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Original Research Article

The Prevalence and Distribution of Pulp Stones: A Cone-Beam Computed Tomography Study In a Group of Turkish Patients

Pulpa Taşlarının Prevalansı ve Dağılımı: Bir Grup Türk Hastada Konik Işınlı Bilgisayarlı Tomografi Çalışması

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ABSTRACT

Aim: This study aimed to assess the presence of pulp stones using cone-beam computed tomography (CBCT) and correlate their prevalence with gender, age, dental arch, and side, tooth type, and dental restoration in a group of Turkish patients.

Material and Methods: CBCT images of 148 patients were randomly selected from the database retrospectively and 3910 teeth were examined. The associations of pulp stones with gender, age, dental arch and side, tooth type, and presence of dental restoration were evaluated.

Results: From the total of 148 patients, 69 were found to have pulp stones present (46.6%), and pulp stones were detected in 230 (5.9%) of the 3910 examined teeth. The prevalence of pulp stones was similar between the genders, ages, and arches. The most pulp stones were seen in the first molars (21.0%) and then in the second molars (12.8%) ($p<0.05$). In the maxilla and mandible, the prevalence of pulp stone on the right sides was highest in the first molars, followed by the second molars ($p<0.05$).

Conclusion: In a group of Turkish patients, the presence of pulp stones was not found to be related to gender, age, or distribution between maxillary and mandibular teeth. The first molars and then the second molars on the right side showed the highest occurrence of pulp stones. CBCT can serve as a highly effective method for detecting pulp stones and assist in making decisions during endodontic treatment.

Keywords: Cone-Beam Computed Tomography; Dental pulp calcification; Pulp stones

ÖZET

Amaç: Bu çalışmanın amacı, bir grup Türk hastasında pulpa taşlarının varlığını konik ışınlı bilgisayarlı tomografi (KIBT) kullanarak değerlendirmek ve prevalansını cinsiyet, yaş, diş arkı ve sağ -sol taraf, diş tipi ve diş restorasyonu ile ilişkilendirmektir.

Gereç ve Yöntem: 148 hastanın KIBT görüntüleri retrospektif olarak veri tabanından rastgele seçilmiş ve 3910 diş incelenmiştir. Pulpa taşlarının cinsiyet, yaş, diş arkı ve sağ-sol taraf, diş tipi ve diş restorasyonu varlığı ile ilişkileri değerlendirildi.

Bulgular: İncelenen 148 dişin 69'unda (%46.6) ve incelenen 3910 dişin 230'unda (%5.9) pulpa taşı görüldü. Pulpa taşı prevalansı cinsiyet, yaş ve arklar arasında benzerdi. Pulpa taşları en fazla birinci azı dişlerinde (%21.0), ardından ikinci azı dişlerinde (%12.8) görüldü ($p<0.05$). Maksilla ve mandibulada sağ tarafta pulpa taşı prevalansı en fazla 1. azı dişlerde olup, bunu 2. azı dişler takip etmektedir ($p<0.05$).

Sonuç: Bir grup Türk hastada, pulpa taşlarının varlığının cinsiyet, yaş veya maksiller ve mandibular dişler arasındaki dağılımla ilişkili olmadığı bulundu. Sağ taraftaki birinci azı dişleri ve ardından ikinci azı dişleri en fazla pulpa taşı oluşumunu göstermiştir. KIBT, pulpa taşlarının saptanmasında oldukça etkili bir yöntem olabilir ve endodontik tedavi sırasında karar vermede yardımcı olabilir.

Anahtar Kelimeler; Dental pulpa kalsifikasyonu; Konik-Işınlı Bilgisayarlı Tomografi, Pulpa taşları

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INTRODUCTION

Pulp stones are mineralized aggregates that are frequently encountered as discrete structures within the dental pulp and have a higher prevalence in posterior teeth. They are generally formed after a trauma.[1] Homeostasis is a physiological process that occurs in response to chemical or surgical interventions. As a result of this process, dental pulp tissue can produce dentin or osteodentin. Also, the increased activity of pulp cells leads to the onset of calcification in the pulp tissue.[2]

Advanced age, orthodontic treatment, and dental transplantation are among the potential etiologic factors linked with pulp calcification development. Additionally, genetic predisposition is recognized as an important factor in the development of pulp calcifications and is classified as idiopathic in etiology. The high incidence of pulp stones is positively correlated with genetic disorders such as Van der Woude syndrome, dentinogenesis imperfecta, and dentin dysplasia.[3] When pulp stones are present, the color of the crown appears yellowish, exhibiting reduced translucency and a darker hue.[4] The presence of pulp stones can lead to difficulties in performing endodontic treatment. These challenges include potential obstruction of the pulp chamber access due to coronal calcification, restricted file access due to radicular calcification, and potential obstruction of a comprehensive endodontic treatment.[5] Recently, an association has been established between pulp calcifications and numerous systemic disorders such as coronary artery disease, diabetes, renal diseases, and autoimmune diseases. Furthermore, researchers claim that pulp stone detection may be a diagnostic marker for systemic disease.[6,7] Therefore, the detection of pulp calcification is of significant importance, not only for dental procedures but also because it can provide information about a patient's systemic condition. Various chemical and mechanical techniques can be used to identify dental pulp stones.[8]

To identify whether pulp stones are present, several different radiographic techniques are employed, including intraoral periapical, bitewing, and panoramic radiography. Today, a method commonly used in complex endodontic procedures for diagnostic purposes is cone-beam computed tomography (CBCT). An advantage of CBCT is its ability to provide a comprehensive three-dimensional representation covering all parts of the imaged object. CBCT offers complementary data for diagnosis and treatment planning.[6] Furthermore, compared to digital radiographic techniques, CBCT has been described as a highly sensitive diagnostic method for detecting pulp stones.[9]

In the literature, researchers have demonstrated that the prevalence of pulp stones can vary significantly according to the population.[10,11] Different ethnic and geographical groups may account for these differences in prevalence.

In the current study, the aim was to identify the prevalence of pulp stones utilizing CBCT as well as to explore potential associations among pulp stones and tooth groups, tooth localization in addition to the presence of dental restorations.

MATERIAL AND METHODS

Approval to conduct the study was obtained from the Near East University Faculty of Medicine Ethical Review Board (IRB/2019/73-908). The CBCT records of 148 patients who received treatment at the Near East University Dental Hospital between 2018 and 2019 were retrospectively reviewed. The patients were divided into 4 groups according to quartiles; 18-23, 24-34, 35-46 and older than 47 years old. Patients who were selected for the study had a mean age of 36.6 years. In total, the evaluation of 3910 dental images in sagittal, coronal, and axial planes was performed to examine the pulp chamber and root canals to identify pulp stones (Figure 1). Of the total patient population, 58.8% were male, and their mean age was 36.7 years, while 41.2% were female, who had a mean age of 36.4 years. CBCTs have been obtained previously for various purposes such as implant surgeries, orthodontics, or impacted teeth evaluation. Exclusion criteria included individuals under the age of 18 years with deep caries lesions, crowns, and teeth showing root resorption, as well as patients who had previously undergone root canal procedures. The study group consisted of individuals with fully developed permanent tooth roots according to the inclusion criteria. CBCT images were acquired using the Sirona Orthophos XG 3D system (Bensheim, Germany) and the FOVs employed in this research were 80 mm x 80 mm

and 110 mm x 100 mm. Imaging parameters varied between 60 and 90 kVp and 3 and 16 mA according to the FOV. A voxel size of 0.08 mm and a scan duration of 14 seconds were used. After images had been acquired, the same software program was utilized to determine whether pulp stones were present in coronal, axial, and sagittal sections.

If it was determined that a radiopaque mass was present within the pulp chamber, this was recorded as a pulp stone. Parameters recorded included whether pulp stones and restorations were present, as well as the position of the tooth within the mandibular and maxillary arch. Furthermore, the teeth were categorized into specific groups: mandibular molars, maxillary molars, mandibular premolars, maxillary premolars, mandibular canines, maxillary canines, mandibular incisors, and maxillary incisors. The presence (presence/absence) of pulp stones and the evaluation of other parameters were performed by two Oral and Maxillofacial Radiologists. Intraobserver or interobserver variability was <5%.

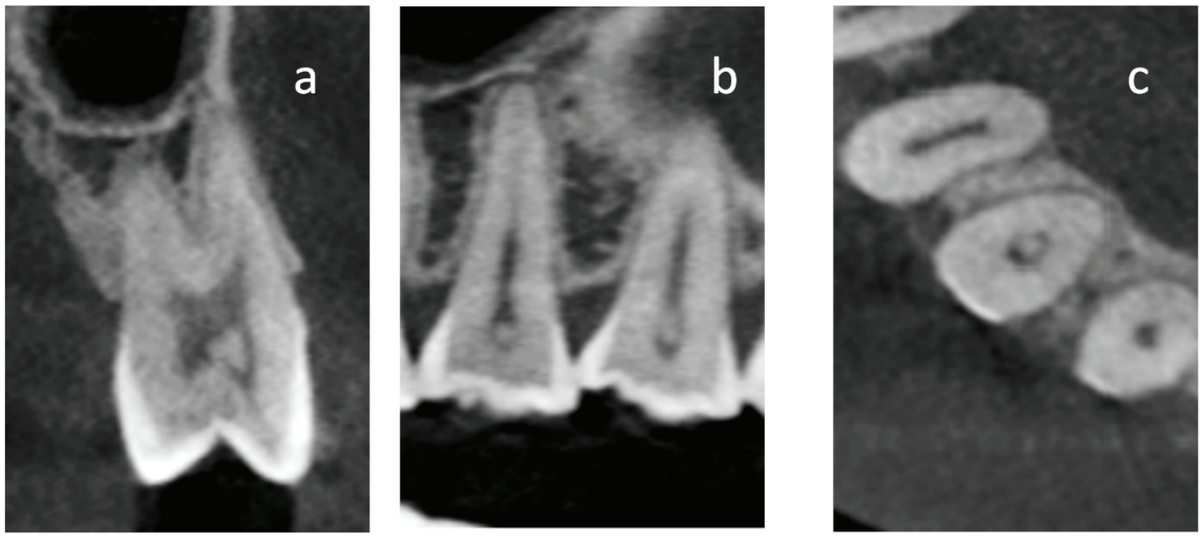

Figure 1. Teeth with pulp stones on different sections of cone-beam computed tomography (CBCT). (a) Coronal CBCT section of the maxillary first molar. (B) Sagittal CBCT section of maxillary premolars c) Axial CBCT section of incisors

Statistical analysis

Data were transferred to IBM SPSS Statistics version 24 (SPSS, Chicago, IL, USA). In the process of analyzing the data, Fisher's Exact tests with cross-tabulations were employed to determine the categorical distributions of the pulp stone in terms of gender, age, and specific location within the jaw.

RESULTS

Of the total of 148 patients, 69 were found to have pulp stones present (46.6%). When the distribution of pulp stones by gender was analyzed, it was found that 52.2% of women and 42.5% of men had pulp stones. Differences between genders were not statistically significant (p>0.05) (Table 1).

In Table 2, the distribution of pulp stones based on age is presented. According to the findings, 26% of individuals aged 18-23 years, 24% of individuals aged 24-34 years, 24.7% of individuals aged 35-46 and 24.7% of individuals aged 47 years and older had pulp stones. Consequently, differences in the age-related distribution were not statistically significant (p>0.05).

CBCT was used in the examination of 3910 teeth in total. It was determined that 230 of these teeth (5.88%) had pulp stones. The distribution of pulp stone according to the dental arch, side, and tooth type is shown in Table 3. However, there was a significant difference in the formation of pulp stones according to tooth type. The highest prevalence was observed in the first molars (21.0%), followed by the second molars (12.8%) (p<0.05).

Table 1. Distribution of patients with pulp stones by gender

Gender	No. of patients scanned	No. of patients With pulp stones	P-value [a]
Female	61	32 (52.2%)	0.233
Male	87	37 (42.5%)	
Total	148	69 (46.6%)	

a Fisher's exact test

Table 2. Distribution of patients with pulp stones by age

		Age							
		18-23	**24-34**	**35-46**	**47 and more**	**Total**	**χ2**	**df**	**P-vale[a]**
No Pulp Stone	**n**	24	20	18	18	80	1.586	3	0.663
	%	61.50%	55.60%	48.60%	50.00%	54.10%			
Pulp Stone	**n**	15	16	19	18	68			
	%	38.50%	44.40%	51.40%	50.00%	45.90%			
Total	**n**	39	36	37	36	148			

aPearson Chi-Square

Table 3. Pulp stone distribution according to the dental arch, side, and tooth type

Variable	Group	No. of teeth scanned	No. of teeth with pulp stones	P value [a]
Dental Arch	Maxilla	1897	113 (6.0%)	0.848
	Mandibula	2013	117 (5.8%)	
Side	Right	1939	128 (6.6%)	0.058
	Left	1971	102 (5.2%)	
Tooth type	Incisor	548	10 (1.8%)	<0.001
	Lateral Incisor	558	9 (1.6%)	
	Canine	570	22 (3.9%)	
	First premolar	521	11 (2.1%)	
	Second premolar	471	16 (3.4%)	
	First molar	396	83 (21.0%)	
	Second molar	485	62 (12.8%)	
	Third molar	361	17 (4.7%)	

a Fisher's exact test

Restorative treatments existed in 54 teeth which constituted approximately 23.5% of the overall sample of 230 teeth in which pulp stones were present.

The teeth in which the prevalence of pulp stones was determined to be the highest were the maxillary first molars, while the prevalence was slightly lower in the second molars and the difference was statistically significant ($p<0.05$). In terms of the side of the maxilla, pulp stones were statistically significantly more prevalent on the right in comparison to the left ($p<0.05$). Similarly, concerning second molars, a statistically significant increase in pulp stone formation was observed on the right side ($p<0.05$). A dense pulp stone was observed on the right side of the mandible. Regarding the first and second molars, pulp stones were more prevalent on the right side than on the left side ($p<0.05$). However, when all tooth groups were considered, the prevalence of pulp stones in the teeth on the left and right sides was not found to be statistically significantly different ($p>0.05$). The relevant data are presented in Table 4.

Table 4. Comparison of pulp stone distribution in teeth

Dentalach	Side			Tooth type							Total		p value [a]
				Incisor	Lateral Incisor	Canine	First Premolar	Second Premolar	First Molar	Second Molar	Third Molar		
Maxilla	Right	Pulp stone	n	4	3	3	4	4	27	19	2	66	<.001
			%	3.10%	2.30%	2.10%	3.30%	3.50%	26.00%	15.60%	2.40%	7.00%	
		Total teeth	n	128	131	141	121	113	104	122	84	944	
	Left	Pulp stone	n	0	0	6	1	2	22	12	4	47	<.001
			%	0.00%	0.00%	4.30%	0.80%	1.90%	21.00%	9.50%	4.40%	4.90%	
		Total teeth	n	129	135	138	122	108	105	126	90	953	
			%										
Mandibula	Right	Pulp stone	n	3	4	6	3	4	20	18	4	62	<.001
			%	2.10%	2.70%	4.10%	2.20%	3.30%	21.50%	15.40%	4.40%	6.20%	
		Total teeth	n	145	146	145	136	122	93	117	91	995	
			n										
	Left	Pulp stone	%	3	2	7	3	6	14	13	7	55	<.001
			n	2.10%	1.40%	4.80%	2.10%	4.70%	14.90%	10.80%	7.30%	5.40%	
		Total teeth	n	146	146	146	142	128	94	120	96	1018	
			n										
Total teeth												3910	

a Fisher's exact test

DISCUSSION

In the current research, the prevalence of pulp stones and their association with variables including dental quadrant, dental arch, type of tooth, age, and gender were assessed using a non-invasive method. Previous studies on pulp stones have been predominantly based on conventional radiography or histologic examination.[3,12,13] For the detection of pulp stones, two-dimensional radiographs require a calcified structure exceeding 200 µm to be present, which may cause the true prevalence of pulp stones to be underestimated.[10,12] In addition, in these modalities, the pulp stones can be hampered by the superposition of the alveolar bone. However, CBCT effectively addresses the problem of superposed anatomical structures and allows the capture of high-resolution images in the axial, coronal, and sagittal planes. Therefore, CBCT is emerging as an advantageous imaging technique for determining whether pulp stones are present.[14] Histologic analysis has proven its reliability by revealing a significantly higher prevalence of pulp calcifications in dental specimens compared with radiologic assessments. However, it should be noted that histologic analysis may have limitations in accurately identifying pulp stones. This is especially true when only a limited number of sections are prepared for each specimen and the analysis is performed only *in vitro*.[15]

Pulp stones are usually observed as an incidental finding in radiography. Pulp stones can be detected not only through radiographs taken before treatment but also while performing root canal treatment. However, since 2-dimensional radiographs (panoramic, periapical, or bite-wing) are currently used for the diagnosis of teeth requiring root canal treatment if a pulp stone is present in the tooth, it can be diagnosed before the dentist starts root canal treatment. The use of radiographs to detect pulp stones is considered more advantageous for the dentist because the treatment can be started with knowledge of the pulp stone detected beforehand, thus ensuring that any sudden complications are not encountered. Upon identifying pulp stones through 2D radiographic methods, CBCT should be used for treatment planning in complex endodontic procedures.[6]

In this study, CBCT imaging was used to examine and evaluate the potential correlation between pulp stones and various factors such as age, gender,

dental arch and side, tooth type, and presence of dental restorations. Furthermore, the use of CBCT may be an effective method to reduce the limitations associated with standard radiographs and histologic examination. CBCT is being increasingly utilized in clinical practice for diagnostic purposes. By providing a three-dimensional representation, CBCT allows dental practitioners to comprehend the relationships among the teeth, dental arches, and facial skeletal structures.[10,16]

In some previous studies and this study, although pulp stones were more observed in females, there was no statistically significant difference between genders.[10,14,17,18] The higher prevalence observed in these studies may be attributed to the fact that females have an increased incidence of bruxism, which results in the teeth becoming irritated in the long term.

According to our findings, which are consistent with previous studies[10,18] no statistically significant difference was observed in terms of the formation of pulp stones according to age groups. However, other studies in the literature have found that pulp stones are more prevalent in the elderly.[17,18] The disparity between this finding of our research and past studies could be because elderly patients were not sufficiently represented in our sample, as only 12 patients (8%) were 60 years of age or older. Therefore, this can be regarded as one of the study's limitations.

The findings of this study indicate that the distribution of pulp stones between the maxillary and mandibular teeth and between right- and left-sided teeth was not statistically significantly different when considering all tooth groups. Similar findings were reported by Tassoker *et al*.[17], Gulsahi *et al*.[19], and al-Hadi Hamasha *et al*.[21] for both maxillary and mandibular arches. In these studies, no significant difference was found regarding maxillary and mandibular teeth. However, some studies have shown that the formation of pulp stones in the maxillary and mandibular teeth occurred at a significantly different rate.[10,18,20] Regarding the distinction between right- and left-sided teeth, our findings are consistent with those of Hsieh *et al*.[10] and Çolak *et al*.[20] who reported that the prevalence in right- and left-sided teeth was not statistically significantly different. While one study19 stated that pulp stones are more common on the right side, other researchers suggested that they are more common on the left side.[22,23] This difference with our study may be because other studies were conducted with a larger patient group.

In both dental arches, pulp stones had a higher prevalence in the upper first molars of 21.0% ($p<0.05$). This observation concurs with the findings of previous researchers.[10,18,24] This could be explained by molar tooth size differences. Larger teeth exhibit greater blood perfusion, facilitating the dental pulp calcification process compared to smaller-sized teeth.[10] It has also been observed that molars tend to erupt before premolars, leading to longer exposure to degenerative factors or irritants.[25]

In the entire sample of 230 teeth with pulp stones, a subset of 54 teeth were found to have restorations, representing approximately 23.5% of the observed cases. According to the findings reported above, the conclusion can be made that the dental restorations being present contribute to a higher incidence of pulp stones. The results reported by Tassoker *et al*.[17] and da Silva *et al*.[15] support our findings regarding the positive correlation between dental restorations and the presence of restorations. It has been hypothesized that the formation of pulp stones is influenced by permanent irritations such as dental restorations, dental caries, and atypical oral habits.[26]

CONCLUSION

In summary, no significant relationship was observed between pulp stone formation and variables such as gender, age, or distribution between maxillary and mandibular teeth. The first molars on the right side exhibited the highest prevalence of pulp stones, followed by the second molars. As a result of the high-resolution imaging capability of CBCT, pulp stones can be more accurately detected, allowing for the development of more effective strategies in treatment planning and execution.

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