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Prevalence of mineralization in the pulp chamber in patients according to CBCT data

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Abstract
INTRODUCTION. Pulp calcifications, first described as denticles by Norman and Johnson in 1921, are classified as pulp stones, calcifications, or obliterations of the tooth cavity. These conditions are often asymptomatic and detectable only by imaging, with cone-beam computed tomography (CBCT) offering high-resolution, three-dimensional visualization. Pulp canal calcifications complicate endodontic treatment by increasing the risk of perforation and making canal negotiation difficult. Although various etiological factors have been proposed – including aging, genetics, trauma, restorations, and systemic conditions – the exact causes remain unclear. Data on the prevalence of pulp calcifications in the Russian Federation, particularly in the Northwest region, are currently lacking.
AIM. This study aimed to retrospectively investigate the occurrence of pulp canal obliteration and calcific deposits within the tooth cavity through cone-beam computed tomography (CBCT) analysis.
MATERIALS AND METHODS**.** The study included 102 patients (3078 teeth) aged 18 to 65 years. When evaluating the CBCT results, the presence of calcifications and obliteration of the pulp chamber were taken into account. The prevalence of these lesions was analyzed depending on gender, age, tooth type, dental status and periodontal diseases. The median and interquartile range were used to describe the quantitative data. Comparison of quantitative variables was performed using the nonparametric Kruskal-Wallis and Mann-Whitney tests. Categorical variables are presented as absolute values and percentages and their comparison was performed using Fisher's exact test or the Chi-squared test. The nonparametric Spearman rank correlation test was used to assess the correlation. The statistical significance of differences was accepted at $p < 0.05$.
RESULTS. Calcifications were detected in 63 (61.76%) patients in 276 (8.96%) teeth. Obliteration of the pulp chamber was detected in 86 (84.31%) patients in 445 (14.46%) teeth. A statistically significant positive correlation was found between age and obliteration of the pulp chamber ($r = 0.44$; p-value < 0.001), as well as the amount of calcifications ($r = 0.24$; p-value $= 0.015$). Analysis of cases of obliteration and calcifications depending on gender, the presence or absence of periodontal diseases, and dental status did not reveal statistically significant differences.
CONCLUSIONS. Calcifications and obliteration of pulp chamber were found in more than half of the patients. Their number increases with age, and in women occurs more often than in men. They were most often detected in the first molars. For a dentist, data on the prevalence of calcifications and mineralization of pulp chamber are one of the key aspects for planning high-quality root canal treatment.

Keywords: calcifications, denticles, obliteration of the pulp chamber, CBCT

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Распространенность минерализации в полости зуба по данным конусно-лучевой компьютерной томографии

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Резюме
ВВЕДЕНИЕ. Кальцификаты пульпы, впервые описанные как дентикли Норманом и Джонсоном в 1921 г., классифицируются как пульпарные камни, кальцификаты или облитерация полости зуба. Эти состояния часто протекают бессимптомно и выявляются только с помощью методов лучевой диагностики, при этом конусно-лучевая компьютерная томография (КЛКТ) обеспечивает получение высококачественных трехмерных изображений с высоким разрешением. Кальцификация каналов пульпы осложняет проведение эндодонтического лечения, повышая риск перфорации и затрудняя прохождение каналов. Хотя были предложены различные этиологические факторы, включая старение, генетическую

предрасположенность, травму, реставрации и системные заболевания, точные причины их возникновения остаются неясными. Данные о распространенности кальцификатов пульпы в Российской Федерации, в частности в Северо-Западном регионе, в настоящее время отсутствуют.
ЦЕЛЬ. Провести ретроспективный анализ наличия облитерации и кальцификатов в полости зуба по данным конусно-лучевой компьютерной томографии (КЛКТ).
МАТЕРИАЛЫ И МЕТОДЫ. В исследование были включены 102 пациента (3078 зубов) в возрасте от 18 до 65 лет. При оценке результатов КЛКТ учитывалось наличие кальцификатов и облитерации полости зуба. Был произведен анализ распространенности данных образований в зависимости от пола, возраста, типа зуба, стоматологического статуса и заболеваний пародонта. Для описания количественных данных использовались медиана и межквартильный размах. Сравнение количественных переменных выполнялось с использованием непараметрических критериев Краскела-Уоллиса и Манна-Уитни. Категориальные переменные представлены в виде абсолютных значений и процентов, их сравнение осуществлялось с помощью точного критерия Фишера или критерия хи-квадрат. Для оценки корреляции использовали непараметрический критерий ранговой корреляции Спирмена. Статистическая значимость различий принималась при уровне $p < 0.05$.
РЕЗУЛЬТАТЫ. Кальцификаты выявлены у 63 (61,76%) пациентов в 276 (8,96%) зубах. Облитерация полости зуба обнаружена у 86 (84,31%) пациентов в 445 (14,46%) зубах. Выявлена статистически значимая положительная корреляционная зависимость между возрастом и облитерацией полости зуба ($r = 0,44$; p-value < 0,001), а также суммой кальцификатов ($r = 0,24$; p-value = 0,015). Анализ случаев обнаружения облитерации и кальцификатов в зависимости от пола, наличия или отсутствия заболеваний пародонта, от стоматологического статуса статистически значимых различий не выявил.
ВЫВОДЫ. Кальцификаты и облитерация полости зуба были обнаружены больше, чем у половины пациентов. Их количество увеличивается с возрастом, причем у женщин чаще, чем у мужчин. Чаще всего выявлялись в первых молярах. Для врача-стоматолога данные о распространенности кальцификатов и облитерации полости зуба являются одним из ключевых аспектов для планирования качественного лечения корневых каналов.

Ключевые слова: кальцификаты, дентикли, облитерация полости зуба, КЛКТ

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INTRODUCTION

Pulp calcifications were first identified as dental pulp nodules by Norman and Johnson in 1921 and later termed “denticles” [1]. The earliest report of internal calcification within the pulp of permanent teeth was presented by S. James A. Salter in 1856 [2]. Today, this process is well-documented in the scientific literature and classified as pulp stones, calcifications, denticles, or partial to complete obliteration of the tooth cavity [3; 4].

Narrowing of the pulp cavity and the presence of calcifications often do not cause pulp disease or clinical symptoms and are typically diagnosed only by radiographic imaging. Cone-beam computed tomography (CBCT) has gained increasing popularity for detecting denticles and obliterations due to its high sensitivity, ability to eliminate the problem of overlapping structures, and capacity to provide high-resolution images in axial, coronal, and sagittal planes [5].

Conventional endodontic treatment in the presence of obstructions such as calcifications or severely obliterated canals significantly increases the risk of treatment failure [6]. Management of root canals affected by pulp calcifications and obliteration poses significant challenges for clinicians, including the risk of perforating the pulp chamber floor during removal attempts, difficulty in locating canal orifices, and challenges in negotiating and preparing the canals to their full working length [7].

Multiple etiological factors have been proposed for the formation of pulp calcifications and narrowing of the pulp cavity, including aging, genetic predisposition, prolonged exposure to irritants (such as caries, large restorations, chronic inflammation, and attrition), orthodontic tooth movement, trauma, periodontal disease, use of certain medications (e.g., statins), anemia, atherosclerosis, acromegaly, and Marfan syndrome. However, the exact causes remain unknown and widely debated [8; 9].

No statistical data on the prevalence of this condition in the Russian Federation, and particularly in the Northwestern region, were found in the available literature.

AIM

To conduct a retrospective analysis of the presence of obliteration and calcifications within the tooth cavity based on cone-beam computed tomography (CBCT) data.

MATERIALS AND METHODS

We present the results of a retrospective radiographic analysis of patients examined at the Clinic of the Research Institute of Dentistry and Maxillofacial Surgery of Pavlov First Saint Petersburg State Medical University (Pavlov University). The study design was a retrospective observational analysis. CBCT data obtained from 2016 to 2024 were evaluated.

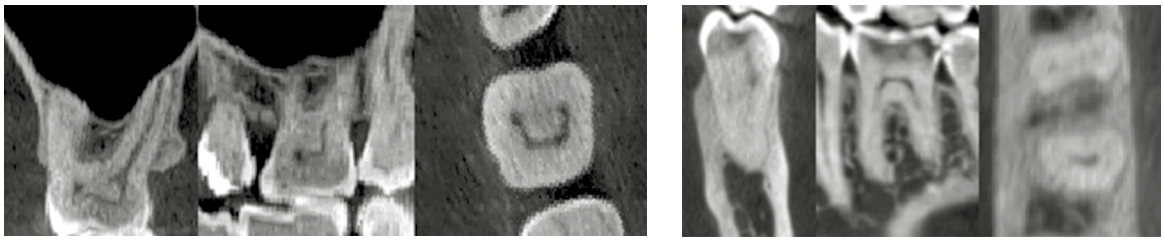

Fig. 1. CBCT-image (axial, frontal, sagittal view): A – maxilla first molar with calcification; *B* – mandible first molar with partial obliteration

Рис. 1. КЛКТ-изображение (аксиальная, фронтальная, сагиттальная плоскость): *А* – первого моляра верхней челюсти с кальцификатом; *В* – нижнего первого моляра с частичной облитерацией

Inclusion criteria: patients aged 18–65 years; high-quality CBCT images; teeth with fully developd roots. Exclusion criteria: teeth with filled root canals, post-retained restorations, root resorption, poor image quality, or CBCT scans with artifacts.

The study included data from 102 patients (3078 teeth), aged between 18 and 65 years (mean age: 32.86 ± 9.56 years), of whom 61 were female (59.8%) and 41 were male (40.2%). The total number of teeth evaluated in occlusion was 2981.

CBCT scans were performed using a PLANMECA Pro Max 3D Mid (Finland), serial number TFMP10327, with the following settings: continuous scan mode of 12.001 seconds, image size of 8.0 × 5.0 cm, and voxel size of 200 µm.

The presence of calcifications and obliteration within the tooth cavity was assessed in sagittal, axial, and coronal planes of the CBCT images. A tooth was classified as having calcifications if one or more radiopaque structures larger than 200 µm were detected in the pulp chamber. Obliteration was defined as partial or complete closure of the pulp cavity space (Fig. 1).

The following parameters were recorded and analyzed: patient age and sex, dental status, and periodontal disease.

Statistical analysis was performed using R software, version 4.4.1. Quantitative data were described using the median (Me) and interquartile range (IQR). Comparisons of continuous variables were conducted using non-parametric Kruskal-Wallis and Mann-Whitney U tests. Categorical variables were presented as absolute numbers and percentages; their comparisons were performed using Fisher's exact test or the chi-squared test, as appropriate.

Spearman's rank correlation coefficient was used to assess correlations between variables. Statistical significance was set at $p < 0.05$.

RESULTS

According to the CBCT data, denticles were detected in 63 patients (61.76%) and in 276 teeth (8.96%). Pulp cavity obliteration was identified in 86 patients (84.31%) and in 445 teeth (14.46%).

Seventeen patients (16.7%) showed no evidence of either calcifications or obliteration. In 22 patients (21.6%), only pulp cavity obliteration was observed.

Thus, obliteration of the pulp cavity was found more frequently than calcifications–84.31% vs. 61.76% in the patient group and 14.46% vs. 8.96% in the total number of teeth examined.

These findings were supported by correlation analysis, which revealed a positive correlation between obliteration and denticle presence with a statistically significant level of $p \leqslant 0.001$ (Spearman's $r = 0.68$).

The mean age of male and female patients did not differ significantly (females: 33 ± 11 years; males: 31 ± 7 years). Correlation analysis confirmed an age-related increase in pulp cavity obliteration in both males ($p < 0.05$) and females ($p < 0.001$), with a stronger correlation observed in the female group (Fig. 2).

According to the results of the correlation analysis, age showed a moderate positive correlation with pulp cavity obliteration ($r = 0.44$; $p < 0.001$) and a weak positive correlation with the total number of calcifications ($r = 0.24$; $p = 0.015$) (Table 1).

Calcifications were most frequently detected (⩾30%) in the first molars of both the maxilla and mandible. They were slightly less common (18–25%) in the second molars of both jaws (Fig. 3).

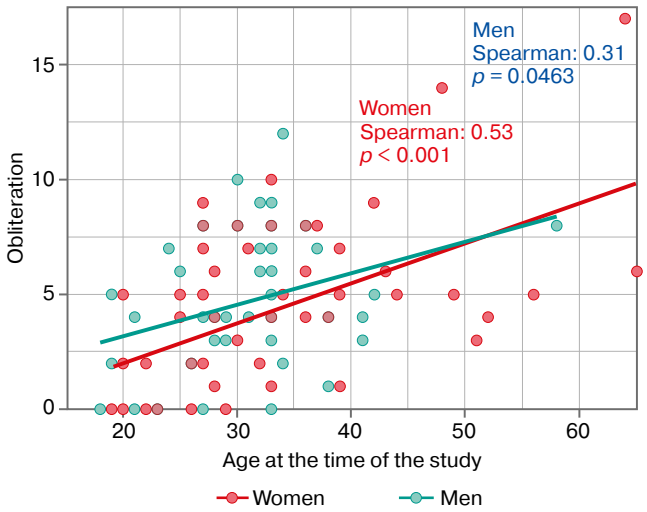

Fig. 2. Correlation between obliteration of the pulp chamber and age

Рис. 2. Корреляция между облитерацией полости зуба и возрастом

The frequency of calcification detection between the maxilla and mandible showed no statistically significant differences, although a trend toward a higher prevalence in maxillary teeth was observed (53.3% vs. 46.7%). No statistically significant differences were found between the right and left sides; however, teeth on the right side were slightly more frequently affected (52.2 vs. 47.8%).

The analysis of tooth topography with pulp cavity obliteration yielded results similar to those observed for teeth with calcifications. As shown in the diagram (Fig. 4), pulp cavity obliteration was most frequently detected (⩾55%) in the first molars of both the maxilla and mandible. It was somewhat less common, occurring at a frequency of 30–40%, in the second molars of both jaws.

No statistically significant differences were found in the presence of pulp cavity obliteration between maxillary and mandibular teeth, or between the right and left sides (Fig. 4).

A correlation analysis was conducted to assess the relationship between pulp calcifications and obliteration with the patients' dental status. The results of the analysis examining the association of calcifications and pulp cavity obliteration with the DMFT (Decayed, Missing, and Filled Teeth) index are presented in Table 2.

No statistically significant correlations were found between pulp calcifications or obliteration and the DMFT index, caries, or the number of dental restorations; all correlations were negative.

Periodontal disease was diagnosed in 91 patients. Among them, 44 patients had periodontitis of varying severity and 47 patients had periodontosis of varying severity. The degree of severity for periodontitis and periodontosis was not considered in the analysis (Table 3).

The analysis of pulp cavity obliteration and the total number of denticles among patient groups without periodontal disease, with periodontitis, and with periodontosis revealed no statistically significant differences.

Table 1. Mean value of calcifications and mineralization in groups of men and women

Таблица 1. Средние значения кальцификатов и облдитерации в группах мужчин и женщин

Values	Females $n = 61$	Males $n = 41$	p (Wilcoxon rank-sum test)
	Mean ± SD; Median (IQR)		
Calcifications	2.62±2.94 2.00 (0.00; 5.00)	2.83±2.97 3.00 (0.00; 4.00)	0.8
Obliteration	4.26±3.44 4.00 (2.00; 6.00)	4.68±3.09 4.00 (3.00; 7.00)	0.4

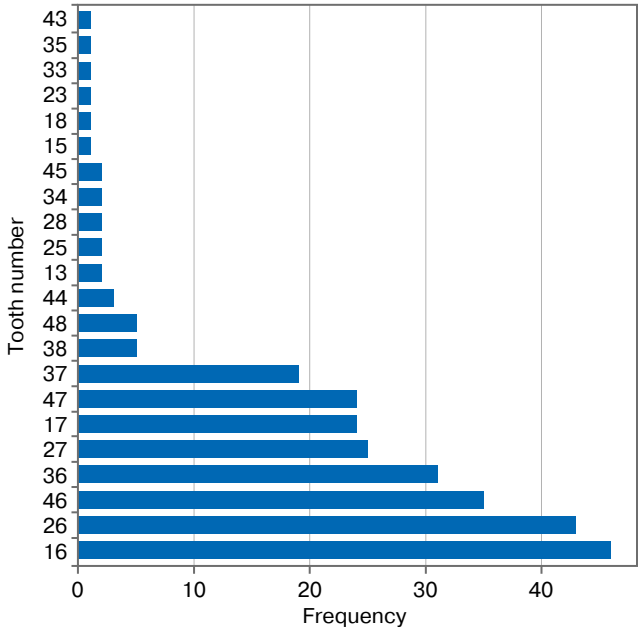

Fig. 3. Frequency of detection of calcifications

Рис. 3. Частота выявления кальцификатов в зубах

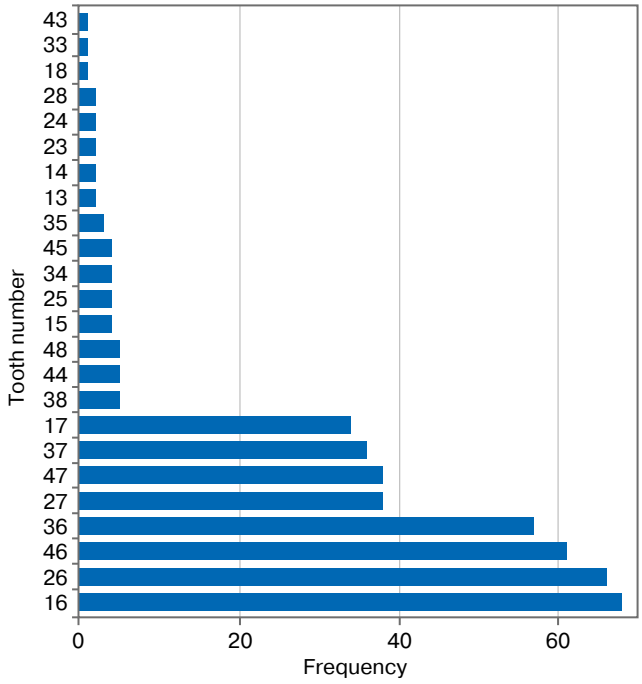

Fig. 4. Frequency of detection of obliteration

Рис. 4. Частота выявления облитерации в зубах верхней и нижней челюсти

Table 2. Spearman correlation coefficient values and statistical significance of differences

Таблица 2. Значения коэффициента корреляции Спирмена (r) и статистическая значимость различий

Values		DMFT index	Caries	Restoration	Caries + restoration
Denticles	r	−0.16	−0.023	−0.11	−0.177
	p	0.119	0.81	0.26	0.092
Obliteration	r	−0.063	−0.095	−0.041	−0.055
	p	0.532	0.343	0.68	0.584

Table 3. Average calcification and obliteration rates in two group of patients

Таблица 3. Средние показатели кальцификатов и облитерации в группах пациентов

Characteristics	Without periodontal disease *n* = 11	Periodontitis *n* = 44	Periodontosis *n* = 47	*p* (Wilcoxon rank-sum test)
	Mean ± SD; Median (IQR)			
Obliteration	3.09 ± 3.05; 2.00 (1.00; 4.00)	5.05 ± 3.39; 5.00 (3.00; 7.00)	4.17 ± 3.21; 4.00 (2.00; 6.50)	0.13
Sum of calcifications	2.18 ± 2.40; 2.00 (0.00; 4.00)	2.66 ± 3.06; 2.00 (0.00; 4.00)	2.87 ± 2.98; 2.00 (0.00; 5.00)	0.8

However, a trend toward a lower number of pulp cavity obliterations was observed in patients without periodontal disease (3.09 ± 3.05) compared to those with periodontitis (5.05 ± 3.39) and periodontosis (4.17 ± 3.21).

DISCUSSION

In our study, calcifications were found in 8.96% (276 of 3078) of the examined teeth and in 61.76% (63 of 102) of all examined patients. Pulp cavity obliteration was detected in 14.46% (445 of 3078) of teeth and in 84.31% (86 of 102) of patients. Among the patients, pulp cavity obliteration was more common than calcifications (84.31% vs. 61.76%), as was the case among the examined teeth (14.46% vs. 8.96%).

The obtained results are consistent with those reported by other researchers. In the study by M. Tassoker et al., denticles were detected in 7.7% (434 of 5656) of teeth and in 52% (105 of 202) of patients [9]. W. Zhang et al. reported a prevalence of 7.4% of teeth (373 of 5066) and 49.0% of patients [10]. L. M. Kenawi et al. observed a higher prevalence of calcifications: 15.92% (1644 of 10,326) of teeth and 78.97% (308 of 390) of patients [11].

Pulp cavity obliteration generally increases with age, and it has been reported that approximately 90% of individuals aged 50 years and older exhibit varying degrees of pulp calcification [12]. Age is considered the most significant factor for pulp cavity obliteration due to the progressive deposition of secondary and tertiary dentin, which leads to a reduction in the size of the pulp chamber [13].

In our study, a statistically significant positive correlation was found between age and pulp cavity obliteration ($r = 0.44$; $p < 0.001$) as well as the total number of calcifications ($r = 0.24$; $p = 0.015$), with a stronger correlation observed for obliteration. The correlation between age and obliteration was more pronounced in females ($p < 0.001$) than in males ($p < 0.05$).

Our findings are consistent with the results reported by S.S. Zahran and R.A. Alamoudi, who found that pulp cavity obliteration was most common in individuals over the age of 40 [3]. However, studies by A. Alsweed et al. and R.A. Alamoudi et al. reported a higher prevalence of calcifications in younger patients, which may be explained by the inclusion of dental patients with systemic diseases in their study samples [14; 15].

In accordance with our data, no statistically significant gender differences were found in the prevalence of either calcifications or pulp cavity obliteration. These findings align with the conclusions of M. Tassoker et al., N. Yemenoğlu et al., and S.S. Zahran and R.A. Alamoudi, who also did not observe gender-related differences in the prevalence of denticles and pulp cavity obliteration [3; 9; 16]. However, studies by W. Zhang et al. and G.P. Sezgin et al. reported a significantly higher prevalence of denticles in females, with gender identified as a risk factor [10; 17].

The conflicting results across studies may be attributed to geographic differences, cultural factors, variations in imaging techniques, and differences in study sample characteristics.

The results of our study confirmed the widely recognized observation that pulp cavity obliteration and pulp calcifications are most frequently detected in the first and second molars. No statistically significant differences were found between the maxilla and mandible, although a trend toward a higher prevalence of denticles in the maxilla was noted (53.3 vs. 46.7%). No differences were detected between the right and left sides of the jaws.

Other studies have reported a statistically significant predominance of calcifications in maxillary teeth [17–19]. Mirah et al. and F. Tunç et al. found that denticles occurred more frequently on the right side [18; 20], which may be associated with the preferential use of the right-side during mastication.

In our study, negative correlations between pulp cavity obliteration, calcifications, and the DMFT index and its components were not statistically significant. Similarly, S. Ravanshad et al. reported no relationship between the condition of the tooth crown and the presence of pulp calcifications [21]. However, F. Tunç et al. observed a higher frequency of calcifications in teeth with intact crowns compared to restored or carious teeth [20], which supports our findings of negative correlations and suggests that irritation is not a primary factor in pulp calcification.

Conversely, other studies have reported statistically significant associations between crown condition and pulp calcification [9; 22]. da Silva et al. noted that calcifications were more common in teeth with restorations placed for deep caries [23], and Sezgin et al. reported a higher incidence in teeth with moderately deep

restorations [17]. S.S. Zahran and R.A. Alamoudi found an association between caries and the type of calcification ($p = 0.013$), but not with restoration status [3].

The periodontium and pulp are closely linked structures that interact physiologically through various pathways and pathologically through cracks and fractures. While the impact of pulp pathology on periodontal tissues is well recognized, the reverse relationship remains unclear and controversial [24].

In our study, patients without periodontal disease exhibited only a trend toward lower pulp cavity obliteration (3.09 ± 3.05) compared to patients with periodontitis (5.05 ± 3.39) and periodontosis (4.17 ± 3.21).

A radiographic study by V. Nissrin et al. also found no association between attachment loss and pulp cavity calcifications [22]. Similarly, A.S. Alqahtani reported no association between periodontitis and denticles using logistic regression and multivariate odds ratio adjustment [24]. S.S. Zahran and R.A. Alamoudi reported that most teeth with denticles (76%) or obliteration (93%) had healthy, intact periodontium [3].

These results are consistent with the histological study of Sabeti et al., which compared 35 intact teeth extracted due to severe bone loss with teeth extracted for orthodontic reasons. The authors concluded that severe periodontitis had no significant effect on pulp vitality or calcification [25].

However, opposing results were reported by M. Kuzekanani et al., who found a correlation between attachment loss and pulp calcification [26], and by N. Yemenoğlu et al., who in a retrospective radiographic study observed an association between periodontitis severity and the presence of denticles [16].

CONCLUSION

1. Denticles were detected in 8.96% (276 of 3078) of examined teeth and in 61.76% (63 of 102) of patients. Pulp cavity obliteration was found in 14.46% (445 of 3078) of teeth and in 84.31% (86 of 102) of patients. Obliteration was more prevalent than calcifications both at the patient level (84.31% vs. 61.76%) and at the tooth level (14.46% vs. 8.96%).

2. A statistically significant positive correlation was established between age and pulp cavity obliteration ($r = 0.44$; $p < 0.001$) as well as the total number of calcifications ($r = 0.24$; $p = 0.015$). The correlation between age and obliteration was stronger, with females showing a more pronounced correlation than males ($p < 0.001$ vs. $p < 0.05$).

3. Pulp cavity obliteration and calcifications were most frequently observed in the first and second molars. A slight trend toward a higher prevalence of denticles in the maxilla (53.3 vs. 46.7%) was noted, with no significant differences between the right and left sides of the jaws.

4. The analysis of obliteration and calcifications in relation to periodontal disease and dental status showed no statistically significant differences. A non-significant trend toward lower obliteration rates was observed in patients without periodontal disease (3.09 ± 3.05) compared to those with periodontitis (5.05 ± 3.39) and periodontosis (4.17 ± 3.21).

In clinical dental practice, it is essential to recognize the presence of calcifications and obliterations through radiographic imaging and to understand their prevalence and patterns for the optimal planning of high-quality endodontic treatment.

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