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Research | Araştırma

Comparison Of Cone Beam Computed Tomography, Panoramic Radiography And Ultrasonography For The Detection Of Soft Tissue Calcification

Yumuşak Doku Kalsifikasyonlarının Tespitinde Konik Işınlı Bilgisayarlı Tomografi, Panoramik Radyografi Ve Ultrasonografinin Karşılaştırılması

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ABSTRACT

Objective: The aim of the study is to determine the distribution of soft tissue calcifications according to age, gender and localization and to compare 3 different imaging techniques in the detection of these heterotopic structures.

Materials and Method: The data of 1150 patients who were previously examined and known to have calcification were scanned. 102 patients, aged between 13 and 90, with calcification detected in cone beam computed tomography (CBCT), panoramic radiography and ultrasonography(USG) images, were selected and included in the study. Patient data were evaluated by two dentomaxillofacial radiology specialists retrospectively one month apart to evaluate the detectability of calcifications. A two-degree scale was adopted for the presence/absence of lesions.

Results: When it was evaluated whether there was a difference between the three different imaging techniques in detecting calcification, a statistically significant difference was found between CBCT, panoramic radiography and USG ($p<0.001$). The sensitivity of panoramic radiography was lower compared to CBCT in the detection of tonsillolith, arterial calcification, antrolith and triticeous cartilage calcifications (34%, 75%, 40%, 75%, respectively). The sensitivity of ultrasonography (USG) was found to be quite low compared to CBCT in the detection of tonsillolith and triticeous cartilage calcifications (5.7%, 12.5%, respectively). Laryngeal cartilage calcification, anthrolith, rhinolith, and stylohyoid ligament ossification could not be detected by USG.

Conclusion: Panoramic radiography can be used as an alternative imaging method compared to CBCT in the detection of maxillofacial soft tissue calcifications. USG is useful in evaluating some calcifications noticed on radiographs. The detectability of soft tissue calcifications with USG will increase with the widespread use of USG in the field of dentistry and the increase in the experience of physicians.

Key Words: Calcification, Cone Beam Computed Tomography, Panoramic Radiography, Ultrasonography.

ÖZ

Amaç: Çalışmanın amacı yumuşak doku kalsifikasyonlarının yaşa, cinsiyete ve lokalizasyona göre dağılımını belirlemek ve bu heterotopik yapıların tespitinde 3 farklı görüntüleme tekniğini karşılaştırmaktır.

Gereç ve Yöntemler: Daha önce muayene edilen ve kalsifikasyon olduğu bilinen 1150 hastanın verileri tarandı. Konik ışınlı bilgisayarlı tomografi (KIBT), panoramik radyografi ve ultrasonografi görüntülerinde kalsifikasyon tespit edilen, yaşları 13 ile 90 arasında değişen 102 hasta seçilerek çalışmaya dahil edildi. Hasta verileri, kalsifikasyonların tespit edilebilirliğini değerlendirmek amacıyla iki dentomaksillofasiyal radyoloji uzmanı tarafından birer ay arayla retrospektif olarak değerlendirildi. Lezyonların varlığı/yokluğu için iki dereceli bir ölçek benimsendi.

Bulgular: Üç farklı görüntüleme tekniği arasında kalsifikasyonların saptanmasında fark olup olmadığı değerlendirildiğinde CBCT, panoramik radyografi ve USG arasında istatistiksel olarak anlamlı fark bulundu ($p<0,001$). Tonsillolit, arteriyel kalsifikasyon, antrolit ve tritisöz kıkırdak kalsifikasyonlarının tespitinde panoramik radyografinin duyarlılığı CBCT'ye göre daha düşüktü (sırasıyla %34, %75, %40, %75). Tonsillolit ve tritisöz kıkırdak kalsifikasyonlarının saptanmasında ultrasonografinin (USG) duyarlılığı yine CBCT'ye göre oldukça düşüktü (sırasıyla %5,7, %12,5). USG'de laringeal kıkırdak kalsifikasyonu, antrolit, rinolit ve stilohyoid ligament ossifikasyonu tespit edilemedi.

Sonuç: Panoramik radyografi, maksillofasiyal yumuşak doku kalsifikasyonlarının tespitinde CBCT'ye kıyasla alternatif bir görüntüleme yöntemi olarak kullanılabilir. USG radyografilerde fark edilen bazı kalsifikasyonların değerlendirilmesinde faydalıdır. USG'nin diş hekimliği alanında kullanımının yaygınlaşması ve hekimlerin deneyiminin artmasıyla birlikte yumuşak doku kalsifikasyonlarının USG ile tespit edilebilirliği artacaktır.

Anahtar Kelimeler: Kalsifikasyon, Konik Işınlı Bilgisayarlı Tomografi, Panoramik Radyografi, Ultrasonografi

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INTRODUCTION

Calcium salts accumulate in bone tissue under normal conditions. Sometimes calcium phosphate may accumulate in other tissues. The anomaly caused by these structures, which are formed in a different place than where they should normally be, is called heterotopia. Heterotopic calcifications occur when calcium salts accumulate in soft tissues without being organized, and heterotopic ossifications occur when they accumulate in an organized manner. Three types of calcifications are seen in soft tissue, depending on the condition of the tissue or the serum calcium-phosphate levels; dystrophic calcification, metastatic calcification and idiopathic calcification (1-5). Dystrophic calcifications include calcified lymph node, tonsillolith, cysticercosis, and calcified atherosclerotic plaque; whereas idiopathic calcifications include sialolith, phlebolith, laryngeal cartilage calcification, anthrolith, rhinolith, and dacryolith. Heterotopic ossifications include osteoma cutis, myositis ossificans, and stylohyoid ligament ossification (1-5). These structures may be asymptomatic and may be discovered incidentally on panoramic radiographs obtained from patients for different purposes. The anatomical locations, numbers, distributions, and patterns of calcifications/ossifications are important diagnostic criteria in the radiographic evaluation of to soft tissue opacities. Accurate diagnosis of calcifications is important as the findings may indicate a serious disease condition. It may require treatment or follow-up of the disorders that cause these structures to form (1-5). For this reason, dentists should be able to identify, diagnose and treat pathologies encountered in radiography, and refer them to the relevant specialist when necessary (6). When these structures, which are detected by incidental on panoramic radiography, are superimposed on anatomical structures, it is a complex task to determine whether the calcification belongs to these anatomic structures or soft tissue. Therefore, additional radiographic techniques may be needed. Standard occlusal or lateral oblique radiography, submentovertex projection, Waters graphy, sialography, angiography, CBCT, and MRI are some of these techniques (6,7,9). In addition to these imaging techniques, ultrasonography (USG), which is a method that does not contain ionizing radiation; the agency of its rapid imaging feature, non-invasiveness, and reproducibility, it is frequently used in the imaging of soft tissues in the maxillofacial region and in the examination of parenchymal organs (2,3-11). Artifacts are undesirable and normally non-existent images in an image. Artifacts in USG can prevent the diagnosis and sometimes conversely be useful in the interpretation of the image. An acoustic shadowing artifact occurs when strong reflectors such as bones, stones, calcifications, or air reflect numberous sound waves, leaving a hypoechoic shadow behind them. This artifact helps the physician in the ultrasonographic diagnosis of a calcified structure in the head and neck region (12-15). When we reviewed the literature regarding evaluating maxillofacial calcification on three imaging techniques (CBCT, USG, and panoramic radiography) using the PubMed database, we could find no reports comparing these three imaging techniques. Therefore, the study aims to determine the sensitivity, specificity, and diagnostic accuracy of the detectability of soft tissue calcification and ossifications in different imaging techniques (CBCT, USG and panoramic radiography) and to determine the distribution of these heterotopic structures in terms of age, gender and localization.

MATERIAL AND METHODS

Selection Of The Patient Group

Radiographic and ultrasonographic images of patients who applied to Zonguldak Bülent Ecevit University Faculty of Dentistry, Dentomaxillofacial Radiology Department between 2017 and 2019 were used. Panoramic radiography is taken during routine clinical examination in patients admitted to our faculty. CBCT and USG are performed as advanced imaging when conditions such as cysts, tumors, calcifications, impacted teeth, and anatomical variations are suspected on panoramic radiography. For advanced imaging, a request can be made from our department or other departments. The data of patients under 13 years of age, who had undergone previous surgery in the maxillofacial region, and patients with syndrome or congenital anomalies, cysts, tumors and fracture were excluded from the study. Bilateral images with 8x10 cm FOV area in CBCT images were included in the study. In our study, the data of the patients who gave consent for the use of radiographic and ultrasonographic images in the studies were used. The data of 1150 patients who were previously examined and known to have calcification/ossification were scanned. 102 patients, aged between 13 and 90, who had calcification/ossification on CBCT, panoramic radiography and ultrasonography images, were selected and included in the study. The patients' data were archived and evaluated retrospectively for the detectability of calcifications.

Obtaining The Data

CBCT images of the patients were obtained in Dentomaxillofacial Radiology Clinic with Veraviewepocs 3D R100/F40 (J Morita Mfg. Corp., Kyoto, Japan) tomography device using 90 kVp 5 mA and 0.125 mm3 voxel size in 8x10 cm FOV area. CBCT images were evaluated in axial sagittal and coronal planes using i-Dixel 2.0 software (J. Morita Corporation, Osaka, Japan).

Panoramic radiography images were obtained with the Veraview IC5 HD (J Morita Mfg. Corp., Kyoto, Japan) panoramic device at adult dosage and standard acquisition protocol. Radiographs presence a high rate of artifacts and those considered diagnostically inadequate were excluded from the study. Ultrasonography images were obtained with the MyLab™Twice US (Esaote SpA Genoa, Italy) device using an extraoral linear probe in the 4 - 13.0 Mhz frequency range. Ultrasonographic images were reviewed using dedicated offline ultrasound imaging MyLab Desk software (Esaote SpA, Genoa, Italy). In the routine USG examination protocol of all patients; temporomandibular joint, parotid gland, maxillary sinuses, submandibular gland and lymph nodes, floor of the mouth, carotid artery, thyroid gland, laryngeal cartilage and surrounding tissues are evaluated. The patients were positioned in a supine position, with the head being scanned as two symmetrical hemispheres and slightly tilted backwards. The entire USG examinations are recorded in AVI format as video and/or snapshots in TIFF file format. All imaging was performed by a dentomaxillofacial radiologist with 9 years of experienced.

Assessment Of Radiographic Images

CBCT, panoramic radiography and ultrasonography images of 102 patients were filed for retrospective evaluation. A dentomaxillofacial radiology specialist (3 years experienced) and a research assistant (2 years experienced) evaluated the classified data 2 times with 1 month intervals to determine intra-observer and inter-observer consistency. CBCT images were accepted as the gold standard in the evaluation, and the detectability of calcifications in panoramic radiography and ultrasonography images was evaluated. Radiographic appearances (number, localization, distribution, pattern) were taken into account in the evaluation of calcifications and ossifications in CBCT and panoramic radiography. Hyperechoic lesions that posterior acoustic shadowing on USG images were considered calcification. Evaluating USG images, ultrasonographic appearances were also taken into account. A two-point scale for the presence/absence of calcification was admitted for assessment. (0: absence; 1: presence) (Figure 1, 2).

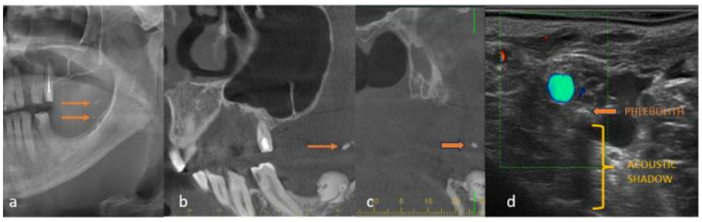

Figure 1: The appearance of phlebolith in Panoramic radiography(a), CBCT(b,c) and USG(d)

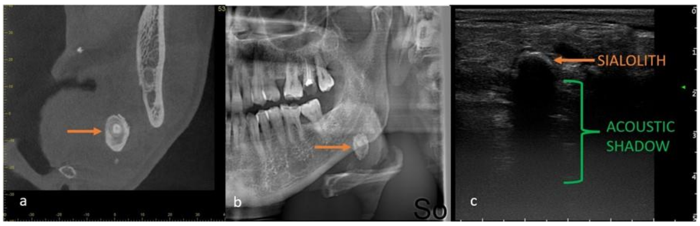

Figure 2: The appearance of sialolith, in CBCT (a), panoramic radiography (b), USG (c)

Ethical Approval

Ethical approval for the study was obtained from the Clinical Research Ethics Committee of Zonguldak Bülent Ecevit University, with Protocol number 2018-214-24/10.

Statistical Analysis Of Data

Statistical analysis was performed using the SPSS 19.0 (Statistical Package for Social Sciences, Chicago IL, USA) program. Descriptive statistics were expressed as frequencies and percentages. The Cochran Q test was used to determine the differences between the three techniques. When there was a difference between the methods after the Cochran Q test, Dunn's test was used for pairwise comparison of the methods. Differences within and between observers were evaluated with the Mc Nemar test. Kappa statistics were used to determine the inter- and intraobserver agreement and $p<0.05$ was considered statistically significant for all tests.

RESULTS

In our study, the data of 102 patients with soft tissue calcification and ossification in the maxillofacial region were used. The mean age of the patients was 48 ± 16.457 and the youngest age was 15 and the oldest was 89. Of the patients included in the study, 48 (47.1%) were male and 54 (52.9%) were female. The most common type of calcification/ossification in both gender was ossification of the stylohyoid ligament (Table 1).

Calcification was present in all 102 patients with CBCT. In Panoramic radiography images, calcification was detected in 92.1% of the patients, while it could not be detected in 7.8%. However, the rate of calcification detection in USG images was 29.4% and the rate of non-detection was 70.6%.

Considering the inter-observer kappa values; there was good agreement in the detection of stylohyoid ligament ossification on panoramic radiography between the first readings of the first and second observers, and moderate agreement in the detection of triticeous cartilage calcifications (Table 4).

Calcification type / Gender		Calcified lymph node	Tonsillolith	Arterial calcification	Sialolith	Phlebolith	Laryngeal cartilage calcification	Rinolith	Antrolith	Ossified stylohyoid ligament	Triticeous cartilage calcification
Male	**(n)**	2	19	3	9	2	7	0	3	**26**	4
	(%)	2.0%	18.6%	2.9%	8.8%	2.0%	6.9%	0.0%	2.9%	25.5%	3.9%
Female	**(n)**	1	34	1	11	0	8	1	2	**37**	4
	(%)	1.0%	33.3%	1.0%	10.8%	0	7.8%	1.0%	2.0%	36.3%	3.9%
Total	**(n)**	3	53	4	20	2	15	1	5	**63**	8
	(%)	2.9%	52.0%	3.9%	19.6%	2.0%	14.7%	1.0%	4.9%	61.8%	7.8%

Table 1: Distribution of calcifications and ossifications by gender.

When the distribution of calcifications/ossifications according to imaging techniques is commented;

- 174 calcifications were detected in 102 patients on CBCT images. The most common type of calcification was stylohyoid ligament ossification (61.8%), and the second most common calcification was tonsillolith (52%).
- 143 calcifications were detected in 94 patients on panoramic radiography images. The most common type of calcification was stylohyoid ligament ossification (70.6%). The second most common calcification was sialolith (19.6%).
- 32 calcifications were detected in 30 patients on USG images. The most common type of calcification was determined as sialolith (Table 2).

Considering the kappa values between the 1st and 2nd intra-observer readings; only for the first observer, good agreement was observed in the detection of stylohyoid ligament ossification on the panoramic radiograph, and moderate agreement was observed in the detection of triticeous cartilage calcifications (Table 3).

In detecting calcifications and ossifications; There is no difference between the 1st and 2nd intraobserver readings of the 1st and 2nd observers for each of the CBCT, panoramic radiography and USG techniques ($p = 1.000$). In detecting only stylohyoid ligament ossifications; For the panoramic radiography technique, a difference was found between the 1st and 2nd readings of the 1st observer ($p = 0.022$). In the detection of calcifications and ossifications; there is no difference between the 1st and 2nd interobserver readings of the 1st and 2nd observers for each of the CBCT, panoramic radiography and USG techniques ($p = 1.000$).
When the three techniques were compared considering the intra-observer values; CBCT was found to be more sensitive in detecting tonsilloliths. Laryngeal cartilage calcification, anthrolith, rhinolith, and stylohyoid ligament ossification could not be detected by USG. The sensitivity of panoramic radiography was 40% compared with CBCT in imaging the anthrolith. The sensitivity of USG in the detection of triticeous cartilage calcifications was observed to be quite low (12.5%) (Table 5).
It was evaluated whether there was a difference between three different imaging techniques in detecting calcifications and ossifications in intraobserver values:

Calsification Type / Imaging Technique		Calcified lymph node	Tonsillolith	Arterial calcification	Sialolith	Phlebolith	Laryngeal cartilage calcification	Rinolith	Antrolith	Ossified Stylohyoid Ligament	Triticeous cartilage calcification	TOTAL
CBCT	**(n)**	3	**53**	4	20	2	15	1	5	63	8	174
	(%)	2.9%	**52%**	3.9%	19.6%	2%	14.7 %	1%	4.9%	61.8%	7.8%	
Panoramic radiography	**(n)**	3	19	3	20	2	14	1	2	72	7	143
	(%)	2.9%	18.6%	2.9%	19.6%	2%	13.7 %	1 %	2%	70.6%	6.9%	
USG	**(n)**	3	3	3	20	2	0	0	0	0	1	32
	(%)	2.9%	2.9%	2.9%	19.6%	2%	-	-	-	-	1%	

Table 2: Distribution of calcifications / ossifications by imaging.

CALCIFICATION TYPE	**1. observer 1. and 2. reading**			**2. observer 1. ve 2. reading**		
	CBCT	**Panoramic radiography**	**USG**	**CBCT**	**Panoramic radiography**	**USG**
Calcified lymph node	1.000	1.000	1.000	1.000	1.000	1.000
P value	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*
Tonsillolith	1.000	0.82	1.000	0.98	0.859	1.000
P value	*1.000*	*0.063*	*1.000*	*1.000*	*1.000*	*1.000*
Arterial calcification	1.000	1.000	1.000	1.000	1.000	1.000
P value	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*
Sialolith	1.000	1.000	1.000	1.000	1.000	1.000
P value	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*
Phlebolith	1.000	1.000	1.000	1.000	1.000	1.000
P value	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*
Laryngeal cartilage calcification	1.000	0.917	-	1.000	1.000	-
P value	*1.000*	*1.000*	-	*1.000*	*1.000*	-
Rhinolith	1.000	1.000	-	1.000	1.000	-
P value	*1.000*	*1.000*	-	*1.000*	*1.000*	-
Anthrolith	1.000	1.000	-	1.000	1.000	-
P value	*1.000*	*1.000*	-	*1.000*	*1.000*	-
Ossified Stylohyoid Ligament	1.000	0.718	-	0.979	0.954	-
P value	*1.000*	*0.022*	-	1.000	0.5	-
Triticeous cartilage calcification	0.918	0.583	1.000	1.000	0.918	1.000
P value	*1.000*	*0.125*	*1.000*	*1.000*	*1.000*	*1.000*
p<0.05, (-) values that cannot be compared						

Table 3: Kappa and p values for intraobserver agreement between the first and second readings are shown.

CALCIFICATION TYPE	1. reading, Observer 1-2			2. reading, Observer 1-2		
	CBCT	Panoramic radiography	USG	CBCT	Panoramic radiography	USG
Calcified lymph node	1.000	1.000	1.000	1.000	1.000	1.000
P values	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*
Tonsillolith	1.000	0.886	1.000	0.98	0.933	1.000
P values	*1.000*	*0.25*	*1.000*	*1.000*	*0.50*	*1.000*
Arterial calcification	1.000	1.000	1.000	1.000	1.000	1.000
P values	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*
Sialolith	0.968	0.917	1.000	0.968	1.000	1.000
P values	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*
Phlebolith	1.000	1.000	1.000	1.000	1.000	1.000
P values	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*
Laryngeal cartilage calcification	1.000	0.917	-	1.000	1.000	-
P values	*1.000*	*1.000*	-	*1.000*	*1.000*	-
Rhinolith	1.000	1.000	-	1.000	1.000	-
P values	*1.000*	*1.000*	-	*1.000*	*1.000*	-
Anthrolith	1.000	1.000	-	1.000	1.000	-
P values	*1.000*	*1.000*	-	*1.000*	*1.000*	-
Ossified Stylohyoid Ligament	0.979	0.698	-	1.000	0.931	-
P values	*1.000*	*0.057*	-	*1.000*	*0.250*	-
Triticeous cartilage calcification	0.928	0.583	1.000	1.000	0.918	1.000
P values	*1.000*	*0.125*	*1.000*	*1.000*	*1.000*	*1.000*
p<0.05, (-) values that cannot be compared						

Table 4: Kappa and p values for interobserver agreement between the first and second readings are shown.

- A statistically significant difference was found between CBCT, panoramic radiography and USG in terms of the detecting of calcifications and ossifications. The reason for this was the low detection rate of calcifications and ossifications in USG imaging.

- A statistically significant difference was found between CBCT, panoramic radiography and USG in detecting tonsilloliths. The reason for this difference is that CBCT has a higher value in detecting tonsilloliths than the other two techniques. The reason for the significant difference between panoramic radiography and USG is that panoramic radiography can detect this calcification at a higher rate than USG.

- A statistically significant difference was found between the three techniques in detecting laryngeal cartilage calcification, antrolith, stylohyoid ligament ossification and triticeous cartilage calcification. The reason for this difference is that USG shows a lower rate of detecting calcifications and ossifications compared to other techniques. For other calcifications, no statistically significant differences were found between the three techniques (Table 6).

		CBCT				
		Sensitivity	**Specificity**	**Accuracy Rate**	**Positive Predictive Value**	**Negative Predictive Value**
Calcified Lymph Node	Panoramic Radiography	100%	100%	100%	100%	100%
	USG	100%	100%	100%	100%	100%
Tonsillolith	Panoramic Radiography	34%	98%	48%	95%	42%
	USG	5.7%	100%	51%	100%	49%
Arterial Calcification	Panoramic Radiography	**75%**	100%	99%	100%	99%
	USG	**75%**	100%	99%	100%	99%
Sialolith	Panoramic Radiography	100%	100%	100%	100%	100%
	USG	100%	100%	100%	100%	100%
Phlebolith	Panoramic Radiography	100%	100%	100%	100%	100%
	USG	100%	100%	100%	100%	100%
Laryngeal Cartilage Calcification	Panoramic Radiography	93%	100%	87%	100%	99%
	USG	-	-	-	-	-
Rhinolith	Panoramic Radiography	100%	100%	100%	100%	100%
	USG	-	-	-	-	-
Anthrolith	Panoramic Radiography	40%	100%	97%	100%	97%
	USG	-	-	-	-	
Ossified Stylohyoid Ligament	Panoramic Radiography	98%	74%	62%	86%	97%
	USG	-	-	-	-	-
Triticeous Cartilage Calcification	Panoramic Radiography	75%	99%	93%	86%	98%
	USG	12.5%	100%	93%	100%	93%

Table 5: Sensitivity, specificity, accuracy rate, positive predictive value (PPV), and negative predictive value (NPV) of panoramic radiography and USG technique compared to CBCT.

	1.Obserever 1st Reading	1.Observer 2nd Reading	2.Observer 1st Reading	2.Observer 2nd Reading
Calcification And Ossification Detection	p<0.001	p<0.001	p<0.001	p<0.001
Calcified Lymph Node	1.000	1.000	1.000	1.000
Tonsillolith	p<0.001	p<0.001	p<0.001	p<0.001
Arterial Calcification	0.368	0.368	0.368	0.368
Sialolith	1.000	1.000	0.368	0.368
Phlebolith	1.000	1.000	1.000	1.000
Laryngeal Cartilage Calcification	p<0.001	p<0.001	p<0.001	p<0.001
Rhinolith	0.368	0.368	0.368	0.368
Anthrolith	0.022	0.022	0.022	0.022
Ossified Stylohyoid Ligament	p<0.001	p<0.001	p<0.001	p<0.001
Triticeous Cartilage Calcification	0.018	0.005	0.005	0.004
p<0.05				

Table 6: The p values of the Cochran Q test to determine the differences between the three techniques are shown.

DISCUSSION

Soft tissue calcifications and ossifications in the maxillofacial region are detected incidentally on panoramic radiographs during routine radiographic examinations. These structures, which are distinguished by anatomical localization, number, size, distribution and calcification patterns, are usually asymptomatic (16).

Panoramic radiographic images are planar, two-dimensional radiographs, which can make localization and diagnosis of lesions problem. With two-dimensional imaging, low diagnostic success is achieved, particulary in the diagnosis of small calcifications or calcified structures superimposed on anatomical structures (9).

Therefore, the use of computed tomography in the imaging of calcified structures may provide a more sensitive and accurate information in the detection of calcifications (17). Distortion and superimposition problems on panoramic radiographs are not seen in CBCTs (2). In addition to diagnosing soft tissue calcifications and determining the precise localization, CBCT scanning is also an ideal technique for determining the size and shape of calcifications/ossifications (18).

In addition to radiographs, calcifications can be examined by USG, particulary by evaluating the relationship between calcifications misdiagnosed on radiographs and soft tissues, making it easier for the physician to reach the correct diagnosis. The use of USG in dentistry is becoming more common due to its advantages such as not requiring ionizing radiation, using sound waves to create images, being non-invasive, low cost, and being easily portable. In addition to these advantages, difficulties may arise in the diagnosis of some lesions with USG due to the dense bony structures in the maxillofacial region (19).

In the literature, it has been reported that calcifications/ossifications are observed more frequently in males and unilaterally in previous prevalence studies performed with CBCT (18,20). When the prevalence of calcification is evaluated in the literature; tonsillolith was a more frequent calcification type in Bayramov et al.'s and İçöz et al.'s studies, ossified stylohyoid ligament was more frequent in Ribeiro et al.’s and arterial calcification is the most common in Vengalath et al.'s study (20-23). According to the results of our study, the ossified stylohyoid ligament was the most frequent calcification/ossification in CBCT and panoramic radiography images. In USG, sialolith was the most commonly observed.

A comparison of the three techniques was made on intra-observer values. CBCT was found to be more successful in detecting tonsilloliths. Additionally, the sensitivity of panoramic radiography and USG in the imaging of tonsilloliths is quite low compared to CBCT (Panoramic radiography 34%, USG 5.7%). Regarding this result, we thought that as tonsilloliths are usually superimposed on the ramus of the mandible in panoramic radiographs and the size of the tonsillolith decreases, it can't be observed in a radiograph. The low rate of USG imaging in detecting tonsilloliths was thought to be due to the inability to obtain adequate images of tonsilloliths by ultrasonography since the tonsils are located in deeper tissues rather than superficial ones.

Schwarz et al. conducted a retrospective study comparing ultrasonography, CBCT, and sialoendoscopy imaging techniques for imaging sialoliths. The detection rate of sialoliths by USG was reported as 73%, and the rate of detection by CBCT was reported as 82%. The sensitivity of USG in the detection of sialoliths has been expressed as 70%. They reported that the sonographic appearance with bright echo complexes and a posterior shadowing is misinterpreted because of hyperechoic parts of the gland and additionally, sialoliths with a small diameter located in the periphery of the gland may remain undetected (24). Dreiseidler et al., in their study, compared CBCT, USG and histomorphometric methods in the diagnosis of sialoliths. CBCT was found to be 98.85% more sensitive and specificity in the diagnosis and measurement of sialolith compared with other techniques (25).

Yoon et al. evaluated the diagnostic accuracy of panoramic radiography in detecting carotid artery calcification; 110 patients CT (as the gold standard) and panoramic radiograh data were used. The diagnostic accuracy of panoramic radiographs in the detection of carotid artery calcification was 62.3%; and the sensitivity and specificity were found to be 22.2% and 90%, respectively. They declared that the location of the carotid artery bifurcation is variable and can fall outside of the region covered by panoramic radiographs. If calcifications are very small in size or superimposed on the cervical vertebra, they may not be detected by panoramic radiography. Errors in patient positioning might result in the inability to perceive carotid artery calcification. Hence, it is not proper to use panoramic radiography as a routine screening tool for detecting carotid artery calcification. (26).

Jashari et al. They reported that, compared to CBCT, the sensitivity of USG in detecting arterial calcification was 88.2% and its specificity was 100%. While carotid ultrasound is quite accurate in detecting the presence of calcified atherosclerotic lesions with a volume of ≥8 mm3; it was found to be less accurate in detecting smaller volumes of calcified plaques (27). Ertas et al. compared panoramic radiography and Doppler USG in the diagnosis of carotid artery calcifications. The sensitivity of panoramic radiography was 79.8%, the specificity was 81.1%, and the diagnostic accuracy rate was 80.5% (28). In our study, sensitivity and specificity rates were similar.

Özdede et al. compared panoramic radiography and CBCT in detecting tonsilloliths. Tonsillolith was detected in 33.2% of CBCT images. Only 51.4% of tonsilloliths detected with CBCT could be evaluated with panoramic radiography. As a result of this study, they were reported that tonsilloliths larger than 2 mm can be visualized with panoramic radiography (29). In our study, while the rate of tonsillolith observed in CBCT images was 52%, this rate was 18.6% for panoramic radiography**.** In our study, the main causes for the inconsistency between the 2 imaging techniques may be the calcification levels, the size, and the superimposition on the mandibular ramus of the tonsilloliths.

Çağrankaya et al. evaluated the radiographic data of 170 patients with a mean age of 41.4 years in their study that determined the effectiveness of panoramic radiography in the diagnosis of laryngeal cartilage calcifications using CBCT as the gold standard. The intra-observer agreement kappa value for panoramic radiography in the detection of calcifications was found to be 0.709. The sensitivity of panoramic radiography is 85.4%, and the accuracy rate is 84.6% (30). In our study, the kappa value was found to be 0.917, the sensitivity of panoramic radiography is 93% and the accuracy rate is 87%.

In our study, thyroid cartilage calcification, ossified stylohyoid ligament and antrolith could not be detected on USG. Diffuse calcification of thyroid cartilage impedes ultrasound penetration and appears as an anechoic area behind the hyperechoic calcification (31) In addition, there are not enough studies to show that antrolith can be visualized in healthy air-filled sinuses. In studies, maxillary sinuses that mimic the condition of maxillary sinusitis were studied and foreign bodies were detected(32).

The styloid process is difficult to observe on (MRI), and computed tomography (CT) remains the main diagnostic method. Unfortunately, few articles have described the application of ultrasound in styloid process examination, although, anatomically, ultrasound and CT images are highly consistent. Maher et al. reported an Eagle Syndrome patient treated with ultrasound-guided peristyloid steroid injection, and they reported that the styloid process was located about 2.0cm below the skin, and appeared as a long thin hyperechoic structure, accompanied by an acoustic shadow in USG (33,34).

This may be because the observers have less experience in interpreting USG compared to CBCT and panoramic radiography. On the other hand, USG is a real-time imaging method. In our study, the observers' retrospective evaluation of ultrasonographic patient data may have prevented the detection of some calcifications. Therefore, it would be appropriate to evaluate these calcifications, which cannot be seen in subsequent studies, in a prospective study.

CONCLUSION

Considering the findings of this study, panoramic radiography can be used as an alternative imaging method for detecting maxillofacial calcification compared to CBCT. Maxillofacial calcifications can be diagnosed incidentally during ultrasonography examinations and are useful in evaluating calcified lymph nodes, arterial calcification, sialolith and phlebolith noticed on routine panoramic radiographs or CBCT. We think that the detectability of soft tissue calcifications with USG will increase with the widespread use of USG in the field of dentistry and the increase in the experience of physicians.

REFERENCES

1. Harorlı A. Ağız Diş ve Çene Radyolojisi. 1. baskı. İstanbul: Nobel Tıp Kitapevleri; 2014.p. 416-20.

2. Üçok CÖ, Alkurt TM, Peker İ, Özdede M. Maksillofasiyal bölgede görülen heterotopik kalsifikasyonlar ve ossifikasyonlar. In: Özcan İ. Diş Hekimliğinde Radyolojinin Esasları. 1. Baskı. İstanbul: İstanbul Medikal Sağlık ve Yayıncılık 2017. p. 759-78.

3. Carter LC. Soft Tissue Calcifications and Ossifications. In: White SC, Pharoah MJ. (ed). White and Pharoah's Oral Radiology Principles and Interpretation. 7 Edition. St. Louis, Missouri. Elsevier; 2014. p. 524-41.

4. Avsever H, Orhan K. Çene Kemiği ve Çevre Dokuları Etkileyen Kalsifikasyonlar. Turkiye Klinikleri J Oral Maxillofac Radiol-Special Topics. 2018;4(1):43-52.

5. Omami G. Soft tissue calcification in oral and maxillofacial imaging: a pictorial review. Int J Dentistry Oral Sci. 2016;3(4):219-224.

6. Noffke CEE, Raubenheimer EJ, Chabikuli NJ. Radiopacities in soft tissue on dental radiographs: diagnostic considerations. SADJ. 2015;70(2):53-9.

7. Nasseh I, Sokhn S, Noujeim M, Aoun G. Considerations in detecting soft tissue calcifications on panoramic radiography. Journal of International Oral Health, 2016;8(6):742-46.

8. Arsan B, Erdem TL. Siyalolit teşhisinde ultrasonografi kullanımı. Turkiye Klinikleri J Oral Maxillofac Radiol-Special Topics. 2016;2(3):15-8.

9. Çağlayan F, Sümbüllü MA, Miloğlu Ö, Akgül HM. Are all soft tissue calcifications detected by cone-beam computed tomography in the submandibular region sialoliths? Oral Maxillofac Surg. 2014;72:1531.

10. Özemre MÖ, Seçgin CK, Gülşahı A. Yumuşak doku kalsifikasyonları ve ossifikasyonları: derleme. Acta Odontol Turc. 2016:33(3):166-75.

11. Kumar V, Abbas AK, Aster JC. Inflammation and repair. In: Kumar V, Abbas AK, Aster JC (ed) Robbins and Cotran Pathologic Basis of Disease. Philadelphia: Elsevier Saunders. 2015. p. 65-66.

12. Kremkau FW. Sonography principles and instruments. Elsevier Health Sciences. 2015. p. 11-20.

13. Welkoborsky HJ, Jecker P. Ultrasonography of the Head and Neck: An Imaging Atlas. Springer. 2019. p. 86-9.

14. Feldman MK, Katyal S, Blackwood MS. US artifacts. Radiographics. 2009:29(4);1179-89.

15. Alok A, Singh S, Kishore M, Shukla AK. Ultrasonography–A boon in dentistry. J Res Dent Sci 2019;10(2):98.

16. Patil SR, Alam MK, Moriyama K, Matsuda S, Shoumura M, Osuga N. 3D CBCT Assessment of soft tissue calcification. J Hard Tissue Biol. 2017;26(3):297-300.

17. Takahashi A, Sugawara C, Kudoh T, Uchida D, Tamatani T, Nagai H, Miyamoto Y. Prevalence and imaging characteristics of palatine tonsilloliths detected by CT in 2,873 consecutive patients. Scientific World Journal. 2014;2014:940960.

18. Khojastepour L, Haghnegahdar A, Sayar H. Prevalence of Soft Tissue Calcifications in CBCT Images of Mandibular Region. J Dent (Shiraz). 2017;18(2):88-94.

19. Çağlayan F. Ultrasonografinin diş hekimliğindeki klasik ve yeni kullanım alanları. Turkiye Klinikleri Oral and Maxillofacial Radiology-Special Topics, 2016;2(1):44-53.

20. Bayramov N, Üsdat A, Yalçınkaya ŞE. KIBT görüntülerinde rastlantı bulgusu olarak görülen yumuşak doku kalsifikasyonları. Selcuk J Dent. 2019; 6(4): 228-33.

21. Icoz D, Akgunlu F. Prevalence of detected soft tissue calcifications on digital panoramic radiographs. SRM J Res Dent Sci. 2019;10(1): 21.

22. Ribeiro A, Keat R, Khalid S, Ariyaratnam S, Makwana M, do Pranto M, et al. Prevalence of calcifications in soft tissues visible on a dental pantomogram: A retrospective analysis. J Stomatol Oral Maxillofac Surg. 2018; 119:369-74.

23. Vengalath J, Puttabuddi JH, Rajkumar B, Shivakumar GC. Prevalence of soft tissue calcifications on digital panoramic radiographs: A retrospective study. JIAOMR. 2014;26(4):385.

24. Schwarz D, Kabbasch C, Scheer M, Mikolajczak S, Beutner D, Luers JC. Comparative analysis of sialendoscopy, sonography, and CBCT in the detection of sialolithiasis. Laryngoscope. 2015;125(5):1098-101.

25. Dreiseidler T, Ritter L, Rothamel D, Neugebauer J, Scheer M, Mischkowski RA. Salivary calculus diagnosis with 3-dimensional conebeam computed tomography. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2010;110(1):94-100.

26. Yoon SJ, Yoon W, Kim OS, Lee JS, Kang BC. Diagnostic accuracy of panoramic radiography in the detection of calcified-carotid artery. Dentomaxillofac Radiol. 2008; 37:104-18.

27. Jashari F, Ibrahimi P, Johansson E, Ahlqvist J, Arnerlöv C, Garoff M, Henein M. Atherosclerotic calcification detection: a comparative study of carotid ultrasound and cone beam CT. Int J Mol Sci. 2015;16(8):19978-988.

28. Ertas ET, Sisman Y. Detection of incidental carotid artery calcifications during dental examinations: panoramic radiography as an important aid in dentistry. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2011;112(4):11-7.

29. Özdede M, Akay G, Karadağ Ö, Peker I. The comparison of panoramic radiography and cone-beam computed tomography for detection of tonsilloliths. Med Princ Pract. 2020;29(3):279-84.

30. Çağırankaya LB, Akkaya N, Akçiçek G, Boyacıoğlu Doğru H. Is the diagnosis of calcified laryngeal cartilages on panoramic possible? Imaging Sci Dent. 2018;48(2):121-25.

31. Woo JW, Kim SK, Park I, Choe JH, Kim JH, Kim JS. A novel gel pad laryngeal ultrasound for vocal cord evaluation. Thyroid. 2017;27(4), 553-57.

32. Demiralp KO, Orhan K, Kurşun-Çakmak EŞ, Gorurgoz C, Bayrak S. Comparison of Cone Beam Computed Tomography and ultrasonography with two types of probes in the detection of opaque and non-opaque foreign bodies. Med Ultrason. 2018;20(4):467-74.

33. Zang Y, Chen S, Zang G, Hu M, Xu Q, Feng Z, Pan, A. The anatomic basis for ultrasound in the diagnosis and treatment of styloid process–related diseases. Ann Transl Med. 2020; 8(24):1666.

34. Maher T, Shankar H. Ultrasound-Guided Peristyloid Steroid Injection for Eagle Syndrome. Pain Pract. 2017;17(4):554-57.