Original Research

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Changes in the dentin-pulp complex of teeth through the prism of CBCT-studies: A retrospective analysis

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Abstract

INTRODUCTION. Calcifying metamorphosis and obliteration of the pulp chamber often complicate endodontic treatment, requiring the use of modern visualization and monitoring techniques during therapy.
The application of CBCT diagnostics allows for a better assessment of the condition of the dentin-pulp complex, which helps reduce risks and increase the effectiveness of complex endodontic treatment.
AIM. To conduct a statistical assessment of the prevalence of degenerative changes in the dentin-pulp complex of teeth based on data obtained from CBCT studies, as well as to identify possible correlational relationships between potential factors contributing to the development of calcifying metamorphosis in the pulp space of vital teeth.
MATERIALS AND METHODS. For the retrospective analysis, 187 archival CBCT study data were selected. The obtained images were examined in all planes for the presence of discrete radiopaque masses in the radiolucent pulp space of the teeth, while the obliteration of the root pulp was determined based on the narrowing or complete closure of the root canal space visible on the radiograph. Statistical analysis was performed using SPSS software with a significance level set at $p < 0.05$.
RESULTS. During the statistical analysis, the prevalence of pulp calcifications was identified in 56.7% of cases, and pulp space obliteration was observed in 24%. Teeth with pulp stones were 1.8 times more likely to exhibit radiographic and clinical signs of caries compared to teeth with root canal obliteration. Among all examined teeth, nearly half in each calcification group had restorations. According to the obtained results, a positive correlation was found between pulp calcification and the dental status of the teeth.
CONCLUSIONS. According to the obtained data, a higher frequency of calcifications is associated with pulp inflammation caused by local prolonged irritants, such as the presence of deep restorations, carious processes, previously performed biological treatments, prior orthodontic treatment, trauma, and wear, as well as other systemic aspects.

Keywords: endodontic treatment, degenerative changes in the dentin-pulp complex, root canal obliteration, cone-beam computed tomography

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Изменения дентинно-пульпарного комплекса зубов через призму КЛКТ-исследований: ретроспективный анализ

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Резюме

ВВЕДЕНИЕ. Кальцифицирующий метаморфоз и облитерация пульпарного пространства зачастую усложняют эндодонтическое лечение, что требует применения современных методов визуализации и контроля проводимой терапии. Использование конусно-лучевой компьютерной томограммы в качестве диагностического инструмента позволяет лучше оценивать состояние дентинно-пульпарного комплекса, что способствует снижению рисков и повышению эффективности сложного эндодонтического лечения.

ЦЕЛЬ ИССЛЕДОВАНИЯ. Провести статистическую оценку распространенности дегенеративных изменений в дентинно-пульпарном комплексе зубов на основании данных, полученных в ходе КЛКТ-исследований, а также выявить возможные корреляционные связи между потенциальными факторами, способствующими развитию кальцифицирующего метаморфоза в пульпарном пространстве витальных зубов.
МАТЕРИАЛЫ И МЕТОДЫ. Для ретроспективного анализа было отобрано 187 КЛКТ-исследований. Полученные изображения были исследованы во всех плоскостях на предмет наличия дискретной рентгеноконтрастной массы в пульпарном пространстве зубов, в то время как, облитерация корневой пульпы определялась на основе сужения или полного закрытия пространства корневого канала. Статистический анализ был выполнен с использованием программного обеспечения SPSS с установленным уровнем значимости $p < 0,05$.
РЕЗУЛЬТАТЫ. В ходе статистического анализа распространенность пульпарных кальцификатов была выявлена в 56,7% случаев, облитерация пульпарного пространства наблюдалась в 24%. Зубы с пульпарными камнями в 1,8 раза чаще имели рентгенологические и клинические признаки кариеса, в отличии от зубов с облитерацией корневого каналами. Среди всех обследованных почти половина зубов в каждой группе кальцификаций имела реставрации. Согласно полученным результатам, выявлена положительная взаимосвязь между кальцификацией пульпы и стоматологическим статусом зубов.
ВЫВОДЫ. Согласно полученным данным, более высокая частота возникновения кальцификаций связана с воспалением пульпы, вызванным местными длительными раздражителями, такими как наличие глубоких реставраций, кариозный процесс, раннее проведенное лечение биологическим методом, предшествующее ортодонтическое лечение, травма и истирание, а также с другими общесоматическими аспектами.

Ключевые слова: эндодонтическое лечение, дегенеративные изменения дентинно-пульпарного комплекса, облитерация корневых каналов, конусно-лучевая компьютерная томография

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INTRODUCTION

According to current data from the World Health Organization (WHO), the increase in average life expectancy contributes to a decreasing trend in early tooth loss among the majority of patients [1]. In light of this, modern scientific and clinical advancements are focused on improving endodontic treatment strategies aimed at preserving teeth within the dental arch. The primary objective of endodontic therapy is to perform thorough chemo-mechanical preparation and achieve a hermetic obturation of the root canal system to prevent further microbial contamination [2]. However, factors such as the degree of root canal infection and the anatomical and morphological complexity of the root system significantly affect the difficulty of endodontic treatment [3].

In their study, O. Essam et al. identified 19 factors that may lead to complications or unfavorable outcomes in endodontic therapy. One such factor is the presence of pulp stones within the pulp chamber, which results in a reduced chamber volume and limited visualization of root canal orifices. Another complicating factor is pulp space obliteration, which can be caused by the deposition of secondary or tertiary dentin due to pathological processes such as deep carious lesions, restorative procedures, prior trauma, as well as age-related changes and orthodontic tooth movement [4]. These conditions lead to partial or complete sclerosis of the root canal system, significantly increasing treatment duration, the risk of intraoperative complications, and compromising the prognosis of the therapy.

In 2005, the American Association of Endodontists (AAE) developed the Endodontic Case Difficulty Assessment Form, wherein teeth with pulp stones and calcified canals are classified as moderate to high difficulty cases [5]. This is due to the fact that complex endodontic treatments are associated with a number of procedural risks, including perforation of the pulp floor or furcation area, canal transportation, excessive removal of pericervical dentin, ledge formation, and instrument separation [6]. Such complications ultimately may result in the undesired loss of the tooth [7].

According to the joint position statement by the American Academy of Oral and Maxillofacial Radiology (AAOMR) and the AAE, cone-beam computed tomography (CBCT) is recommended for preoperative assessment of teeth with complex root morphology, for intraoperative evaluation of anatomical variations or additional canals, and for the diagnosis of teeth with previous endodontic treatment errors [8]. It is noteworthy that, based on radiographic assessments, the reported prevalence of degenerative changes in the pulp chamber varies widely from 2.1% to 63.3% [9; 10]. This variability is attributed to the limitations of two-dimensional imaging, which does not allow for the reliable detection of small calcified structures (<200 μm) within the pulp cavity [10–12]. Consequently, CBCT is considered a more sensitive imaging modality for detecting degenerative changes in the dentin-pulp complex compared to traditional panoramic and intraoral periapical radiographs [12].

Given the above, there is an evident need for a more comprehensive investigation into the factors influencing

the development of degenerative changes in the dentin-pulp complex. The use of modern imaging techniques, such as cone-beam computed tomography, significantly enhances the quality of preoperative diagnostics and helps minimize complications, thereby improving the overall efficacy of endodontic treatment.

AIM

To perform a statistical assessment of the prevalence of degenerative changes in the dentin-pulp complex of vital teeth based on data obtained from cone-beam computed tomography (CBCT) studies, as well as to identify possible correlations between potential factors contributing to the development of calcific metamorphosis.

MATERIALS AND METHODS

This descriptive, retrospective, cross-sectional study was conducted from September 2024 to May 2025 at the Department of Therapeutic Dentistry and Endodontics, A.I. Evdokimov Research and Educational Institute of Dentistry.

During the analysis, archival cone-beam computed tomography (CBCT) data of 317 patients aged 18 to 74 years were reviewed. A total of 187 CBCT scans meeting the inclusion criteria were selected for the study. The inclusion criteria were: patients over 18 years of age with signs of pulp calcification or root canal obliteration. The exclusion criteria included: patients under 18 years of age, absence of degenerative pulp changes, and radiographs of inadequate diagnostic quality.

CBCT images were obtained using the KaVo DEXIS ORTHOPANTOMOGRAPH™ 3D Pro system (KaVo, Germany) at 85 kV, 5 mA, and an exposure time of 14.4 seconds. The acquired scans were evaluated in coronal, sagittal, and axial planes to identify the presence of discrete radiopaque masses within the radiolucent pulp chamber, as well as root pulp obliteration, which was defined as narrowing or complete closure of the root canal space visible on the radiograph.

Statistical analysis was performed using SPSS software (IBM Corp., USA). Pearson's chi-square (χ^2) test was used to assess the prevalence of degenerative changes in the dentin-pulp complex and to evaluate potential associations with other variables. A p-value of < 0.05 was considered statistically significant.

RESUTLS

The overall prevalence of pulp calcifications in the dental pulp tissues of all examined patients was 56.7%. The highest frequency of pulp stones was observed in maxillary and mandibular molars – 71.2% (Fig. 1, *A*, *B*, *D*). In contrast, the lowest prevalence was recorded in the incisors – 5% (Fig. 1, *C*). No statistically significant difference in the occurrence of pulp stones was found between genders ($p > 0.05$). Pulp canal obliteration was identified in 24% of the teeth with calcifications. The degree of calcification ranged from partial (15.1%) to complete obliteration of the root canal space in 8.9% of cases. Nevertheless, despite radiographic evidence of complete obliteration, a narrow, barely discernible root canal lumen may still be present at the microscopic level [12; 13].

Among patients aged 18–44 years, pulp calcifications predominated, whereas obliteration of the root canals was more frequently observed in the older age group (60–74 years) (Table 1).

The percentage distribution of predictors associated with the development of calcific metamorphosis is presented in Fig. 2. Among teeth with pulp stones, 46% showed no signs of carious lesions, whereas 54% exhibited radiographic and clinical evidence of caries (Fig. 1, *A*). In cases with root canal obliteration, deep carious lesions were identified in 28.7% of cases. Statistical analysis confirmed a significant correlation between the presence of pulp calcifications and dental caries ($p = 0.01$).

The presence and depth of restorations did not demonstrate a statistically significant difference depending on the type of calcific metamorphosis ($p > 0.05$). Nearly half of the teeth in each calcification group had restorations. Notably, deep restorations were more frequently observed among teeth with root canal obliteration (Fig. 1, *D*).

In the group of teeth previously treated using biologically based calcium-containing materials, obliteration of the root canal space was observed twice as often as pulp stones. A relatively low prevalence of pulp calcifications (15%) was noted in teeth with a history of orthodontic treatment. Interestingly, in unerupted (retained) teeth that had not been exposed to external factors, pulp calcifications were identified in 18% of cases, which may indicate an idiopathic nature of these degenerative changes.

Table 1. Distribution of teeth with degenerative changes in the pulp cavity according to group affiliation

Таблица 1. Распределение зубов с дегенеративными изменениями в пульпарной полости в соответствии с групповой принадлежностью

Affiliation	Pulp stones, %	Root canal obliteration, %
Age group affiliation		
18–44 years	35.7	6.1
45–59 years	52.3	25,2
60–74 years	12.0	68.7
Gender affiliation		
males	42.2	46.7
females	57.8	53.3
Group affiliation		
maxilla	54.0	53.3
mandible	46.0	46.7
Tooth type		
incisors	5.0	13.3
canines	6.6	10.0
premolars	17.2	23.4
molars	71.2	53.3

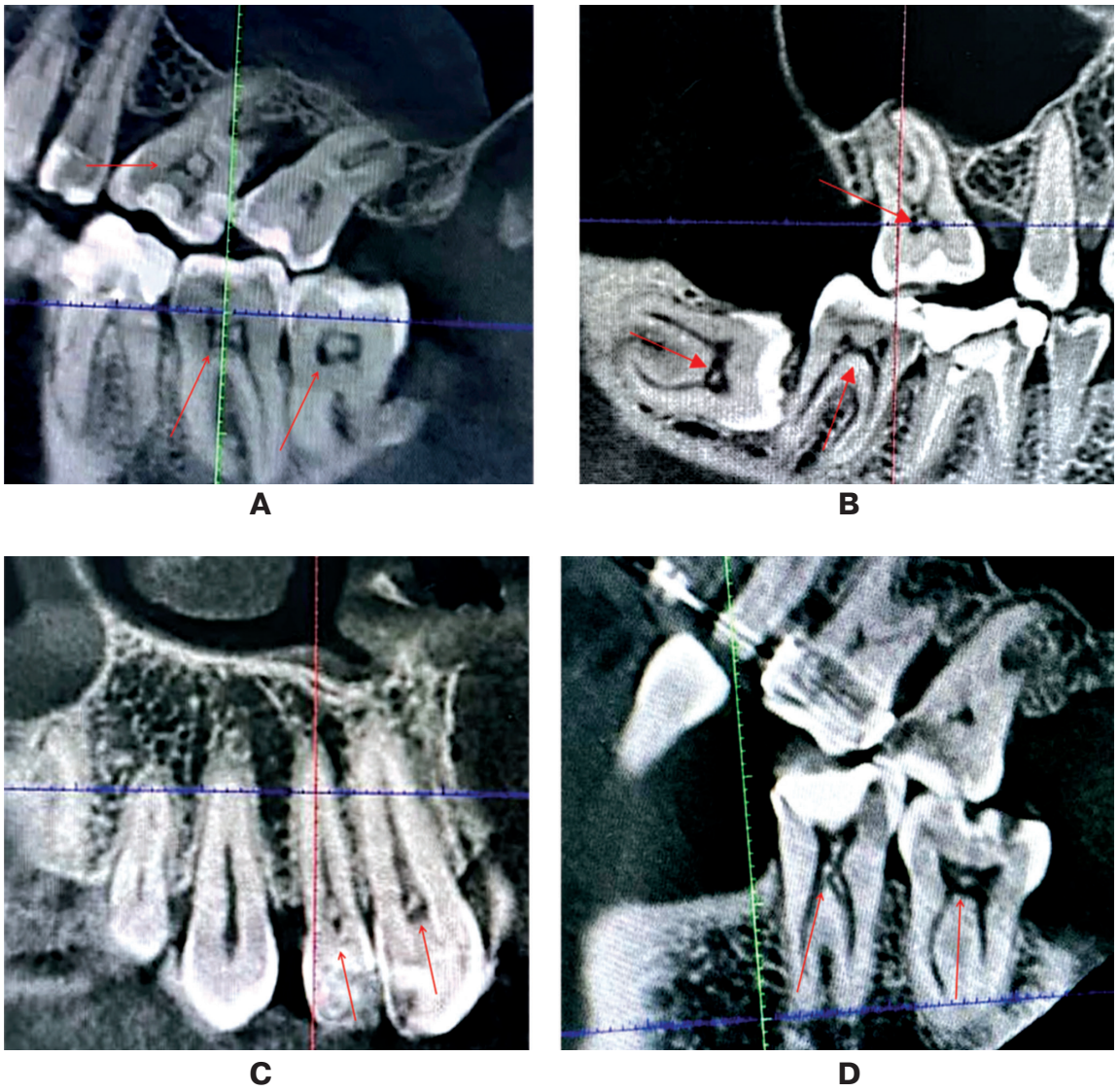

Fig. 1. Sagittal Sections of Dental CBCT Studies: *A* – Pulp calcifications in the cavities of teeth 2.7 (presence of secondary caries), 3.7, 3.8; *B* – Pulp calcifications in the cavities of teeth 1.7, 4.7, 4.8 (impacted, ectopic); *C* – Pulp calcifications in the cavities of teeth 1.1, 1.2; *D* – Pulp calcifications in the cavity of tooth 3.6 (presence of deep restoration), 3.7

Рис. 1. Сагиттальные срезы дентальных КЛКТ-исследований: *A* – пульпарные кальцификаты в полости зубов 2.7 (наличие вторичного кариеса), 3.7, 3.8; B – пульпарные кальцификаты в полости зуба 1.7, 4.7, 4.8 (ретинированный, дистопированный); *C* – пульпарные кальцификации в полости зуба 1.1, 1.2; *D* – пульпарные кальцификации в полости зуба 3.6 (наличие глубокой реставрации), 3.7

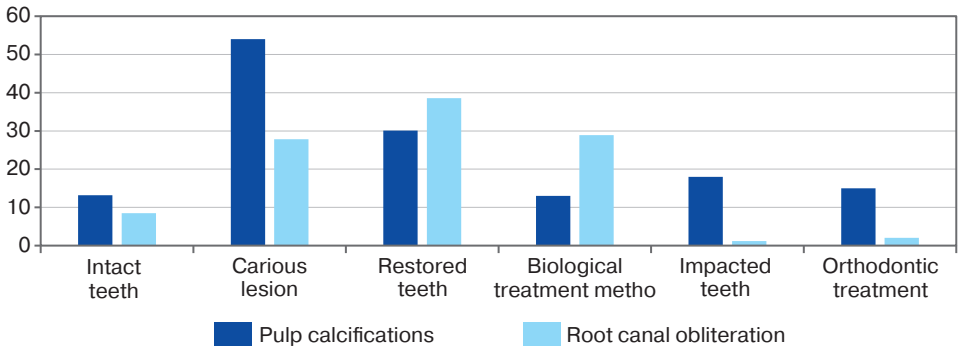

Fig. 2. Potential factors of calcifying metamorphosis development

Рис. 2. Потенциальные факторы развития кальцифицирующего метаморфоза

DISCUSSION

The aim of this study was to evaluate the radiographic characteristics of various types of dental pulp calcifications and their association with specific dental indicators.

Correlation analysis revealed a significant predisposition for the formation of pulp calcifications in molars, which is consistent with previously published studies [13–15]. The high prevalence of calcifications in this tooth group may be attributed to their anatomical features: as the largest teeth in the dental arch, molars possess a more developed pulpal blood supply, which creates favorable conditions for calcification formation [16]. Furthermore, they are the first permanent teeth to erupt and bear the greatest occlusal load throughout life, making them more susceptible to carious lesions and restorative procedures [17]. Notably, the study by A. Palatyńska-Ulatowska et al. indicated that pulp calcifications are more commonly found in the coronal pulp than in the radicular pulp space [18].

In this study, no statistically significant difference was found between gender and the presence of degenerative changes in the dentin-pulp complex. However, a number of authors report a higher prevalence of such changes among females, which is attributed to a greater incidence of bruxism and the influence of hormonal factors [15–19].

Regarding age-related indicators, an inverse correlation was identified between patient age and the presence of degenerative pulp changes (p = 0.001). Pulp calcifications were predominantly observed in younger individuals (18–44 years), whereas root canal obliteration was more prevalent in patients over the age of 60. It is well established that aging promotes the formation of secondary and tertiary dentin, resulting in a gradual reduction in the size of the pulp chamber and root canal [17].

The results of the present study demonstrated a positive correlation between pulp calcification and the dental condition of the affected teeth. A higher frequency of calcifications was associated with pulpal inflammation caused by prolonged local irritants such as restorations, carious lesions, prior biologically based treatments, orthodontic therapy, trauma, and attrition, as well as idiopathic factors [20]. These findings support the hypothesis that chronic irritants may contribute to the formation of pulp stones.

CONCLUSION

The present study revealed that degenerative changes within the pulp space are a common finding, occurring in 80.7% of cases. Their formation is closely associated with both physiological and pathological conditions of the teeth and may be triggered by prolonged exposure to local irritants. These findings underscore the importance of a deeper understanding of the mechanisms underlying calcific metamorphosis in order to develop more effective strategies for the prevention and management of diseases affecting the dentin-pulp complex.

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