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PhD THESIS

**MODERN APPROACHES IN THE EVALUATION OF
TREATMENTS AND ROOT CANAL FILLINGS**

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The decision to pursue a Ph.D. in endodontics stems from a deep-rooted passion for addressing the intricate challenges associated with dental pain and pulpal disorders. Recognizing the significant impact of untreated dental issues on patients' well-being and oral functionality, I am driven to contribute meaningfully to the field.

Moreover, my choice to focus on coronal restoration in the context of endodontic therapy reflects a commitment to holistic patient care. Understanding the importance of this stage in the recovery process and exploring advanced techniques and materials for durable dental crown restoration aligns with my vision to enhance the overall quality of endodontic treatments.

The completion of residency studies in the current specialty is an additional reason that motivated me to choose this research topic.

Endodontics represents a complex set of therapeutic procedures designed to treat and heal pulpal and periapical diseases. Through these procedures, the affected dental pulp is removed, followed by meticulous cleaning and disinfection of the root canals, and then filling them with biocompatible materials. The final goal of this process is to save the affected tooth, thereby eliminating discomfort and restoring its functionality in the oral cavity.

Recent technological improvements have revolutionized the field of endodontics, providing dental professionals with more precise and efficient tools and techniques. The use of endodontic microscopes and advanced imaging technologies allows for a detailed and accurate visualization of the internal structures of the teeth, thereby facilitating treatment and reducing discomfort for patients.

The foundation of endodontic treatments lies in achieving meticulous cleaning, effective disinfection, and precise filling of the

endodontic space, ensuring the prevention or resolution of apical periodontal infections. Achieving these objectives depends on a detailed understanding of the varied and complex morphologies of teeth and the endodontic space. Additionally, understanding the dynamic interaction between microorganisms and the host's defense mechanisms in the pulp space is crucial.

This thesis aims to explore the complex landscape of endodontics, investigating microscopic and imaging details, as well as the clinical applications that define modern practice in endodontics. By combining cutting-edge research results with clinical expertise, this work seeks to bridge the gap between laboratory investigations and direct applications in the dental office.

The studies presented in this paper began five years ago within the Department of Dental Propedeutics and Dental Materials, Faculty of Dental Medicine, Victor Babeș University of Medicine and Pharmacy in Timișoara, Research Center in Dental Medicine Using Conventional and Alternative Technologies, “Victor Babeș” University of Medicine and Pharmacy Timișoara, Romania.

The doctoral thesis is structured into two parts: the general part, which presents aspects from the relevant literature for the thesis subject, and the special part, consisting of personal contributions. It concludes with conclusions, followed by bibliographic references and appendices.

The **general part** includes a brief history and a chapter with two sections highlighting the current state of knowledge in the field and contextualizing the selected research topics in the experimental part of the thesis in contemporary endodontic treatments.

In the first section, it is concluded that successful endodontic therapy relies on three key principles: diagnosis, preparation, and obturation. The mechanical preparation of root canals, involving creating access, negotiating canals based on morphology, and establishing the working length, is crucial. Various manual and rotary techniques, along with careful consideration of canal irrigants, contribute to effective cleaning and shaping. The use of multiple irrigants, such as saline, sodium hypochlorite, chlorhexidine, EDTA, and hydrogen peroxide, ensures comprehensive cleaning. Each irrigant serves specific purposes, emphasizing the need for their judicious application for successful endodontic outcomes.

The principles of endodontic obturation focus on achieving a three-dimensional seal of the root canal to prevent reinfections and ensure long-term treatment success. In the second section of the general part, critical aspects are established, including three-dimensional sealing, proper biocompatibility, biomechanical efficacy, removal of the smear layer, conservation of anatomy, and radiographic evaluation. The choice of endodontic filling materials, such as epoxy resin-based, zinc oxide-eugenol, methacrylate resin-based, bioceramic-based, silane-based, and modified glass ionomer-based sealers, depends on specific case requirements. Gutta-percha and Resilon are solid filling components with distinct properties. The selection between them should consider individual cases and procedural requirements.

The **special part**, comprising personal research, is structured into 3 distinct chapters, providing a detailed presentation of the conducted studies. Each chapter incorporates essential elements such as the purpose and objectives of the research, the materials and methods employed, presentation of the obtained results, discussions, specific

conclusions for each study, and ultimately, general conclusions. This section highlights personal contributions, emphasizing the originality and relevance of the conducted research. Additionally, a bibliography is included to support and contextualize the scientific background of these contributions.

For conducting the studies described in this thesis, after presenting the research protocol, approval was requested and received from the Research Ethics Committee (CECS) of the "Victor Babeș" University of Medicine and Pharmacy in Timișoara (Appendix 1 – No.25/28.09.2018). A part of the materials used and the experimental activity were financially supported through the doctoral grant won in the competition organized by UMFVBT, contract no. 16082/02.11.2018.

Chapter 3 provides a study of approaches and analyses of endodontic treatments and periapical lesions using an endoscope and optical coherence tomography (OCT). The study aimed to observe the current state of knowledge regarding the two devices used in dental medicine and beyond. The use of a flexible endoscope enhances real-time three-dimensional images in endodontics, bringing the potential for treatment success. Optical coherence tomography (OCT) is a non-invasive technique that allows for the early diagnosis of dental problems, providing superior three-dimensional images compared to traditional radiographs and assisting in various dental evaluations.

Chapter 4 aims to track endodontic therapy, which involves the mechanical cleaning and shaping of the root canal system, removal of organic and inorganic residues, followed by sealing with permanent filling materials, and its analysis. The teeth selected for this study underwent a mechanical treatment involving cleaning and disinfection of the root canal, followed by endodontic obturation.

The evaluation of endodontic fillings using en face OCT, microCT, and SEM is a study that assessed the quality of endodontic fillings and their adaptation to the morphology of the root canal space using three distinct imaging technologies: optical coherence tomography (OCT) in en-face time-domain, micro-computed tomography (μ CT), and scanning electron microscopy (SEM).

En face OCT images revealed defects at the interface between the root canal wall and the filling material. Some samples exhibited defects in the filling material. The analysis highlighted the presence of different elements at the interface between the material and the identified void, indicating the absence of artifacts in the examined area.

Chapter 5, titled "Mechanical and Fractographic Evaluations of Different Types of Endodontic Post Systems Used in the Restoration of Devitalized Teeth," aimed to select ideal materials for coronal reconstruction of teeth that have lost a considerable amount of hard dental tissue. For this study, fiber-reinforced photopolymerizable resins, pressed ceramic, and pressed ceramic on fiberglass were used. In addition to fractographic analysis, the samples underwent compression tests, and three values were obtained: maximum force, displacement at maximum force, and breaking energy.

As **conclusions** of this doctoral thesis, it was observed that despite continuous progress, materials cannot meet all the requirements for three-dimensional sealing of the root canal space. Using μ CT technology, defects such as gaps in root canal fillings and at interfaces between root canal walls can be confirmed. The high resolution provided by micro-CT reveals a detailed map of the complex morphology of the endodontic space. SEM can accurately reveal the quality of root canal fillings and gaps between the material and canal walls.

The choice of a specific type of endodontic post system for the rehabilitation of devitalized teeth is a complex and multifactorial process, considering multiple considerations. The use of non-metallic or mixed posts proves to be a viable therapeutic option, considering aspects related to the restoration of physiognomy in devitalized teeth. Fractographic analysis of the surfaces of different post systems provided a deeper understanding of their clinical behavior. This explanatory method helps understand how post systems respond to functional and parafunctional demands.

The **personal contributions** included in this doctoral thesis are:

- The use of endoscopes and optical coherence tomography (OCT) significantly improved the diagnostic accuracy for endodontic lesions. These tools allowed for a more detailed visualization of the root canal anatomy and the extent of periapical lesions, challenging to discern with traditional radiographs. The application of these advanced imaging techniques also contributed to better treatment outcomes, facilitating more precise removal of diseased tissue, accurate determination of the working length, and thorough canal debridement, leading to enhanced success rates in root canal treatments.
- One of the standout advantages of using OCT, in particular, is its non-invasive nature. Unlike conventional methods, OCT provides detailed cross-sectional images of the tooth structure without any discomfort to the patient, making it a patient-friendly option.
- The use of en face OCT, microCT, and SEM provided an in-depth assessment of Resilon fillings. En face OCT revealed the adaptation of the material to the canal walls in real-time, microCT offered insights into the internal structure and volume consistency, and SEM allowed for high-resolution surface examination.

- One of the significant findings was the enhanced sealing ability of Resilon compared to traditional gutta-percha. The imaging analyses showed a better adaptation to the canal walls and reduced incidence of voids and gaps, suggesting a potential for improved long-term outcomes of endodontic treatments.
- The study revealed significant differences in the mechanical strength among different types of endodontic post systems. Materials like pressed ceramic on glass fiber posts showed better flexural strength and resilience under stress compared to other groups, indicating their potential for better performance in clinical applications.
- Through fractographic analysis, distinct fracture patterns were identified for each type of post system. Fiber-reinforced and ceramic posts showed more brittle fracture patterns. These findings are crucial in understanding the failure mechanisms of different post systems and their implications for long-term tooth restoration.

The results of the experimental studies in this thesis may lead to the development of clinical protocols that provide safety and predictability in current endodontic practice regarding the use of modern preparation systems and endodontic filling materials. The publication of these research results in high-impact journals and their numerous citations in other valid specialty articles validate the quality of the undertaken studies.