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Comparison of the Presence and Frequency of Pulp Stones in Mandibular Teeth with Panoramic Radiography and Cone Beam Computed Tomography Images: A Retrospective Study

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Abstract

Background: This study aimed to evaluate and compare the diagnostic effectiveness of cone beam computed tomography (CBCT) and panoramic radiography in detecting pulp stones in mandibular teeth and investigate the relationship between pulp stone prevalence and demographic variables.

Methods: This retrospective study analyzed a total of 1947 mandibular teeth from 150 patients (80 males, 70 females) using both CBCT and panoramic radiography images. Teeth were categorized into 4 anatomical groups: incisors, canines, premolars, and molars. The presence of pulp stones was assessed by a calibrated observer for each imaging modality. Chi-square tests were employed to determine statistical significance ($P < .05$) in detection rates between imaging modalities and across demographic variables.

Results: Cone beam computed tomography demonstrated significantly greater sensitivity in the detection of pulp stones compared to panoramic radiography, particularly in molars (27.3% vs. 8.7%) and anterior teeth, where panoramic radiography frequently failed to detect pulp stones. A statistically significant difference in pulp stone prevalence was observed in the canine group, with higher detection rates in females than males (11.4% vs. 1.3%, $P = .009$). The CBCT demonstrated superior sensitivity (94.1%, 95% CI: 89.2%-97.3%) compared to panoramic radiography (31.7%, 95% CI: 24.8%-39.4%) for pulp stone detection, with specificity values of 100% for both modalities.

Conclusion: Cone beam computed tomography is significantly more effective than panoramic radiography for detecting pulp stones in mandibular dentition, offering enhanced diagnostic capability, particularly in complex anatomical regions. While sex may influence pulp stone prevalence in specific tooth groups, age does not appear to be a determining factor within the examined cohort.

Keywords: Cone beam computed tomography, panoramic radiography, pulp stones

What is already known on this topic?

- *Pulp stones are calcified structures that can develop in both healthy and diseased teeth, with prevalence varying significantly across different populations and imaging methods.*
- *Cone beam computed tomography (CBCT) provides 3-dimensional imaging with superior diagnostic capabilities compared to conventional 2-dimensional panoramic radiography for detecting various dental pathologies.*
- *Previous studies have reported conflicting results regarding the influence of demographic factors such as age and sex on pulp stone formation, with most research focusing on single imaging modalities rather than direct comparisons.*

What does this study add on this topic?

- *This study provides the first direct within-subject comparison of CBCT versus panoramic radiography for pulp stone detection in mandibular teeth, demonstrating that CBCT detects more than 3 times as many pulp stones in molars (27.3% vs. 8.7%).*

INTRODUCTION

Pulp stones are calcified structures that can develop in both healthy and diseased teeth.[1] They may be located freely within the pulp chamber or root canal, or they may be attached to the dentinal walls or embedded within the dentin itself. Pulp stones

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- *The research reveals significant sex-related differences in pulp stone prevalence specifically in canine teeth, with females showing substantially higher rates (11.4%) compared to males (1.3%) when detected using CBCT.*
- *This study establishes that panoramic radiography significantly underdiagnoses pulp stones, particularly in anterior teeth where it failed to detect any pulp stones, highlighting the clinical importance of choosing appropriate imaging modalities for accurate endodontic diagnosis and treatment planning.*

exhibit various sizes, and those measuring less than 200 microns in diameter are typically undetectable through conventional radiographic examinations.[2] The exact mechanism underlying the formation of pulp stones remains unclear.

It has been suggested that remnants of Hertwig's epithelial root sheath may contribute to their development.[3] Additionally, several factors such as aging, dental caries, restorative procedures, periodontal diseases, and orthodontic treatments have been associated with the formation of pulp stones.[4,5]

Although pulp stones are most frequently observed in the apical third of the root, they can also be found in any region of the crown or root.[6]

Pulp stones can be classified according to various criteria, including their location, morphological characteristics, and histological features. Based on their structure, pulp stones are classified as true or false. True pulp stones are composed of dentin and are typically surrounded by odontoblasts. In contrast, false pulp stones consist of mineralized degenerated cells and do not exhibit the organized tubular structure characteristic of dentin. According to their location, pulp stones are classified as free, attached, or embedded. In free pulp stones, the calcified mass is not in contact with the walls of the pulp chamber and is completely surrounded by soft tissue. Attached pulp stones are partially connected to the dentinal wall of the pulp cavity but are not entirely encased in dentin. In contrast, embedded pulp stones are completely enclosed within the dentin of the canal wall.[7]

The clinical significance of pulp stones in endodontic treatment can be explained in 2 main aspects. Firstly, pulp stones may exert pressure on the pulp chamber, potentially causing idiopathic pain.[8] Secondly, they can complicate root canal treatment by obstructing access to the canal orifices. Large pulp stones within the pulp chamber may hinder canal access and alter the internal anatomy of the tooth. Additionally, attached stones may deflect the tips of endodontic instruments or impede their passage through the canal system.[9]

Due to the challenges pulp stones may pose during endodontic procedures, their identification by the clinician prior to treatment is crucial for ensuring therapeutic success.

In recent years, the use of cone beam computed tomography (CBCT) has become increasingly widespread in dentistry due to its ability to provide 3-dimensional imaging.

The aim of this study is to determine whether there is a difference in the detectability of pulp stones between panoramic radiographs (PR), which provide 2-dimensional images, and CBCT, which offers 3-dimensional visualization.

MATERIALS AND METHODS

The research protocol was conducted in accordance with the principles of the Declaration of Helsinki and was approved by the Çanakkale Onsekiz Mart University Ethics Committee for Non-Interventional Clinical Research (Approval no: 2025-07/07-23; Date:17.04.2025). This study aims to compare the visibility of pulp stones in mandibular teeth on CBCT and PR. In this retrospective study, images of patients who had previously applied to the hospital for various reasons and had panoramic and CBCT images were examined. Images of patients who signed an informed consent form regarding the use of the images obtained for scientific purposes were included in the study. Therefore, CBCT (NewTom 5G XL, Italy) and PR images (Planmeca promax, Finland) of 150 patients who had previously applied to Çanakkale Onsekiz Mart University Faculty of Dentistry for various reasons were compared. The sample size was calculated based on previous similar studies.[10-12] The CBCT images were acquired using standardized protocols: 90 kVp, 8 mA, 0.2 mm voxel size, limited field of view (10 × 5

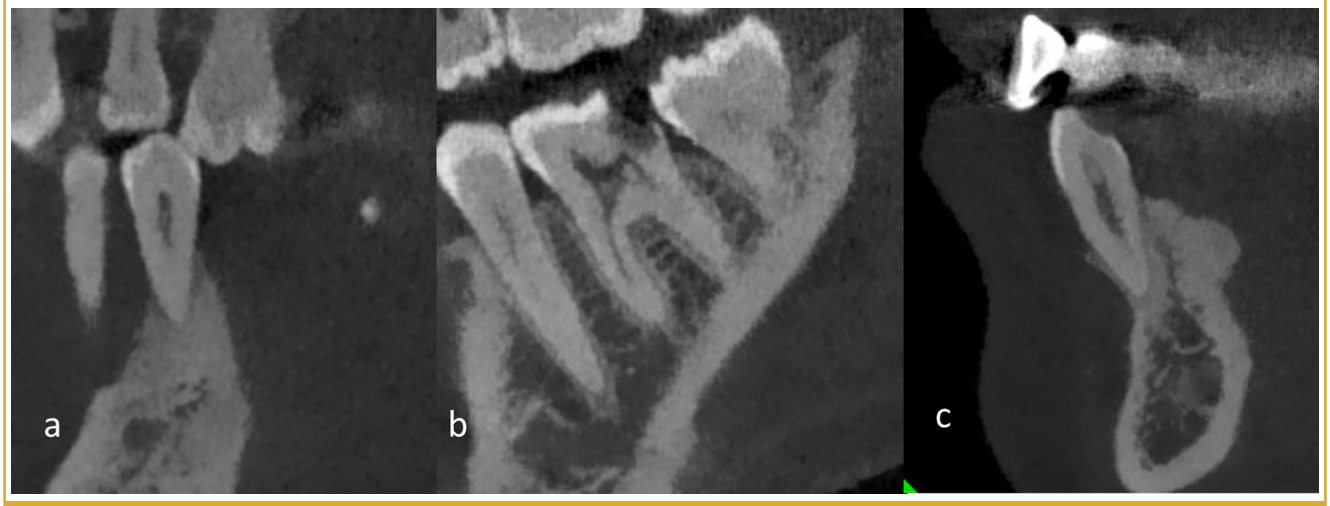

Figure 1. CBCT sagittal view demonstrating pulp stone (a); CBCT coronal view showing pulp stone near the root canal (b); CBCT view showing large pulp stone obstructing access to canal (c).

and 15 × 5 cm), and 18-second exposure time. Panoramic radiographs were obtained at 73 kVp, 10 mA, with standard exposure protocols. All images were evaluated on calibrated monitors under controlled lighting conditions.

In this study, the teeth were categorized into 4 groups: incisors, canines, premolars, and molars. Each group was evaluated proportionally within itself in terms of the presence and frequency of pulp stones. A total of 1947 mandibular teeth from 150 patients, including 591 incisors, 298 canines, 586 premolars, and 472 molar were examined using both CBCT and PR. Each tooth was evaluated by 2 observers with consensus to compare the detectability of pulp stones using the 2 imaging modalities. Additionally, the patients were grouped by sex as male and female, and a comparison was made to assess whether there was a statistically significant difference in the prevalence of pulp stones between the sexes. The appearance of pulp stones in CBCT and PR images is presented in the figures below (Figures 1 and 2).

To ensure the reliability and reproducibility of pulp stone detection, interobserver agreement was assessed between 2 calibrated observers. Prior to the study, both observers underwent a calibration session using 30 randomly selected cases that were not included in the final analysis. During this calibration, observers independently evaluated the presence of pulp stones and discussed any discrepancies until consensus was reached.

For the interobserver reliability analysis, both observers independently assessed 50 randomly selected cases (representing 33% of the total sample) for pulp stone presence using both CBCT and panoramic radiography. The observers were blinded to each other's evaluations and to patient demographic information. Interobserver agreement was calculated using Cohen's kappa coefficient, with values interpreted as follows: $\kappa < 0.20$ (poor agreement), $\kappa = 0.21$–0.40 (fair agreement), $\kappa = 0.41$–0.60 (moderate agreement), $\kappa = 0.61$–0.80 (substantial agreement), and $\kappa > 0.80$ (excellent agreement).

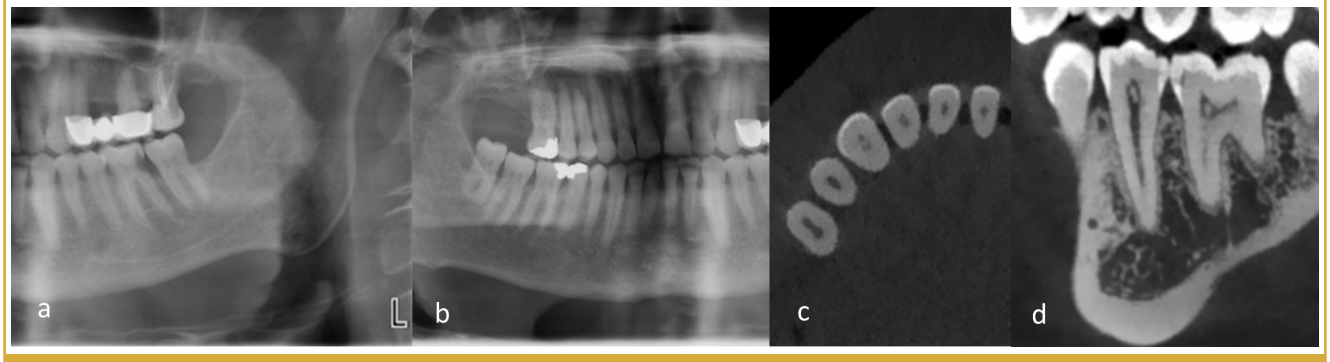

Figure 2. Panoramic view showing pulp stones in mandibular molars (a, b); CBCT axial view of mandibular canine and lateral incisor with pulp stone (c); CBCT image showing pulp stone in mandibular premolar and molar teeth (d).

Table 1. General Descriptive Statistics of Patient Demographic and Imaging Findings (n=150)

		n	%
Sex	Male	80	53.3
	Female	70	46.7
Age (years)	<30	58	38.7
	31-50	55	36.7
	51-70	37	24.7
CBCT incisor	Pulp stone absent	141	94.0
	Pulp stones present	9	6.0
CBCT canine	Pulp stone absent	141	94.0
	Pulp stones present	9	6.0
CBCT premolar	Pulp stone absent	147	98.0
	Pulp stones present	3	2.0
CBCT molar	Pulp stone absent	109	72.7
	Pulp stones present	41	27.3
PR incisor	Pulp stone absent	150	100.0
	Pulp stones present	0	0.0
PR canine	Pulp stone absent	148	98.7
	Pulp stones present	2	1.3
PR premolar	Pulp stone absent	149	99.3
	Pulp stones present	1	0.7
PR molar	Pulp stone absent	137	91.3
	Pulp stones present	13	8.7

CBCT, cone beam computed tomography; PR, panoramic radiograph.

Statistical Analysis

In calculating the sample size for this study, a minimum statistical power of 80% and a type I error rate (α) of 5% were assumed for each variable. Descriptive statistics were reported as frequency (n) and percentage (%). The Chi-square test was used to analyze the associations between imaging findings and categorical variables or measurements. A *P*-value of less than .05 was considered statistically significant. All statistical analyses were performed using BM SPSS Statistics version 26 software (IBM SPSS Corp.; Armonk, NY, USA).

RESULTS

The following data summarizes the fundamental demographic characteristics (sex and age group) of the 150 patients included in the study, along with the frequency (n) and percentage (%) distribution of pulp stone presence in different tooth groups (incisors, canines, premolars, molars), as detected by 2 distinct imaging modalities: CBCT and PR (Table 1).

The sex distribution within the study group was relatively balanced. The proportion of male patients (53.3%, n=80) was slightly higher than that of female patients (46.7%, n=70). Examination of the patient age distribution revealed that the largest group consisted of individuals under 30 years of age (38.7%, n=58). This was followed by the 31-50 age group (36.7%, n=55) and the 51-70 age group (24.7%, n=37), respectively. This indicates that the study cohort predominantly comprised younger and middle-aged adults.

The prevalence of pulp stones in incisors evaluated by CBCT was low (6.0%, n=9). In the vast majority of patients (94.0%), no pulp stones were detected in these teeth using CBCT. Similarly, the prevalence of pulp stones in canines detected via CBCT was low (6.0%, n=9). The frequency of pulp stones observed in premolars using CBCT was very low (2.0%, n=3). Pulp stones were absent in premolars in almost all patients (98.0%) upon CBCT examination. The situation was markedly different for molars. The frequency of pulp stones detected in molars via CBCT was considerably high (27.3%, n=41). More than a quarter of the patients exhibited pulp stones in their molar teeth as identified by CBCT.

No pulp stones were detected in incisors using PR evaluation (0.0%, n=0). The frequency of pulp stones detected in canines with PR was very low (1.3%, n=2). Also, the frequency of pulp stones in premolars detected via PR was very low (0.7%, n=1). Although the frequency of pulp stones in molars detected by PR (8.7%, n=13) was higher compared to other tooth groups assessed with this modality, it was markedly lower than the rate identified with CBCT (27.3%). Pulp stones were most frequently observed in molar teeth within this cohort.

The CBCT demonstrated significantly higher sensitivity in detecting pulp stones compared to PR. Specifically, while

Table 2. Association and Distribution Between Patient Sex and Imaging Findings (Presence of Pulp Stones) (n=150)

		CBCT					PR				
		Male		Female			Male		Female		
	Pulp Stones	n	%	n	%	*P	n	%	n	%	*P
Incisor	Absent	76	95.0	65	92.9	.581	80	100.0	70	100.0	
	Present	4	5.0	5	7.1		0	0.0	0	0.0	
Canine	Absent	79	98.8	62	88.6	**.009***	79	98.8	69	98.6	.924
	Present	1	1.3	8	11.4		1	1.3	1	1.4	
Premolar	Absent	79	98.8	68	97.1	.483	79	98.8	70	100.0	.348
	Present	1	1.3	2	2.9		1	1.3	0	0.0	
Molar	Absent	61	76.3	48	68.6	.292	74	92.5	63	90.0	.587
	Present	19	23.8	22	31.4		6	7.5	7	10.0	

CBCT, cone beam computed tomography; PR, panoramic radiograph.
* Chi-square test results and significance levels.

CBCT detected pulp stones in 27.3% of molars, PR detected them in only 8.7%.

In incisors, canines, and premolars, the frequency of pulp stones was low with both imaging modalities; however, PR demonstrated very limited detection capability for pulp stones in these anterior and premolar teeth (yielding 0% detection in incisors).

The interobserver agreement analysis demonstrated excellent reliability between the 2 observers. For CBCT imaging, the Cohen's kappa coefficient was 0.89 (95% CI: 0.82-0.96), indicating excellent agreement. For panoramic radiography, the kappa coefficient was 0.85 (95% CI: 0.76-0.94), also indicating excellent agreement. The high interobserver reliability values confirm the reproducibility of pulp stone detection using both imaging modalities and validate the consistency of the evaluation criteria employed in this study.

Table 2 compares the distribution of pulp stone presence, detected by 2 different imaging modalities (CBCT and PR) across various tooth groups (incisor, canine, premolar, molar), stratified by patient sex within the total study cohort (Table 2). In the assessment using CBCT, a statistically significantly higher prevalence of pulp stones was detected only in canine teeth among female patients compared to males. The presence of pulp stones was statistically significantly more frequent in females (11.4%, n=8) compared to males (1.3%, n=1). No significant sex-based differences were found with CBCT for the other tooth groups (incisor, premolar, molar). Across that, in the assessment using PR, no statistically significant difference in pulp stone prevalence between male and female patients was detected for any of the examined tooth groups. This may indicate a higher propensity for pulp stone formation in canine teeth among females.

The prevalence of pulp stones was similar between male and female patients for the majority of tooth groups and imaging modalities examined. The only statistically significant difference identified was in canine teeth evaluated by CBCT, where female patients exhibited a significantly higher frequency of pulp stones compared to male patients. For all other tooth groups (incisor, premolar, molar) and across both imaging techniques (CBCT and PR), no significant sex-based differences in pulp stone prevalence were detected. Notably, even for molar teeth, where pulp stones were most frequently observed, the detection rates via CBCT did not differ significantly between sexes. Sex does not have a pronounced overall influence on pulp stone prevalence, though there may be a specific, higher tendency in canine teeth among females.

These findings suggest that CBCT, being a more sensitive method, was able to reveal the sex difference in canine teeth, whereas PR, due to its generally lower sensitivity, failed to detect this difference (and potentially other minor differences in other tooth groups). Overall, the absence of a clear sex

Table 3. Association and Distribution Between Patient Age Groups and Imaging Findings (Presence of Pulp Stones) (n=150)

		CBCT							PR						
		Age <30		Age 31-50		Age 51-70			Age <30		Age 31-50		Age 51-70		
	Pulp Stones	n	%	n	%	n	%	*P	n	%	n	%	n	%	*P
Incisor	Absent	57	98.3	50	90.9	34	91.9	.212	58	100.0	55	100.0	37	100.0	
	Present	1	1.7	5	9.1	3	8.1		0	0.0	0	0.0	0	0.0	
Canine	Absent	54	93.1	50	90.9	37	100.0	.185	56	96.6	55	100.0	37	100.0	.201
	Present	4	6.9	5	9.1	0	0.0		2	3.4	0	0.0	0	0.0	
Premolar	Absent	57	98.3	53	96.4	37	100.0	.466	58	100.0	54	98.2	37	100.0	.419
	Present	1	1.7	2	3.6	0	0.0		0	0.0	1	1.8	0	0.0	
Molar	Absent	44	75.9	36	65.5	29	78.4	.309	53	91.4	50	90.9	34	91.9	.986
	Present	14	24.1	19	34.5	8	21.6		5	8.6	5	9.1	3	8.1	

CBCT, cone beam computed tomography; PR, panoramic radiograph.
*Chi-square test results and significance levels.

difference with either method, even in molar teeth where pulp stones are more common, suggests that sex may not be a major risk factor for pulp stone formation, although there might be a slight predisposition in females specifically for canine teeth.

Table 3 compares the distribution of pulp stone presence, detected via 2 different imaging modalities (CBCT and PR) across various tooth groups (incisor, canine, premolar, molar), by stratifying the study participants into 3 distinct age groups (Table 3). There were no statistically significant differences in the prevalence of pulp stones among the examined age groups (<30, 31-50, and 51-70 years) for any of the tooth groups (incisor, canine, premolar, molar) when evaluated by either CBCT or PR. Although numerical trends suggested a slightly higher prevalence of pulp stones in the middle age group (31-50) for certain tooth groups (e.g., CBCT molar), these differences failed to reach statistical significance. These findings corroborate the previous combined analysis and strongly indicate that within the age range encompassed by this study (up to 70 years), age does not exert a statistically significant influence on the prevalence of pulp stone formation, or at least such an effect was not detectable with the employed methods and sample size. Considering the general literature suggesting an increase in pulp stone prevalence with age, it might be postulated that the age range in this study (particularly the lack or low number of individuals above 70 years) was insufficient to reveal this association, or that factors other than age were more influential in this specific population.

Table 4 compares the detection rates of pulp stones in different tooth types (incisor, canine, premolar, molar) within the same patient group (n=150) using 2 distinct imaging modalities (Table 4). The detection rate of pulp stones in incisors differed significantly between the 2 methods. While CBCT detected pulp stones in 6.0% (n=9) of patients, no pulp stones were identified with PR (0.0%, n=0). This clearly demonstrates that CBCT is significantly more sensitive than PR in detecting pulp stones in incisor teeth.

Table 4. Association and Distribution Between Imaging Modalities (CBCT vs. PR) and Imaging Findings (Presence of Pulp Stones) (n=150)

	Pulp Stones	CBCT		PR		*P
		n	%	n	%	
Incisor	Absent	141	94.0	150	100.0	**.002**
	Present	9	6.0	0	0.0	
Canine	Absent	141	94.0	148	98.7	**.032**
	Present	9	6.0	2	1.3	
Premolar	Absent	147	98.0	149	99.3	.314
	Present	3	2.0	1	0.7	
Molar	Absent	109	72.7	137	91.3	**.001**
	Present	41	27.3	13	8.7	

CBCT, cone beam computed tomography; PR, panoramic radiograph.
*Chi-square test results and significance levels.

The detection rate of pulp stones in canine teeth also showed a significant difference between the 2 methods. Pulp stones were found in 6.0% (n=9) of patients with CBCT, whereas this rate was only 1.3% (n=2) with PR. This statistically significant difference indicates the superiority of CBCT over PR in detecting pulp stones in canine teeth as well.

A highly significant difference was observed between the 2 methods regarding the detection rate of pulp stones in molar teeth. The CBCT identified pulp stones in 27.3% (n=41) of patients, compared to only 8.7% (n=13) with PR. This substantial difference very clearly reveals that CBCT possesses markedly higher sensitivity compared to PR in detecting pulp stones in molar teeth. The PR misses a significant portion of pulp stones present in molars.

This analysis clearly demonstrates significant differences between the imaging modalities used for pulp stone detection. The CBCT, providing 3-dimensional imaging, was found to be statistically significantly more sensitive (superior) compared to PR, which provides 2-dimensional panoramic imaging, particularly in detecting pulp stones in incisor, canine, and molar teeth. The most pronounced difference emerged in molar teeth, where pulp stones are most commonly found; CBCT detected more than 3 times the number of pulp stones identified by PR. Panoramic radiograph largely overlooks pulp stones, especially in incisor and canine teeth. Only in premolars, likely due to the very low intrinsic prevalence of pulp stones, was no significant difference detected between the methods. These findings strongly support the conclusion that CBCT is a much more reliable method than PR for the accurate diagnosis and determination of the prevalence of pulp stones. The choice of imaging modality in clinical decision-making and research studies should be evaluated in light of these results.

DISCUSSION

This retrospective study presents a detailed comparative analysis of pulp stone detectability in mandibular teeth using CBCT and PR. It simultaneously examines demographic variables such as sex and age to highlight the diagnostic advantages of CBCT and the complex etiology of pulp stone in a Turkish population. The CBCT demonstrated notably higher detection rates, especially in molars and anterior teeth, areas where PR frequently underperformed. A noteworthy finding was the sex-related difference in detecting pulp stones in canines, favoring females as identified by CBCT.

The substantial discrepancy in pulp stone detection—27.3% in molars with CBCT versus 8.7% with PR—underscores the limitations of 2-dimensional imaging. This observation aligns with previous research (2) confirming CBCT's ability to visualize pulp stones obscured by overlapping structures or limited contrast. Similarly, Lin[13] reported elevated detection in Taiwan (31.3%), and Krikštopaitis[14] observed a prevalence of 35.24% in Lithuania using high-resolution intraoral imaging.

Panoramic radiograph-based studies show markedly lower detection rates. For example, Al-Habshi[15] in Yemen reported 3.99% per tooth, Sandeepa[16] in India found 1.45%, and Ranjitkar[11] in Australia observed 10.1%. These figures mirror the PR data and reinforce how imaging choice impacts reported prevalence.

A within-subject design was employed to compare CBCT and PR images in 150 patients, focusing exclusively on the mandibular arch. This approach enabled direct comparisons across modalities and demographic groups while reducing variability. In contrast, prior studies often relied on single-modality or mixed-arch data. For instance, Mian[12] and Patil[17] used CBCT for broader evaluations but lacked intra-individual comparisons with PR. Sezgin[18] focused on restoration-related findings using CBCT but did not include PR, precluding cross-method analysis.

Krikštopaitis[14] utilized quadrant-focused bitewing and periapical radiographs, limiting generalizability. The full-arch mandibular approach provides a more inclusive view. Alharthi et al[19] and Lin[13] used PR and CBCT images, respectively; however, Ranjitkar[11] reported a 10.1% prevalence in Australia, and Sandeepa[16] noted 1.45% using PR imaging in India. Al-Habshi[15] found a 3.99% prevalence in Yemen, while Mian[12] reported 98.3% using CBCT in Saudi Arabia—highlighting dramatic sensitivity differences across methods. These findings emphasize how diagnostic technique, anatomical focus, and demographic structure shape prevalence outcomes. The study's within-subject and mandibular-only design offers precise comparison not commonly found in the literature.

Molars were the most frequently affected teeth across nearly all populations.[14] This is expected due to their large pulp chambers and complex morphology, which increase the likelihood of pulp stones. The findings were consistent with global trends. Although anterior teeth showed lower prevalence, CBCT uncovered pulp stones often missed by PR—proving CBCT's clinical value in subtle diagnostics.

The role of sex remains controversial. The results showed a significantly higher incidence of pulp stones in female canines (11.4%) compared to males (1.3%), in line with studies by Çolak[2] and Lin.[13] Others, like Sezgin,[18] found no sex-based difference, suggesting possible regional or hormonal factors.

While age is often considered a contributor to pulp stones, the findings were not statistically significant—though a minor increase was noted in the 31-50 age group. This partially matches Sandeepa[16] and diverges from Sezgin,[18] who reported stronger age-related trends. The relatively small sample size of elderly patients may account for the results.

When compared globally, the CBCT-based molar prevalence (27.3%) is slightly below Taiwan (31.3%)[13] and Lithuania (35.24%),[14] and higher than Australia (10.1%),[11] India (1.45%),[16] and Yemen (3.99%).[15] Mian et al[12] observed a remarkably high prevalence of 98.3% per arch using CBCT in Saudi Arabia, highlighting how study design—particularly arch-level versus tooth-level focus—affects outcomes. The PR findings (8.7%) align with Ranjitkar[11] (10.1%) and Alharthi et al[19] (14.7%). Meanwhile, studies using bitewing or periapical images, such as Krikštopaitis,[14] generally showed higher tooth-level prevalence due to improved resolution.

The methodology of the present study aligns with a range of prior investigations in terms of retrospective design and use of radiographic modalities to assess the prevalence of pulp stones. Consistent with prior reports from Çolak et al,[2] Kalaji et al,[15] and Sandeepa et al;[16] the current research employed large sample sizes, anatomical classification of teeth, and demographic stratification by age and gender.

What differentiates the current study is its comparative use of 2 diagnostic modalities: panoramic radiography and CBCT. While the aforementioned studies relied on a single radiographic method, the study juxtaposes both, offering a direct comparative assessment of their diagnostic efficacy. This is particularly relevant given the increasing incorporation of CBCT into endodontic diagnostics, as discussed in Hsieh et al[19] and Mirah et al.[20]

Moreover, in contrast to studies that analyzed both arches (e.g., Sadoon et al;[21] Ranjitkar et al[11]), the study focused exclusively on the mandibular region, enhancing localized anatomical interpretation. Unlike Kalaji et al[15] and Ranjitkar et al,[11] who excluded restored teeth to reduce potential imaging artifacts, the present methodology reflects real-world diagnostic complexity by including all teeth irrespective of restorations. This integrative and comparative approach not only strengthens the diagnostic relevance of the findings but also emphasizes the superiority of CBCT in clinical settings where accurate pulp stone detection is critical.

Several limitations should be acknowledged in this study. First, the retrospective design inherently limits the control over imaging parameters and patient selection criteria. The images were acquired for various clinical purposes, which may have resulted in variations in image quality and positioning that could affect pulp stone detection sensitivity. Second, the study population was limited to a specific geographic region (Turkish population), which may limit the generalizability of findings to other ethnic groups or populations with different genetic backgrounds and dietary habits.

Third, the age distribution of the study cohort was skewed toward younger and middle-aged adults, with a limited representation of elderly patients (>70 years). This age distribution may have influenced the observed lack of statistically significant age-related differences in pulp stone prevalence.

Fourth, the study did not differentiate between true and false pulp stones, as histological confirmation was not feasible due to the retrospective nature of the study. Additionally, the minimum size threshold for pulp stone detection was not standardized, which may have introduced variability in the detection criteria.

Fifth, the study focused exclusively on mandibular teeth, limiting the comprehensiveness of pulp stone prevalence assessment. The exclusion of maxillary teeth may provide an incomplete picture of overall pulp stone distribution in the oral cavity. Finally, the study did not account for potential confounding factors such as systemic diseases, medications, or specific dental treatments that might influence pulp stone formation, which could have provided additional insights into the etiology of pulp stones.

While this study demonstrates the superior diagnostic capability of CBCT over panoramic radiography for pulp stone detection, the cost-effectiveness of CBCT implementation in clinical practice must be carefully considered. The CBCT imaging involves higher costs compared to conventional 2-dimensional radiography, including equipment acquisition, maintenance, operator training, and increased radiation exposure to patients. The decision to use CBCT should be based on a risk-benefit analysis that considers the clinical significance of pulp stone detection for treatment planning.

The enhanced diagnostic accuracy of CBCT may be particularly cost-effective in complex endodontic cases where precise knowledge of pulp stone location and size is critical for treatment success.[22] Early identification of pulp stones can prevent complications during root canal procedures, potentially reducing treatment time, the need for retreatment, and associated costs.[23] However, for routine dental examinations or simple endodontic cases, the additional cost and radiation exposure associated with CBCT may not be justified solely for pulp stone detection.

Healthcare providers should consider implementing CBCT selectively, prioritizing its use in cases where pulp stones are suspected clinically or when conventional radiography provides inconclusive results. Future cost-effectiveness studies comparing treatment outcomes and economic implications of CBCT-guided versus conventional radiography-guided endodontic treatment would provide valuable insights for evidence-based clinical decision-making in pulp stone management.

CONCLUSION

This study substantiates the diagnostic superiority of CBCT over panoramic radiography in the detection of pulp stones, particularly in mandibular molars and anterior teeth. Through a within-subject design applied to 150 patients, this research provides high-resolution evidence of CBCT's enhanced sensitivity and clinical relevance. The significant discrepancy in detection rates—27.3% with CBCT versus 8.7% with PR—reinforces the notion that 2-dimensional imaging may lead to underdiagnosis, particularly in complex anatomical regions.

Cone beam computed tomography's ability to identify pulp stones that may be obscured in PRs ensures greater diagnostic accuracy and informs more effective endodontic treatment planning. Additionally, the observed sex-specific distribution, notably higher detection in female canines, adds to the understanding of pulp stone's demographic influences. Although age was not a statistically significant variable, the prevalence pattern in the 31-50 age group warrants further longitudinal research.

Overall, this study highlights the value of using CBCT in cases where precise pulpal visualization is clinically indicated. The within-subject methodology and mandibular-specific focus contribute meaningfully to the literature and set a precedent for future diagnostic studies.

The integration of artificial intelligence (AI) and machine learning algorithms represents a promising avenue for improving pulp stone detection accuracy in conventional radiography. Recent pilot studies by Altındağ et al[24, 25] have demonstrated the potential of automatic deep learning systems for pulp stone detection in both bitewing and PR. These AI-assisted approaches may help bridge the diagnostic gap between conventional 2-dimensional imaging and CBCT, potentially offering enhanced detection capabilities while maintaining cost-effectiveness and reduced radiation exposure. Further research into AI-augmented imaging analysis could complement the findings of this study by optimizing the diagnostic utility of existing imaging modalities.

Data Availability Statement: The data that support the findings of this study are available on request from the corresponding author.

Ethics Committee Approval: Ethical committee approval was received from the Ethics Committee of University of Çanakkale Onsekiz Mart University (Approval no: 2025-07/07-23; Date: 17.04.2025).

Informed Consent: Written informed consent was obtained from all patients prior to inclusion in the study.

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