



# Quality of Endodontic Treatment and Prevalence of Apical Radiolucencies in a Bulgarian Subpopulation: a CBCT Analysis

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## Abstract

**Introduction:** The advent of Cone Beam Computed Tomography (CBCT) in endodontics has enhanced the diagnosis of periapical radiolucencies and the assessment of endodontically treated teeth.

**Aim:** The purpose of this study was to assess the prevalence of periapical radiolucencies in a Bulgarian subpopulation and the quality of previous endodontic treatment using CBCT scans.

**Materials and methods:** This study included 2795 roots from 160 Large FOV CBCT which were evaluated by two independent examiners using two scoring systems: CBCT-PAI and PESS.

**Results:** The inter-examiner agreement spanned from strong to almost perfect (0.892 and 0.983). The prevalence of periapical lesions according to the two scoring systems was 23.1% and 12.9 %, respectively. The prevalence of endodontically treated teeth was high (34.1%). Sixty-five percent of them presented with signs of periapical radiolucencies, while only 1.4% of all non-treated roots had a periapical lesion. A significant association between periapical disease, poor quality of the root canal filling and inadequate coronal seal was found ( $p < 0.001$ ).

**Conclusions:** The prevalence of periapical disease in endodontically-treated teeth in the Bulgarian subpopulation was high. Poor quality of the root canal filling and inadequate coronal seal were assessed as prognostic determinants of treatment failure. CBCT techniques can augment conventional diagnostic techniques in the field of endodontics.

## Keywords

cone-beam computed tomography, periapical diseases, root canal obturation

## INTRODUCTION

The progression of microorganisms from the infected root canal space to the periapical area evokes an inflammatory

response during which pathophysiological changes occur leading to bone resorption.<sup>1,2</sup> The condition is known as chronic apical periodontitis and is represented radiographically as a radiolucent area around the apex of the tooth.

Recent epidemiologic research documents that the prevalence of periapical radiolucencies varies among patients aged 20 to 30 by 33%, aged 30 to 40 by 40%, aged 40 to 50 by 48%, 50 to 60 by 57%, and in patients older than 60 years of age by 62%.<sup>3</sup> The prevalence of chronic apical periodontitis in Bulgaria is high - between 2.0% and 18%.<sup>4</sup> Furthermore, the prevalence of periapical radiolucencies in teeth with root canal treatment is also very high - 71.3%.<sup>4</sup> Therefore, chronic periapical pathosis is regarded as a socially and economically significant disease and a public health problem.

The contemporary method that is most widely used in day-to-day clinical practice for evaluation of the periapical area is the periapical radiography (conventional or digital).<sup>5-7</sup> However, it provides a two-dimensional view of three-dimensional (3D) structures.<sup>8-10</sup> Several studies have reported on the limitations of periapical radiography in detecting periapical lesions due to bone characteristics, lesion location, morphologic variations, surrounding bone density, x-ray angulations and radiographic contrast.<sup>5,8,11</sup> Histologic analysis is considered the most accurate diagnostic method but its application is limited to endodontic surgery only due to its invasive nature.<sup>12</sup>

Recently, CBCT has been successfully implemented in the field of endodontics as it provides a 3D reconstruction of the anatomical structures. Several studies have confirmed the increased accuracy of CBCT in detecting periapical lesions in comparison with conventional radiographic techniques.<sup>13-17</sup> Therefore, CBCT can be beneficial to endodontic diagnosis. The purpose of this study was to describe the periapical health status of a Bulgarian subpopulation via CBCT measurements and estimate the prevalence of disease and treatment.

## MATERIALS AND METHODS

### Cases Selection

The retrospective study was approved by the institutional review board of the Medical University of Plovdiv, with accordance to the ethical standards of the Declaration of Helsinki and with a waiver of informed consent due to the design of the study. Large FOV CBCT images of 120 patients were selected from the database of a dental radiology laboratory in Plovdiv, Bulgaria. The patients included in the study were aged 18-64 (mean age 48.5 years) with a minimum of 10 teeth.

### Imaging methods and analysis

The CBCT images were obtained with the Planmeca ProMax 3D Max dental X-ray unit. The scans' parameters were voxel size of 0.200 & 0.200 & 0.200 mm, 15 bits. The CBCT volumetric data were evaluated by two independent and calibrated examiners with the Planmeca Romexis Dental

Imaging Software. Monitor settings concerning brightness and contrast were adjusted to the preferences of the examiners. A slice thickness of 0.2 mm to 0.5 mm was used for the multiplane views in accordance with the examiner's preferences.

A total of 2795 roots (1843 teeth) were examined. The root was adopted as the unit of observation and each root was scored with two previously published indices. The CBCT-PAI by Estrela et al.<sup>10</sup> scores the size of the lesion, its location, and relationship with the roots of the tooth (**Table 1**). The PESS index by Venskutonis et al.<sup>18</sup> is a complex scoring system evaluating lesion size, root canal treatment quality and possible complications. It consists of two scoring systems – COPI, the complex periapical index (**Table 2**), designed for the identification and classification of periapical bone lesions, and ETTI, the endodontically treated tooth index (**Table 3**), designed for endodontic treatment quality evaluation. For the assessment of the endodontic treatment, the scores were distributed in the following categories: the scores of L2, L3 and L4 were labeled as an inadequate length of the root canal filling, the scores of H2 – as an inadequate quality of the root canal filling and the scores of CS2 – as an inadequate coronal restoration.

**Table 1.** Cone beam computed tomography periapical index scores (CBCTPAI)

Score	Quantitative Bone Alterations in Mineral Structures
0	Intact periapical bone structures
1	Diameter of periapical radiolucency > 0.5–1 mm
2	Diameter of periapical radiolucency > 1–2 mm
3	Diameter of periapical radiolucency > 2–4 mm
4	Diameter of periapical radiolucency > 4–8 mm
5	Diameter of periapical radiolucency > 8 mm
Score (n) + E*	Expansion of periapical cortical bone
Score (n) + D*	Destruction of periapical cortical bone

The variables E (expansion of cortical bone) and D (destruction of cortical bone) were added to each score when either of these conditions was detected in the CBCT analysis.

### Statistical analysis

Data were typed into a spreadsheet, and SPSS software (version 17; SPSS Inc., Chicago, IL) was used to perform the analysis. The Cohen kappa was calculated to assess the inter-examiner agreement for each parameter for the indexes. The Mann-Whitney test was used as the univariate approach to detect statistically significant differences between the categories. Correspondence analysis was used for the assessment of the association of the quality of endodontic treatment and status of the apical periodontium. The level of significance adopted was 1%.

**Table 2.** The Complex Periapical Index (COPI)

Score	S (Size of the radiolucent lesion)
S0	Widening of the periodontal ligament not exceeding two times the width of the lateral periodontal ligament
S1	The diameter of small well-defined radiolucency up to 3 mm
S2	Diameter of medium well-defined radiolucency 3-5 mm
S3	Diameter of large well-defined radiolucency >5 mm
	R (Relationship between root and radiolucent lesion)
R0	No radiolucency, when widening of the periodontal ligament is not exceeding two times the width of the lateral periodontal ligament
R1	Radiolucent lesion appears on one root
R2	Radiolucent lesion appears on more than one root
R3	Radiolucent lesion with involvement of furcation
	D (location of bone destruction)
D0	No radiolucency, when widening of the periodontal ligament is not exceeding two times the width of the lateral periodontal ligament
D1	Radiolucency around one root
D2	Radiolucency is in contact with important anatomical structures
D3	Destruction of cortical bone

**Table 3.** The endodontically treated tooth index (ETTI)

Score	L (length of the root canal filling)
L0	0-2 mm from radiographic apex
L1	>2 mm from radiographic apex
L2	Overfilling (extrusion of material through the apex)
L3	Filling material visible only in pulp chamber
	H (homogeneity of the root canal filling)
H1	Complete obturation (homogenous appearance of the root canal filling)
H2	Incomplete obturation (voids or porous appearance of the root canal filling)
	CS (coronal seal)
CS1	Adequate (coronal restoration appears intact radiographically)
CS2	Inadequate (detectable radiographic signs of overhangs, open margins, recurrent caries, or lost coronal restoration)
	CF (complications/failures)
CF0	No complications
CF1	Root perforation
CF2	Root canal not treated/missed
CF3	Root resorption
CF4	Root/tooth fracture
CF5	Surgically treated tooth with radiolucency

## RESULTS

An overall inter-examiner agreement value of 0.94 was found for the measurements, thus indicating almost perfect agreement. The distribution of the CBCTPAI and PESS results is shown on **Figs 1, 2, 3**. Periapical lesions were assessed in 23.1% of all of the roots according to the CBCTPAI index and in 12.9 % according to the PESS index. According to the CBCTPAI 34.1% of all the roots were endodontically treated and 65% of them presented with signs of

apical radiolucency, while only 1.4% of all non-endodontically treated roots were assessed to have a periapical lesion. The Mann-Whitney test showed a significant association between periapical status and the length of the root canal filling with scores of L2, L3 or L4 ( $p < 0.001$ ); between periapical status and the quality of root canal filling with a score of H2 ( $p < 0.001$ ); and between the periapical status and the quality of the coronal restoration with a score of CS2 ( $p < 0.001$ ).

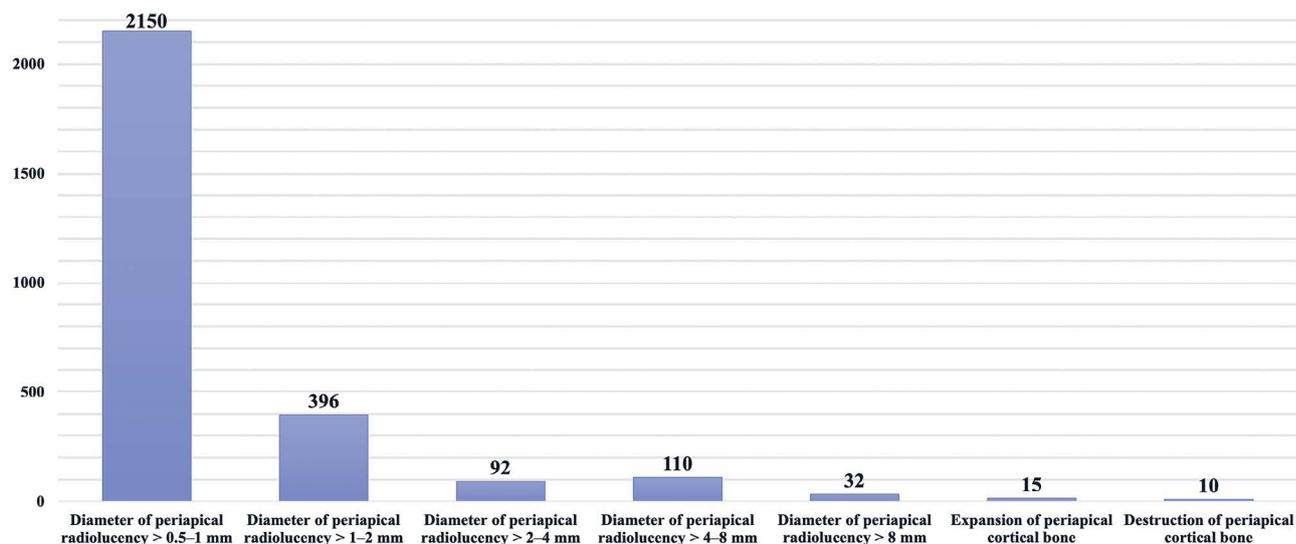


Figure 1. Distribution of CBCTPAI results.

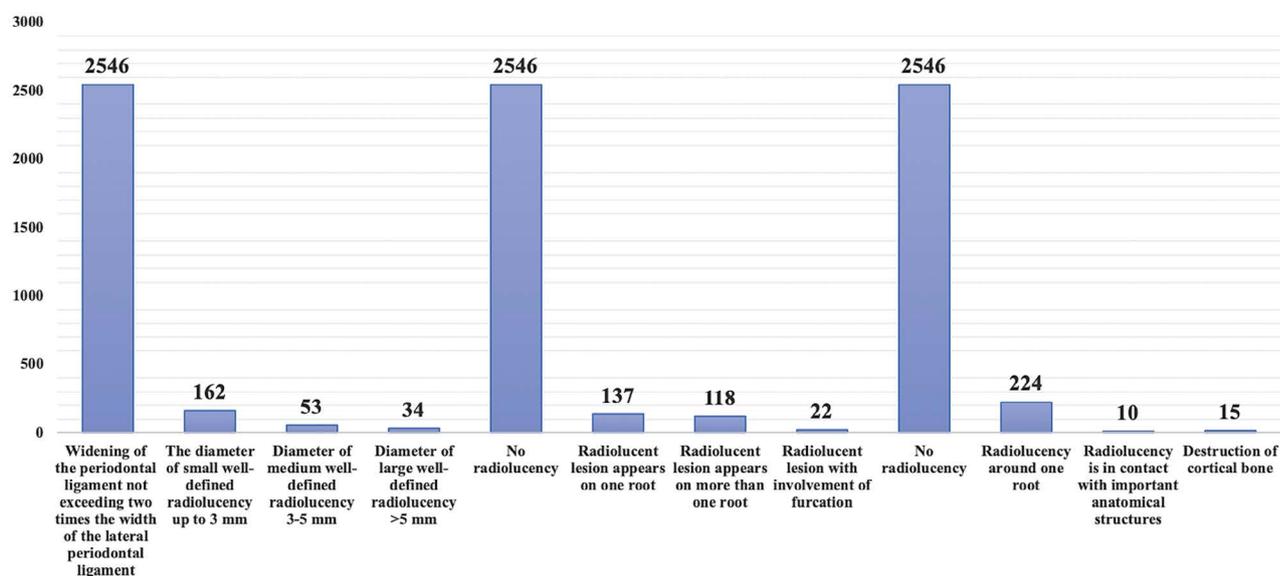


Figure 2. Distribution of COPI results.

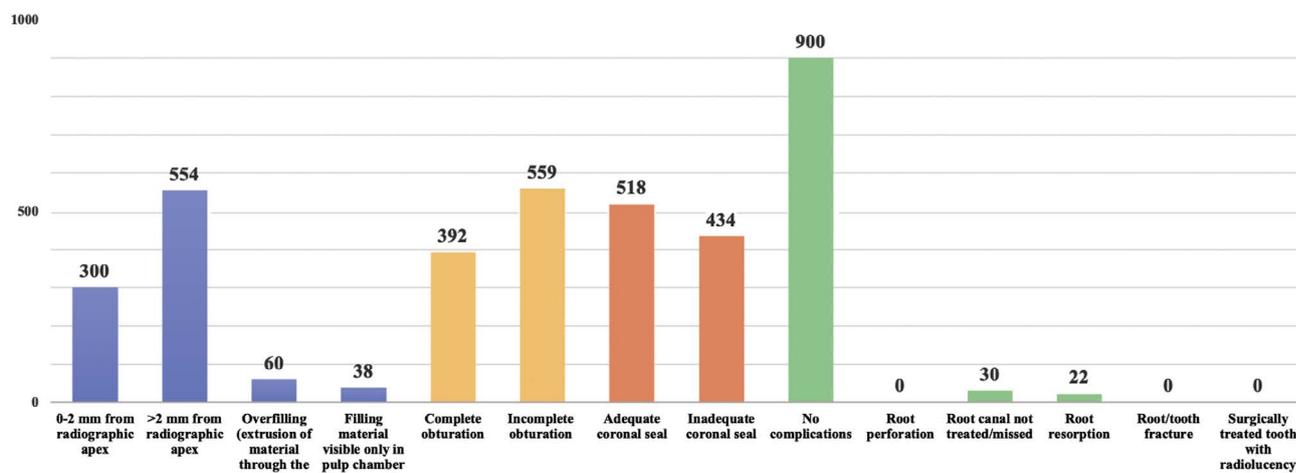


Figure 3. Distribution of ETTI results.

## DISCUSSION

Radiographically detectable periapical radiolucencies mark the presence of a chronic destructive inflammatory process. These chronic lesions are either of primary or secondary endodontic origin and patients generally do not present with any symptoms. Even persistent endodontic lesions can provide functionality and comfort to the patients and they may never seek further treatment until complications arise.<sup>19</sup> Therefore, the cases chronic apical periodontitis tend to accumulate in given population. Effective screening methods are needed for their successful diagnosis and timely treatment.

The high proportion of endodontically treated teeth presented with periapical radiolucency which correlates with previous reports.<sup>19-21</sup> These results can be due to a variety of factors. While endodontically compromised teeth are retained successfully through root canal treatment as it is the effective way to reduce the symptoms and treat periapical disease, unsuccessful treatments do not always present as functional or symptomatic failures and accumulate over time in a population.<sup>22</sup> Furthermore, radiographic screening and cross-sectional studies are an effective way of assessing the prevalence, severity and origin of the problem. However, these snapshot studies cannot distinguish between healing and persistent lesions.<sup>19</sup> One of the limitations of the present retrospective study is that our evaluation was only based solely on the radiographic analysis. No data about the dental history of the patients were available.

The overall prevalence of periapical disease in the Bulgarian subpopulation was higher than previous reports based on conventional radiographic techniques.<sup>4</sup> This can be explained with higher sensitivity of CBCT in the detection of periapical radiolucencies.<sup>23</sup> The prevalence also varied according to the two scoring systems. This is due to the different disease threshold criteria in their design. The conventional strict criteria for endodontic success on conventional two-dimensional radiographs include a complete absence of periradicular radiolucency along with the re-establishment of a normal periodontal ligament space and a defined lamina dura, established in clinical practice.<sup>24</sup> With the advent of the new high-resolution three-dimensional images new, universal criteria need to be established for the successful evaluation of treatment success and prevention of unnecessary treatment.

An evaluation of the quality of previous endodontic treatment was performed with the ETTI scoring system. The high resolution CBCT images provided for the comprehensive assessment of any factors that could have impacted treatment success. Our results indicate that incomplete obturation of the root canals and a compromised coronal seal increase the risk of secondary infection of the root canal system and are associated the development of periapical disease. The results are in accordance with previous reports and underline the need for optimized treatment strategies.<sup>25-30</sup> The best treatment results were associated with a root canal obturation ending 0–2 mm short of the apex,

which is compliant with the accepted standards. The cases examined in this study do not represent a statistically significant sample of the Bulgarian adult population. Nevertheless, the results provide an insight into the poor quality of endodontic treatment and the prevalence of periapical radiolucencies.

## CONCLUSIONS

The present study revealed high prevalence of periapical radiolucencies in endodontically treated teeth among the Bulgarian subpopulation. Our findings underline the need of strict post-treatment endodontic evaluation protocols and continuous post-operative monitoring and care. Within the limitations of the present study, it was concluded that the quality of endodontic treatment in Bulgaria is not up to the accepted clinical standards.

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## REFERENCES

1. Stashenko P, Teles R, D'souza R. Periapical inflammatory responses and their modulation. *Crit Rev Oral Biol Med* 1998; 9(4):498–521.
2. Ahmed GM, El-Baz AA, Hashem AAR, et al. Expression levels of matrix metalloproteinase-9 and gram-negative bacteria in symptomatic and asymptomatic periapical lesions. *J Endod* 2013; 39(4):444–8.
3. Ørstavik D. Endodontic treatment of apical periodontitis. In: Ørstavik D, editor. *Essential Endodontology: Prevention and Treatment of Apical Periodontitis*. 3rd ed. 2019; 313–44.
4. Gusyiska AZ. [Orthographic treatment of chronic apical periodontitis – biological approaches] [PhD dissertation] Medical University, Sofia 2012. [In Bulgarian]
5. Estrela C, Bueno MR, Leles CR, et al. Accuracy of cone beam computed tomography and panoramic and periapical radiography for detection of apical periodontitis. *J Endod* 2008; 34(3):273–9.
6. Özen T, Kamburoğlu K, Cebeci ARI, et al. Interpretation of chemically created periapical lesions using 2 different dental cone-beam computerized tomography units, an intraoral digital sensor, and conventional film. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2009; 107(3):426–32.
7. Patel S, Dawood A, Whaites E, et al. New dimensions in endodontic imaging: part 1. Conventional and alternative radiographic systems. *Int Endod J* 2009; 42(6):447–62.
8. Huumonen S, Ørstavik D. Radiological aspects of apical periodontitis. *Endodontic Topics* 2002; 1(1):3–25.
9. Patel S, Dawood A, Mannocci F, et al. Detection of periapical bone defects in human jaws using cone beam computed tomography and intraoral radiography. *Int Endod J* 2009; 42(6):507–15.
10. Estrela C, Bueno MR, Azevedo BC, et al. A new periapical index based on cone beam computed tomography. *J Endod* 2008; 34(11):1325–31.

11. Halse A, Molven O, Fristad I. Diagnosing periapical lesions - disagreement and borderline cases. *Int Endod J* 2002; 35(8):703–9.
12. Laux M, Abbott PV, Pajarola G, Nair PNR. Apical inflammatory root resorption: a correlative radiographic and histological assessment. *Int Endod J* 2000; 33(6):483–93.
13. Cotton T, Geisler T, Holden D, et al. Endodontic applications of cone-beam volumetric tomography. *J Endod* 2007; 33(9):1121–32.
14. Nair MK, Nair UP. Digital and advanced imaging in endodontics: a review. *J Endod* 2007;33(1):1–6.
15. Velvart P, Hecker H, Tillinger G. Detection of the apical lesion and the mandibular canal in conventional radiography and computed tomography. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2001; 92(6):682–8.
16. Lofthag-Hansen S, Huuomonen S, Gröndahl K, et al. Limited cone-beam CT and intraoral radiography for the diagnosis of periapical pathology. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2007; 103(1):114–9.
17. Nakata K, Naitoh M, Izumi M, et al. Effectiveness of dental computed tomography in diagnostic imaging of periradicular lesion of each root of a multiradical tooth: a case report. *J Endod* 2006; 32(6):583–7.
18. Venskutonis T, Plotino G, Tocci L, et al. Periapical and endodontic status scale based on periapical bone lesions and endodontic treatment quality evaluation using cone-beam computed tomography. *J Endod* 2015; 41(2):190–6.
19. Pak JG, Fayazi S, White SN. Prevalence of periapical radiolucency and root canal treatment: a systematic review of cross-sectional studies. *J Endod* 2012; 38(9):1170–6.
20. Özbaş H, Aşçı S, Aydın Y. Examination of the prevalence of periapical lesions and technical quality of endodontic treatment in a Turkish subpopulation. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2011; 112(1):136–42.
21. Ahmed I, Ali R, Mudawi A. Prevalence of apical periodontitis and frequency of root-filled teeth in an adult Sudanese population. *Clin Exp Dent Res* 2017; 3(4):142–7.
22. Pak JG, White SN. Pain prevalence and severity before, during, and after root canal treatment: a systematic review. *J Endod* 2011; 37(4):429–38.
23. Strindberg LZ. The dependence of the results of pulp therapy on certain factors; an analytic study based on radiographic and clinical follow-up examinations. *Acta odontologica Scandinavica Supplementum* 1956; 10(1):20–7.
24. Ray HA, Trope M. Periapical status of endodontically treated teeth in relation to the technical quality of the root filling and the coronal restoration. *Int Endod J* 1995; 28(1):12–8.
25. Sjögren U, Hägglund B, Sundqvist G, et al. Factors affecting the long-term results of endodontic treatment. *J Endod* 1990; 16(10):498–504.
26. Ng Y-L, Mann V, Rahbaran S, et al. Outcome of primary root canal treatment: systematic review of the literature – Part 1. Effects of study characteristics on probability of success. *Int Endod J* 2007; 40(12):921–39.
27. Gomes AC, Nejaim Y, Silva AI, et al. Influence of endodontic treatment and coronal restoration on status of periapical tissues: a cone-beam computed tomographic study. *J Endod* 2015; 41(10):1614–8.
28. Song M, Park M, Lee C-Y, et al. Periapical status related to the quality of coronal restorations and root fillings in a Korean population. *J Endod* 2014; 40(2):182–6.
29. Gillen BM, Looney SW, Gu L-S, et al. Impact of the quality of coronal restoration versus the quality of root canal fillings on success of root canal treatment: a systematic review and meta-analysis. *J Endod* 2011; 37(7):895–902.

# Качество эндодонтического лечения и распространённость апикальных рентгенопрозрачностей в подгруппе населения Болгарии: анализ КЛКТ

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## Резюме

**Введение:** Внедрение конусно-лучевой компьютерной томографии (КЛКТ) в эндодонтии способствует диагностике периапикальной рентгенопрозрачности и оценке зубов, подвергшихся эндодонтическому лечению.

**Цель:** Целью этого исследования было вычислить частоту периапикальных рентгенопрозрачностей в подгруппе населения Болгарии и качество предшествующего эндодонтического лечения с использованием КЛКТ-сканирования.

**Материалы и методы:** Это исследование включало 2795 корней из 160 изображений КЛКТ с большим полем обзора, которые были оценены двумя независимыми экспертами с двумя различными системами оценки: КЛКТ-РАИ и PESS.

**Результаты:** Соответствие оценок специалистов колебалось от высокого до почти полного (0.892 и 0.983). Частота периапикальных поражений по двум системам оценки составила 23.1% и 12.9% соответственно. Частота случаев эндодонтического лечения зубов была высокой (34.1%). У 65 из них установлено наличие периапикальных рентгенопрозрачностей, в то время как только 1.4% всех необработанных корней имели периапикальные поражения. Были обнаружены значимые связи между периапикальным заболеванием, плохим качеством пломбирования корневых каналов и неправильной коронковой пломбировкой ( $p < 0.001$ ).

**Заключение:** Частота периапикальных заболеваний зубов, подвергнутых эндодонтическому лечению, в подгруппе населения Болгарии была высокой. Плохое качество пломбирования корневого канала и неправильная коронковая пломба были оценены как прогностические факторы, определяющие неэффективность лечения. Методы КЛКТ могут успешно дополнять традиционные диагностические методы в области эндодонтии.

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## Ключевые слова

конусно-лучевая компьютерная томография, периапикальные заболевания, obturация корневых каналов

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