeå Stroke Center, Umeå University Hospital, Sweden. All patients were examined by using computed tomography angiography (CTA) between August 2007 and December 2008 for preoperative evaluation before endarterectomy of carotid artery stenosis. All patients had CCPs, 73 (92.4%) bilaterally and 6 (7.6%) unilaterally. Neck sides with carotid arteries without calcifications (2 in men and 4 in women) were excluded when assessing superimposition of CCPs on the vertebrae. As a result, 108 neck sides in men and 44 in women were investigated for the location of CCPs in relation to the cervical vertebrae in the coronal plane. However, all 158 neck sides were examined for the presence of calcifications in anatomic structures. The study was approved by the Regional Ethics Committee in Umeå (Dnr 07-004M) and was conducted according to the tenets of the Helsinki Declaration (1996). All participants provided written informed consent.

Radiographic examination

CTA was performed according to standard protocols with contrast-enhanced computed tomography (CT) examination of the head and neck region. The examinations were performed either at the referring hospital or at the Department of Diagnostic Radiology, Umeå University Hospital. After intravenous injection of iodine-based contrast media, images were captured in the arterial phase from the top of the aortic arch and superiorly, including the intracranial arteries.

Radiographic evaluation

All evaluations were performed by using CTA images. The neck region was analyzed in the axial view and reformatted sagittal and coronal views. Assessments were performed in the sagittal and coronal views on maximum intensity projections (MIPs). Reconstructions were performed by using GE Healthcare Advantage workstation AW4.3_05, sdc software (GE Healthcare, Chicago, IL) on an HP xw8200 workstation (Hewlett-Packard, Palo Alto, CA) in a room allowing optimal dimmed light conditions. The images were viewed on NEC MultiSync LCD1980 SXi monitors (NEC Corporation, Tokyo, Japan). The window width and level for vertebral observations were set to 2000 and 350 Hounsfield units (HU), respectively. Images were read independently by 2 of the authors (O.B. and M.G.), both of whom were undergoing specialist training in oral and maxillofacial radiology. Before the evaluations, the 2 observers were calibrated with 2 experienced specialists in oral and maxillofacial radiology regarding interpretation of the anatomy and imaging characteristics of various calcifications on CTA images of the neck. Each observer entered data individually. In case of disagreement, consensus was reached after discussion to select the data to be used for statistical analysis.

The vertical locations of osseous anatomic structures and calcifications in soft tissues were determined in relation to the cervical spine in the sagittal view, with each vertebra divided into 3 equal portions: upper (1), middle (2), and lower (3). Intervertebral disc spaces were considered as separate portions (4) and numbered according to the vertebra above the disc space. Using this method, a vertebral body, such as the second cervical vertebra (C2), was divided into 3 portions labeled C2;1, C2;2, C2;3 and the space between C2 and C3 labeled C2;4. Therefore, each vertebra was divided into portions of equal length, creating an interval scale that allowed parametric statistical analysis. C1 and C7, including the disc space below the vertebrae, were not divided and were evaluated as one portion, representing the outer limits of the scale. The vertical locations of the anatomic details were determined for the carotid bifurcation; tip of the greater cornu of the hyoid bone; calcifications in the triticeous cartilage, superior cornu of the thyroid cartilage, tonsils, parotid glands, submandibular glands, and epiglottis; and calcifications in carotid plaques. A calcification in a carotid plaque was registered on 3 levels: the upper border, the lower border, and the most prominent part of the calcification (Figure 2).

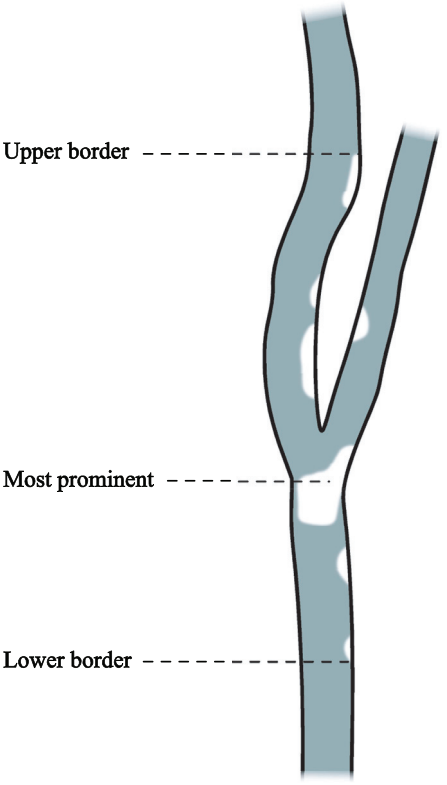

Fig. 2. Illustration of the three levels in which the calcified carotid plaques (CCPs) were registered. The three levels were defined as the upper border, lower border, and the most prominent part of the calcification. A CCP can consist of either 1 single or 2 or more separate calcifications.

To study the extent to which CCPs were superimposed on the vertebrae in the coronal view, the relationship between the CCPs and the cervical vertebrae was registered in a reconstructed coronal CTA MIP. The relationship was defined as covered (completely superimposed on the vertebrae), mostly covered (more than half but not completely superimposed on the vertebrae), mostly free (less than half superimposed on the vertebrae), or free (not superimposed on the vertebrae), as shown in Figures 3A and 3B. The extent of the superimpositions was dichotomized into covered + mostly covered and mostly free + free for statistical analysis.

Statistical methods

The independent samples *t* test was used to analyze the differences in the vertical locations of the osseous anatomic structures and calcifications in soft tissues

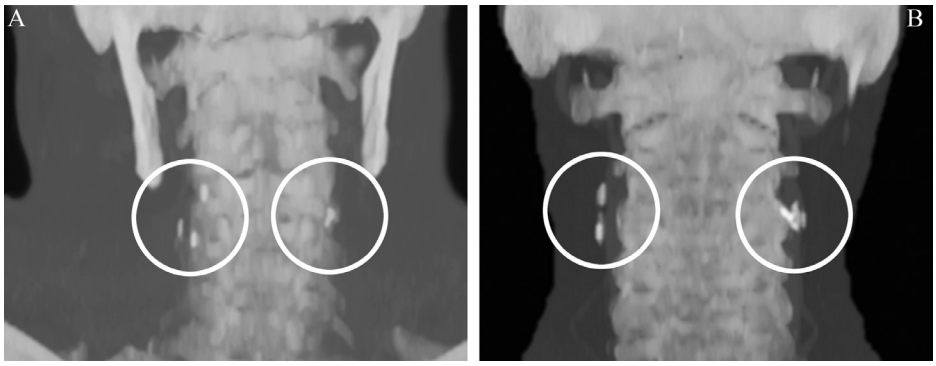

Fig. 3. Computed tomography angiography images with maximum intensity projection (MIP) showing examples of calcifications corresponding to the different grades of superimposition of calcified carotid plaques on the cervical spine. **A,** *Covered*, where all the calcification in the carotid plaque is completely covered by the vertebrae, within the circle on the patient's left side; and *Mostly covered*, where more than half of the calcification is covered, within the circle on the patient's right side. **B,** *Mostly free*, where less than half of the calcification is covered by the vertebrae, within the circle on the patient's left side; and *Free*, with no superimposition of the calcification, within the circle on the patient's right side.

between genders. The *t* test was used on a scale of 1 to 22, with each number corresponding to 1 of the 4 portions of C2-C6 and the undivided portion of C1 and C7. The χ^2 test was used to analyze the differences between genders on the neck side level and also to compare the difference in superimposition of CCPs on the vertebrae between men and women. Agreement between the observers was determined by estimating Cohen's kappa and the interclass correlation coefficient (ICC). The ICC was estimated on the basis of absolute agreement by using a 2-way mixed-effects model. SPSS Statistics for Windows, Version 25.0 (IBM Corporation, Armonk, NY) was used for statistical analyses. Significant differences were defined at $P \leq 0.05$.

RESULTS

Vertical location in the sagittal plane

The vertical locations of the CCPs and the calcified and osseous anatomy in relation to the cervical vertebrae, as assessed in the sagittal plane, are shown in Figure 4. The median level for the most prominent part of the CCP coincided with the 75th percentile because the prominent part was found at C4;1 in most women. The median level for the tip of the greater cornu of the hyoid bone was situated at C3;3 in both men and women. However, the distribution was significantly different between men and women ($P = .007$). The vertical location of CCPs, the carotid bifurcation, the osseous anatomy, and calcifications in the soft tissues and cartilage in men compared with women are shown in Table I. Differences in vertical location between men and women were significant for the carotid bifurcation ($P = .043$) and the tip of the greater cornu of the hyoid bone ($P = .007$). Calcified epiglottic cartilage was only seen in 2 men, both at C4;1.

The numbers of findings of CCPs, the osseous anatomy, and calcifications in the soft tissues and cartilage on neck side level in men compared with women are presented in Table II. Calcified triticeous cartilage was detected significantly more often in neck sides in men (40 of 110 [36.4%]) compared with those in women (8 of 48 [16.7%]) ($P = .013$). Tonsils were calcified significantly more often in neck sides in men (56 of 110 [50.9%]) compared with those in women (14 of 48 [29.2%]) ($P = .011$).

Location of CCPs in relation to the cervical vertebrae in the coronal plane

Data regarding the superimposition of CCPs on the cervical vertebrae on the coronal CTA MIP are shown in Figure 5. Neck sides without calcification in the carotid artery, 2 in men and 4 in women, were excluded from the assessment of superimposition. The CCPs were covered or mostly covered by the cervical spine more often in neck sides in women (22 of 44 [50.0%]) compared with those in men (37 of 108 [34.2%]) but the difference was not statistically significant ($P = .070$).

Interobserver agreement

The interobserver agreement ranged from a kappa of 0.628 to 1, with agreement of 0.61 to 0.8 indicating "good" and 0.81 to 1 "very good".[13] The ICC ranged from 0.815 to 0.966; values between 0.75 and 1 are considered good to excellent reliability.[14]

DISCUSSION

By using CTA images, we defined the locations of different osseous and calcified structures that are also depicted on PRs in close relationship to the CCPs. The upper border of the CCPs was located at the level of C3 or higher in 75% of the neck sides in men and 90% of the neck sides in women. Thus, it appears that in the

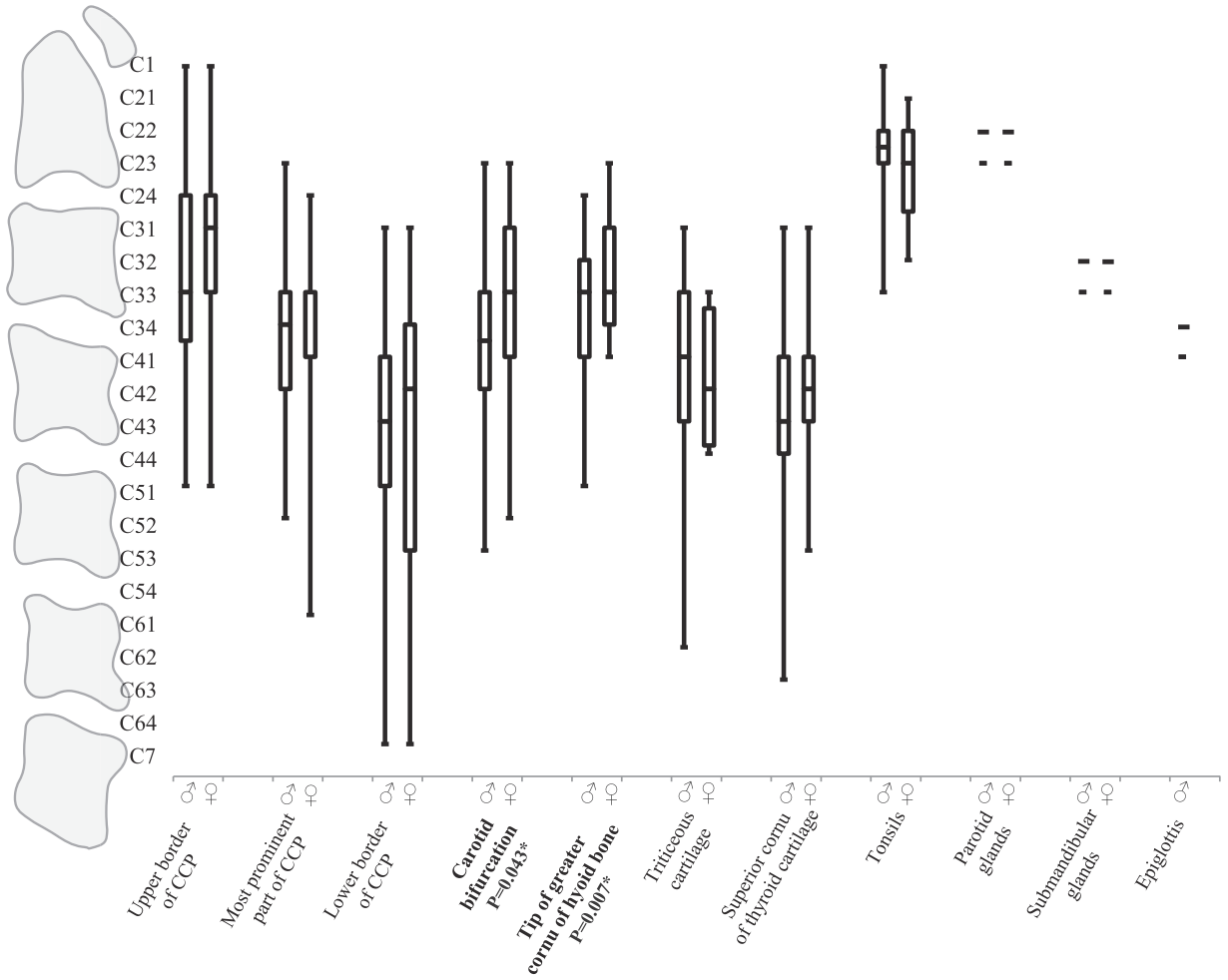

Fig. 4. Schematic drawing of the vertebrae and a box plot of the vertical locations of the calcified carotid plaques (CCPs) and calcified and osseous anatomy in relationship to the cervical vertebrae, as assessed in the sagittal plane in relation to the cervical vertebrae in men and women. *Independent samples *t* test was used for analyses of differences in vertical location between men and women. Significant *P* values are presented in bold.

majority of people, the superior parts of the CCPs are located above the inferior margin of the depicted area of an optimally projected PR, which often includes C3 and C4. However, the absence of carotid calcifications on PRs does not imply that the patient does not have calcifications because they can be situated below the depicted area. The present results are consistent with the outcome of a previous study,[12] in which 99% of extirpated plaques from patients with known stenosis contained calcifications, but 25% of these were not depicted on PRs, in most cases because the calcifications were situated below the inferior level of the depicted area.

Previous panoramic radiographic studies have reported that the greater cornu of the hyoid bone, the calcified triticeous cartilage, and the calcification in the superior cornu of the thyroid cartilage are structures that can be misinterpreted as carotid calcifications on PRs.[8,15-17] The present study's results support these findings by showing that there is a close relationship between these structures and the carotid bifurcation in the sagittal view. Anatomic dissection studies have shown that the triticeous cartilage, with or without calcifications, is present in 13% to 33% of individuals, with a slightly higher prevalence among women than among men.[18,19] In the present investigation, triticeous cartilage with calcification was detected in 48 (30.4%) of all neck sides, significantly more often in men (36.4%) compared with women (16.7%) ($P = .013$). This result is consistent with a forensic radiographic study,[20] but another study reported a higher prevalence of triticeous cartilage with calcifications on PRs in women (12.0%) than in men (5.0%).[16] This difference may be caused by differences in selection criteria and imaging modalities.

The thyroid cartilage is composed of hyaline cartilage and may undergo calcification and ossification.[21] Calcification in the thyroid cartilage is associated with

Table I. Vertical locations of calcified carotid plaques, the carotid bifurcation, the osseous anatomy, and calcifications in the soft tissues and cartilage on neck side level among men and women.

Assessed structures	*Median vertical location*		*P value**
	Men	*Women*	
Calcified carotid plaque (CCP)			
Upper border of CCP	C3;3	C3;1	.159
Most prominent CCP	C3;4	C4;1	.944
Lower border of CCP	C4;3	C4;2	.620
Carotid bifurcation	C4;1	C3;3	**.043**
Tip of greater cornu of hyoid bone	C3;3	C3;3	**.007**
Triticeous cartilage	C4;1	C4;2	.973
Superior cornu of thyroid cartilage	C4;3	C4;2	.195
Tonsils	C2;3	C2;3	.233
Parotid glands	C2;3	C2;3	–
Submandibular glands	C3;3	C3;3	–
Epiglottis	C4;1	–	–

*Independent samples *t* test was used for analyses of differences in vertical location between men and women, significant *P* values in bold. Please also see the illustration in Figure 4.

aging.[20,22,23] CCPs are also more frequently detected in examinations of older populations.[1] These findings indicate a higher probability of detecting a calcified superior cornu of the thyroid cartilage, as well as carotid calcification, on the PRs of older patients. Therefore, it is important to correctly interpret the images to differentiate between these anatomic details. In a previous study of patients 10 to 59 years of age, men had a higher frequency of thyroid cartilage calcification compared with women.[22] However, we did not observe any gender differences. In our study, all patients had CCPs, and their ages ranged from 54 to 83 years (mean 69 years). Thus, the population in our investigation was more likely to have calcifications in any structure compared with a younger cohort. In an earlier study of the location of soft tissue calcifications in the maxillofacial region, assessed on cone beam computed tomography, calcifications in the tonsils were more frequent in men than in women.[24] The results of that study are similar to those of the present study. The calcifications in the tonsils were typically situated at the level of C2;3 in both men and women, and it was, therefore, unlikely that they would be misinterpreted as CCP. One of the interesting findings of our study was calcifications in the epiglottic cartilage in 2 men. Calcifications in the epiglottis are very rare because with aging, epiglottic cartilage transforms into elastic cartilage, which has a low tendency to ossify.[21]

We also found that CCPs are often superimposed on the cervical spine on coronal CTA MIP reconstructions, more frequently in women (50% of the neck sides with CCP) than in men (34.2%; $P = .070$). This suggests that the probability of missing carotid

Table II. Numbers of findings of calcified carotid plaques and anatomic structures among men and women.

Assessed structures	*Neck sides*		*P value**
	Men (n = 110)	*Women (n = 48)*	
Calcified carotid plaque (CCP)	108 (98.2%)	44 (91.7%)	.287
Tip of greater cornu of hyoid bone	110 (100.0%)	48 (100.0%)	1.000**
Triticeous cartilage	40 (36.4%)	8 (16.7%)	**.013**
Superior cornu of thyroid cartilage	103 (93.6%)	46 (95.8%)	.584
Tonsils	56 (50.9%)	14 (29.2%)	**.011**
Parotid glands	2 (1.8%)	1 (2.1%)	–
Submandibular glands	2 (1.8%)	1 (2.1%)	–
Epiglottis	2 (1.8%)	–	–

*χ^2 test was used for analyses of differences between men and women; significant *P* values are in bold.
**Fisher's exact test.

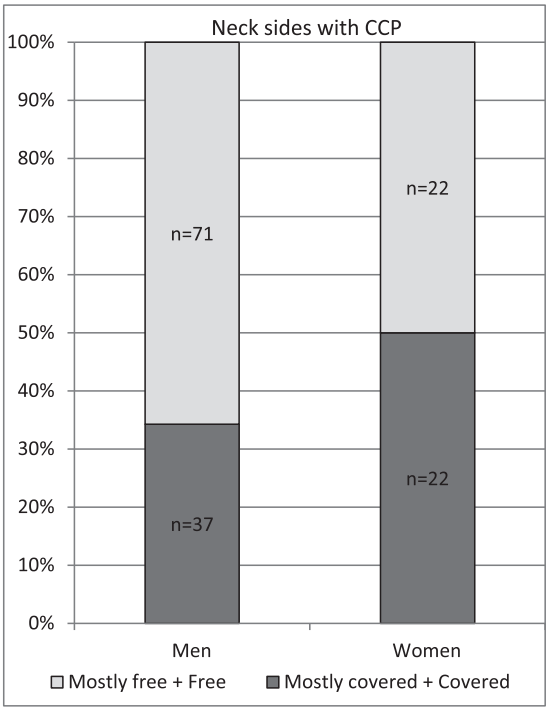

Fig. 5. Numbers of neck sides with different degrees of superimposition of the calcified carotid plaques on the vertebrae in the coronal plane, distributed between men and women (108 neck sides in men and 44 in women). All calcified parts of the plaque were included when determining the degree of superimposition of the calcified carotid plaque. The degree was dichotomized into Mostly free + Free and Mostly covered + Covered. The latter was more frequent among women, but the difference was not statistically significant ($P = .070$).

calcifications in APPs because of superimposition on the cervical spine might be higher among women than among men. This finding could also explain why 11% of persons with calcifications in the area of the carotid arteries, as seen on PRs, were excluded by Johansson et al.,[1] possibly contributing to the lower frequency of carotid stenosis reported by them. In that investigation, confirmation of calcifications on an APP was a criterion for inclusion, which was not the case in other studies.[3,25] Our results support the conclusion of Garoff et al.[12] that APPs do not contribute to the identification of persons with CCPs on PRs when the confirmation of calcifications on an APP is a criterion for inclusion. In contrast, it can lead to the exclusion of patients with CCPs. In the coronal CTA MIP reconstructions, parallel projection is used. In APPs exposed with central projection, the beam diverges, and the CCP will be projected more lateral to the cervical spine. In anteroposterior images exposed in a cephalostat, as often used in dentistry, the difference between the projected position of the CCP relative to the cervical spine and a parallel projection will be a fraction of a millimeter and, therefore, does not change the conclusions drawn from the results of this study.

In future research, the accuracy of observations of CCPs on PRs and APPs should be evaluated by using CTA as the gold standard. Such a study design could reveal the extent to which superimposition affects detection of CCPs on APPs in a clinical context.

Previous studies have suggested that patients with carotid artery calcifications should be referred for further examination of cardiovascular risk factors if these patients are not already aware of and treated for these conditions. The examination can include ultrasound evaluation of the carotid arteries.[5] For cost-benefit reasons, it is important that dentists differentiate between calcifications in neck structures to avoid false-positive diagnoses of CCPs. The goal of this study was to provide information that increases knowledge of this problem. To minimize the risk of false-positive diagnoses and prevent unnecessary concerns in patients, consultation with a specialist in oral and maxillofacial radiology can be valuable.

In this study, ethnic factors were not analyzed because no information concerning this is included in patient records in Sweden.

A weakness of the study is that it included only 24 women, limiting the possibility of drawing conclusions regarding variations among women and differences between men and women. One strength of the study is that the CTA MIP reconstructions presented high contrast between the CCPs and the cervical spine, allowing for accurate estimations of the spatial relationships in the coronal projection. This is not the case with conventional APPs, in which the contrast is much lower.

CONCLUSIONS

Various calcified anatomic structures are in close relationship to CCPs. This must be considered when diagnosing carotid calcifications on PRs. The CCPs are often superimposed on the cervical spine in the coronal view, a problem that is more common in women than in men. Therefore, APPs are not recommended for confirmation of putative CCPs on PRs.

PRESENTATION

Results from this study were presented at the 15th European Congress of Dento-Maxillo-Facial Radiology, Cardiff, UK, June 15−18, 2016 (ECDMFR 2016).

FUNDING

This study was supported by The Swedish Heart-Lung Foundation (Project no. 20160310, 20130226, and 20100220), the Swedish Stroke Foundation, the Northern Swedish Stroke Fund, the County Council of Västerbotten, and the medical faculty of Umeå University.

REFERENCES

1. Johansson EP, Ahlqvist J, Garoff M, Karp K, Jäghagen EL, Wester P. Ultrasound screening for asymptomatic carotid stenosis in subjects with calcifications in the area of the carotid arteries on panoramic radiographs: a cross-sectional study. *BMC Cardiovasc Disord*. 2011;11:44.
2. Ohba T, Takata Y, Ansai T, et al. Evaluation of calcified carotid artery atheromas detected by panoramic radiograph among 80-year-olds. *Oral Surg Oral med Oral Pathol Oral Radiol Endod*. 2003;96:647-650.
3. Almog DM, Horev T, Illig KA, Green RM, Carter LC. Correlating carotid artery stenosis detected by panoramic radiography with clinically relevant carotid artery stenosis determined by duplex ultrasound. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 2002;94:768-773.
4. Bentzon JF, Otsuka F, Virmani R, Falk E. Mechanisms of plaque formation and rupture. *Circ Res*. 2014;114:1852-1866.
5. Johansson E, Ahlqvist J, Garoff M, Levring Jäghagen E, Meimermondt A, Wester P. Carotid calcifications on panoramic radiographs: a 5-year follow-up study. *Oral Surg Oral Med Oral Pathol Oral Radiol*. 2015;120:513-520.
6. Brott TG, Halperin JL, Abbara S, et al. 2011 ASA/ACCF/AHA/AANN/AANS/ACR/ASNR/CNS/SAIP/SCAI/SIR/SNIS/SVM/SVS guideline on the management of patients with extracranial carotid and vertebral artery disease. *Circulation*. 2011;124:e54-e130.
7. Almog DM, Illig KA, Khin M, Green RM. Unrecognized carotid artery stenosis discovered by calcifications on a panoramic radiograph. *J Am Dent Assoc*. 2000;131:1593-1597.
8. Carter LC. Discrimination between calcified triticeous cartilage and calcified carotid atheroma on panoramic radiography. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 2000;90:108-110.
9. Almog DM, Tsimidis K, Moss ME, Gottlieb RH, Carter LC. Evaluation of a training program for detection of carotid artery calcifications on panoramic radiographs. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 2000;90:111-117.

10. Friedlander AH. Identification of stroke-prone patients by panoramic and cervical spine radiography. *Dentomaxillofac Radiol*. 1995;24:160-164.
11. Brito AC, Nascimento HA, Argento R, Beline T, Ambrosano GM, Freitas DQ. Prevalence of suggestive images of carotid artery calcifications on panoramic radiographs and its relationship with predisposing factors. *Cien Saude Colet*. 2016;21:2201-2208.
12. Garoff M, Johansson E, Ahlqvist J, Jäghagen EL, Arnerlöv C, Wester P. Detection of calcifications in panoramic radiographs in patients with carotid stenoses ≥50%. *Oral Surg Oral Med Oral Pathol Oral Radiol*. 2014;117:385-391.
13. Landis JR, Koch GG. The measurement of observer agreement for categorical data. *Biometrics*. 1977;33:159-174.
14. Koo TK, Li MY. A Guideline of selecting and reporting intraclass correlation coefficients for reliability research. *J Chiropr Med*. 2016;15:155-163.
15. Kamikawa RS, Pereira MF, Fernandes A, Meurer MI. Study of the localization of radiopacities similar to calcified carotid atheroma by means of panoramic radiography. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 2006;101:374-378.
16. Ahmad M, Madden R, Perez L. Triticeous cartilage: prevalence on panoramic radiographs and diagnostic criteria. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 2005;99:225-230.
17. Çağırankaya LB, Akkaya N, Akçiçek G, Boyacıoğlu Doğru H. Is the diagnosis of calcified laryngeal cartilages on panoramic radiographs possible? *Imaging Sci Dent*. 2018;48:121-125.
18. Ajmani ML. A metrical study of the laryngeal skeleton in adult Nigerians. *J Anat*. 1990;171:187-191.
19. Wilson I, Stevens J, Gnanandandan J, Nabeebaccus A, Sandison A, Hunter A. Triticeal cartilage: the forgotten cartilage. *Surg Radiol Anat*. 2017;39:1135-1141.
20. Di Nunno N, Lombardo S, Costantinides F, Di Nunno C. Anomalies and alterations of the hyoid-larynx complex in forensic radiographic studies. *Am J Forensic Med Pathol*. 2004;25:14-19.
21. Standring S, Berkovitz BKB, Collins P, Wigley C. Larynx. In: Stranding S, ed. *Gray's Anatomy. The Anatomical Basis of Clinical Practice*, 39th ed., Edinburgh; New York: Elsevier Churchill Livingstone; 2005:633-646.
22. Mupparapu M, Vuppalapati A. Ossification of laryngeal cartilages on lateral cephalometric radiographs. *Angle Orthod*. 2005;75(2):196-201.
23. Fatterpekar GM, Mukherji SK, Rajgopalan P, Lin Y, Castillo M. Normal age-related signal change in the laryngeal cartilages. *Neuroradiology*. 2004;46:678-681.
24. Missias EM, Nascimento E, Pontual M, et al. Prevalence of soft tissue calcifications in the maxillofacial region detected by cone beam CT. *Oral Dis*. 2018;24:628-637.
25. Friedlander A, Garrett N, Chin E, Baker D. Ultrasonographic confirmation of carotid artery atheromas diagnosed via panoramic radiography. *J Am Dent Assoc*. 2005;136:635-640.

Reprint requests:

Oya Barut
Oral and Maxillofacial Radiology
Department of Odontology
Umeå University
SE-901 87 Umeå
Sweden
oya.barut@umu.se