Abstract

Dissertation by Indira Tulegenova on the topic:

“Improvement of treatment of chronic apical periodontitis considering the morphology of the root canal system”,
submitted for the degree of Doctor of Philosophy (PhD)
in the specialty 8D10103 – “Medicine”

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Chronic apical periodontitis (CAP) remains a pressing challenge in therapeutic dentistry due to its high prevalence, the labor-intensive nature of endodontic treatment, and the frequent occurrence of errors and complications. According to multiple studies, the success rate of conservative treatment for CAP averages approximately 85%. However, prognosis is strongly influenced by the clinical form of the disease, the scope and quality of endodontic intervention, the anatomical and morphological characteristics of the root canal system, and the patient's overall health status. Literature indicates that up to 80% of teeth previously subjected to endodontic treatment subsequently require retreatment, and in older patients, complications more often necessitate tooth extraction.

Pathogenic microorganisms play a central role in the etiology of CAP, with *Enterococcus faecalis*, *Streptococcus* spp., *Actinomyces* spp., and *Candida albicans* among the most frequently implicated. The persistence of microbial biofilms and the difficulty of their removal hinder the achievement of long-term remission. Another challenge is the prolonged regeneration of periapical tissues, which may take six months or longer.

One of the main causes of treatment failure is limited knowledge of root canal anatomy. The variability of canal morphology, the presence of lateral branches, and the apical delta substantially complicate thorough cleaning and obturation. Advances in imaging, particularly cone-beam computed tomography (CBCT), enable in vivo visualization of canal morphology in three dimensions and improve diagnostic precision. Most previous studies have focused on maxillary molars and have examined canal morphology by sex and ethnicity, highlighting the need for further investigation of root canal anatomy across diverse populations to improve treatment outcomes.

Another unresolved problem is the standardization of chemical treatment protocols. Current methods show heterogeneous effectiveness (50–70%) in removing microbial biofilms and infected dentin. The absence of unified approaches to antimicrobial management reduces the predictability of endodontic outcomes. Key causes of endodontic treatment failures include inadequate obturation (up to 90.9%), restoration defects (66.6%), missed canals (24.3%), perforations, and fractured instruments left within canals.

Improving CAP treatment effectiveness therefore requires a comprehensive approach that combines detailed understanding of root canal morphology, consideration of population differences, optimization of chemical treatment methods, and the application of modern diagnostic and therapeutic technologies.

Aim of the Study

The aim of the study is to improve the effectiveness of chronic apical periodontitis treatment through a personalized approach that accounts for variations in root canal morphology.

Objectives of the Study

1. To conduct a retrospective analysis of medical records to assess the prevalence of CAP among the population of Almaty.
2. To determine the variability in the anatomical structure and number of root canals in posterior teeth among Almaty residents using CBCT.
3. To develop a personalized endodontic treatment protocol for CAP based on root canal morphology.
4. To evaluate the clinical, microbiological, and radiological effectiveness of the proposed personalized treatment protocol.

Object of the Study

1. Medical records of 300 patients who sought dental care between 2022 and 2024.
2. CBCT scans of untreated posterior teeth (molars and premolars), totaling 300 images.
3. Infected root canal contents obtained during endodontic treatment.
4. Patients aged 18–65 years diagnosed with CAP (K04.5, ICD-10), who received care at the Clinic of the School of Dentistry of Asfendiyarov Kazakh National Medical University and the Dental-City clinic (July 2023 – July 2024).

Subject of the Study

Morphological features of the root canal system of posterior teeth and the endodontic treatment protocol for chronic apical periodontitis

Methods of the Study

Clinical research methods (interview, examination, probing, percussion, palpation), retrospective analysis of patients' outpatient dental records, cone-beam computed tomography (CBCT) for studying the configuration of the root canal system, scanning electron microscopy (SEM) of dentin samples for assessing the effectiveness of irrigation protocols, disk diffusion method for analyzing the antimicrobial activity of irrigants, systematic review and meta-analysis of international data on the prevalence of anatomical variations, bacteriological methods for quantitative assessment of root canal contamination and strain

identification. Statistical analysis was performed using SPSS, χ^2-test, Mann–Whitney U-test, confidence intervals, and correlation analysis methods.

Study Design

To achieve the stated aim, a comprehensive study was conducted, including retrospective, cross-sectional, randomized controlled, and laboratory-clinical stages, as well as a systematic review and meta-analysis.

I. The prevalence of chronic apical periodontitis was studied among patients who sought dental care in Almaty.

II. Using cone-beam computed tomography (CBCT), the variability and number of root canals in premolars and molars were determined according to the classifications of Vertucci and Ahmed et al.

III. A systematic review and meta-analysis were conducted to examine the prevalence of C-shaped root canal configurations.

IV. Changes in the microbiocenosis of the root canal system before and after chemomechanical treatment were assessed in patients with chronic apical periodontitis.

V. A comparative evaluation of the clinical effectiveness of standard and modified (personalized) endodontic treatment protocols was performed, taking into account the morphological features of the root canal system.

VI. Practical recommendations were developed for the individualization of endodontic treatment of chronic apical periodontitis.

Key Provisions Submitted for Defense

1. Morphological variability of the root canal system has a significant impact on the pathogenesis of chronic apical periodontitis (CAP) and is a key factor determining the prognosis of endodontic treatment.
2. The introduction of a personalized approach, based on the morphological typology of root canals, contributes to improving the effectiveness of CAP treatment. Individualization of the treatment protocol ensures a higher level of success and reduces the risk of CAP recurrence.

Main Results of the Study

1. CAP was one of the most frequently diagnosed inflammatory conditions in Almaty, with an overall prevalence of 4.96 cases per patient. The highest burden was among individuals aged 18–45 years, emphasizing its clinical and social significance in the economically active population.
2. CBCT revealed considerable morphological variability: four canals in 23.6% of mandibular first molars, C-shaped canals in 10.3% of premolars, and an additional root (radix entomolaris) in 13.0% of mandibular first molars.
3. A systematic review and meta-analysis demonstrated that C-shaped canals in mandibular second premolars are rare, with pooled prevalence of 1.31% per patient and 0.96% per tooth. Ethnic and geographic factors were shown to influence prevalence.

4. A scientifically grounded personalized treatment protocol was developed, including mandatory CBCT, use of an operating microscope, flexible instruments, activated irrigants, and anatomically adapted obturation methods.
5. Comparative evaluation confirmed superior outcomes for the personalized protocol: improved canal sanitation, reduced microbial contamination, and enhanced clinical and radiological success.

Scientific Novelty

1. For the first time, a retrospective analysis of the prevalence of chronic apical periodontitis among patients seeking dental care in Almaty was conducted, which made it possible to characterize the distribution patterns of this pathology at the regional level.
2. The anatomical and morphological features of the root canal system of posterior teeth were clarified based on CBCT data using the classifications of Ahmed and Vertucci.
3. The microbiocenosis of infected root canals with complex anatomy in chronic apical periodontitis has been clarified. Its characteristics determining resistance to traditional methods of endodontic therapy have been identified.
4. A personalized endodontic treatment protocol was developed and scientifically substantiated, based on individual anatomical features of the root canal system, which ensures increased effectiveness of CAP therapy.

Theoretical and Practical Significance of the Study

1. The obtained data on the prevalence of chronic apical periodontitis and the morphological features of the root canal system can be used in planning and optimizing endodontic treatment.
2. The developed endodontic treatment protocol for chronic apical periodontitis provides a personalized approach by accounting for anatomical variations, which contributes to improving the quality of canal preparation and obturation, as well as enhancing clinical outcomes of treatment.
3. The integration of cone-beam computed tomography at the diagnostic stage allows timely detection of complex root canal anatomy, reduces the risk of iatrogenic complications, and increases the accuracy of treatment strategies.
4. The results of microbiological studies confirm the necessity of individual selection of antiseptic and medicament solutions within an extended endodontic treatment protocol, taking into account the identified microflora.

Personal Contribution of the Doctoral Candidate

Within the framework of this research, the doctoral candidate developed methodological recommendations for the treatment of CAP, based on a comprehensive analysis of the morphological features of the root canal system. The proposed approach made it possible to increase the effectiveness of endodontic therapy by ensuring an individualized treatment plan.

The author independently conducted a clinical study in which the effectiveness of modern methods of chemical treatment of root canals was evaluated, taking into account anatomical variations.

The doctoral candidate proposed improved approaches to the diagnosis of CAP using cone-beam computed tomography (CBCT) and other high-precision imaging methods, which contributed to enhancing diagnostic accuracy and improving treatment prognosis.

Approbation of the Work

The main provisions of the dissertation were presented and discussed at the meeting of the Academic Council of the NJSC "Asfendiyarov Kazakh National Medical University" (Minutes No. 5 dated 13.12.2022) and reported as scientific presentations at the following scientific-practical and international conferences:

1. I International Medical Congress "Human and Health. Multidisciplinary Approach in Medicine", NJSC "Medical University of Semey" (October 17–19, 2022). Report: "Principles of endodontic treatment through the diagnosis of additional canals."
2. Scientific-Practical Conference "Priorities of Pharmacy and Dentistry: from Theory to Practice", NJSC "Asfendiyarov Kazakh National Medical University" (November 14, 2022). Report: "Features of endodontic treatment of teeth with additional root canals."
3. International Online Conference "Current Issues of Pediatric Dentistry and Prevention", Khabarovsk (February 9, 2023). Report: "Improvement of endodontic treatment methods based on the study of root canal morphology."
4. X International Teleconference, Tashkent State Dental Institute, Uzbekistan, Tashkent (February 9–10, 2023). Report: "Improvement of endodontic treatment methods based on the study of root canal morphology."
5. XXXI International Online Congress "Innovative Technologies in Dentistry", Russia, Omsk (March 1–2, 2023). Report: "Principles of endodontic treatment of teeth with complex root canal morphology."
6. 1st International Asfen Forum, Kazakhstan, Almaty (June 5, 2023). Report: "Treatment of chronic apical periodontitis according to the morphology of root canal."
7. XI International Teleconference (Uzbekistan–Russia–Kazakhstan–Belarus), Tashkent State Dental Institute, Uzbekistan, Tashkent (February 15–16, 2024). Report: "Modern aspects of treatment of teeth with complex root canal morphology."
8. International Practical Conference "Ways and Prospects of Development in Dentistry of Kazakhstan: Interdisciplinary Approach in Diagnosis and Treatment of Dental Diseases", Kazakhstan, Almaty (March 27, 2025). Report: "Optimization of endodontic treatment based on the study of root canal morphology using CBCT."

Publications on the Dissertation Topic

Based on the results of the conducted research, 10 scientific papers have been published, including:

- 2 articles in journals indexed in the international databases Scopus and Web of Science Core Collection (Clarivate Analytics);
- 4 articles in journals recommended by the Committee for Quality Assurance in the Sphere of Education and Science of the Ministry of Science and Higher Education of the Republic of Kazakhstan;
- 3 abstracts in the proceedings of international scientific-practical conferences;
- 2 articles published in other editions.

References:

1. International peer-reviewed scientific journal with impact factor (indexed in Scopus, JCR percentile CiteScore 5.9, 93rd percentile, Q1) — Journal of Endodontics:Assessment of the Prevalence of Radix Entomolaris and Distolingual Canal in Mandibular First Molars in 15 Countries: A Multinational Cross-sectional Study with Meta-analysis. 2023 Oct;49(10):1308-1318.
2. International peer-reviewed scientific journal with impact factor (indexed in Scopus, JCR percentile CiteScore 6.7, 89th percentile, Q1) — Scientific Reports:Root and canal configurations of maxillary first premolars in 22 countries using two classification systems: a multinational cross-sectional study.Scientific Reports 15, 19290 (2025).
3. The system of root canal morphology and irrigants used in chronic apical periodontitis.Journal “Nauka i Zdravookhraneniye” (Science and Healthcare), Semey, Vol. 25, No. 6, 2023, pp. 235–245.
4. Evaluation of root canal configuration of mandibular first molars in a Kazakhstan population by using cone-beam computed tomography. Journal “Nauka i Zdravookhraneniye” (Science and Healthcare), Semey, Vol. 25, No. 6, 2023, pp. 122–127.
5. Study of the morphology of root canals of maxillary first premolars in the Kazakh population using cone-beam computed tomography. Journal Pharmacy Kazakhstan, No. 4, August 2024, pp. 111–118.
6. Features of treatment of chronic apical periodontitis using rotary files., Journal «Фтизиопульмонология»No. 4 (46), 2024, pp. 144–152.

Implementation in Practical Healthcare

The main scientific findings and conclusions of this research have been implemented in the practice of the dental clinic “Orbita Dent”, as well as in the educational and clinical enterprise “Daris-TTE” and “Art Dental Clinic” in Almaty.

-Certificate of authorship of the Republic of Kazakhstan No. 56287 dated 01.04.2025.

-3 implementation acts.

Volume and Structure of the Dissertation

The dissertation consists of an introduction, four chapters, a conclusion, findings, a list of references, and appendices. The research work is presented on 130 pages of typescript, including 108 pages of main text, 26 tables, 37 figures and diagrams, as well as appendices. The reference list contains 215 sources in English and Russian.