UNIVERSITATEA DE MEDICINĂ ȘI FARMACIE

“CAROL DAVILA” BUCUREȘTI

UNIVERSITÀ DI SIENA

ACADEMIC THESIS

for Doctor of Philosophy (Ph.D.) degree in Dental Medicine

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Doctoral Candidate:

ALEXANDRU GLIGA

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ATTITUDES AND PERSPECTIVES IN ENDODONTIC THERAPY WITH REGARD TO THE PROSTHETIC-RESTORATIVE APPROACH

ACADEMIC THESIS ABSTRACT

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I dedicate this scientific work to my grandfather, who, through the quiet strength of his example, endless patience, understanding and unwavering perseverance, planted in a child's heart the seeds of courage, honesty, knowledge and wisdom, preparing him for the day he would become an honourable man.

– MOTTO –

"I hope that someday people are going to find out what it means to do enough or do only what is needed. We always lean on doing much more because we are afraid of doing less than enough… Potentially this could be the beauty of science after all… finding cases to confirm that balance is an irrational state we always discover by chance."

Alexandru Gliga, May 2019

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List of Published Scientific Papers

1. **Gliga A**, Imre M, Grandini S, Marruganti C, Gaeta C, Bodnar D, Dimitriu BA, Foschi F. *The Limitations of Periapical X-ray Assessment in Endodontic Diagnosis—A Systematic Review*. Journal of Clinical Medicine. 2023; 12(14):4647. *(study detailed in Chapter 7 (pg. 37-59)*

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2. **Gliga A**, Săndulescu M, Amza O, Stănescu R, Imre M. *Dental pathologies of endodontic origin and subsequent bacterial involvement - a literature review.* Germs. 2023 Dec 31;13(4):373-380. PMID: 38361538; PMCID: PMC10866160. *(study detailed in Chapter 8 (pg. 60-68)*

   ISI indexed - impact factor 1.7, doi: 10.18683/germs.2023.1407

3. **Gliga A**, Gaeta C, Salvati G, Foschi F, Azaripour A, et al (2025) *The Platformless Technique (PFLT): A Minimally Invasive Technique for Removing Separated Instruments: Case Report Study*. Ann Case Report. 10: 2175. *(study detailed in Chapter 9 (pg. 69-77)*

   BDI indexed, https://doi.org/10.29011/2574-7754.102175

4. **Gliga A**, Gaeta C, Foschi F, Grandini S, Aranguren J, Ruiz XF, Azaripour A, Săndulescu M, Diaconu CT, Bodnar D, Imre M. *A Cross-Sectional Survey Assessing the Factors Influencing Dentists' Decisions on Post-Endodontic Prosthetic Crown Restoration.* Journal of Clinical Medicine. 2025; 14(11), 3632. *(study detailed in Chapter 10 (pg. 78-98)*

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Symbols and Abbreviations

AAE	American Association of Endodontists
CBCT	Cone-Beam Computed Tomography
Chi²	Chi-squared Test
CHX	Chlorhexidine
DNA	Deoxyribonucleic acid
EDTA	Ethylenediaminetetraacetic Acid
FI	Fractured Instrument
FOV	Field of View
GDP	General Dental Practitioner
IL-1	Interleukin-1
ISO	International Organization for Standardization (Standardisation of Instruments)
LPS	Lipopolysaccharide
MOE	Margin of Error
MRI	Magnetic Resonance Imaging
NaOCl	Sodium Hypochlorite
OPG	Orthopantomography
PA	Periapical
PFLT	Platformless Technique
PICO	Population, Intervention, Comparison, Outcome
PICOS	Population, Intervention, Comparison, Outcome, Study design
PRISMA	Preferred Reporting Items for Systematic reviews and MetaAnalyses
PUI	Passive Ultrasonic Irrigation
RCT	Root Canal Treatment
ROC Curve	Receiver-operating characteristic curve
SAP	Symptomatic Apical Periodontitis
TNF-α	Tumour Necrosis Factor Alpha
U-file	Ultrasonic File
USA	United States of America

Introduction

Current context in interdisciplinary dentistry

Collaboration between dental specialties, particularly endodontics and prosthodontics, requires active communication and a shared theoretical and practical foundation, enabling clinicians to adopt coherent, patient-centered solutions. Interdisciplinarity should not involve fragmented planning where each specialist focuses solely on a narrow part of the treatment plan. Endodontic therapy is intrinsically linked to the prosthetic-restorative strategy; it conditions prosthetic success, just as the restorative approach influences the long-term outcome of endodontically treated teeth. The prognosis of an endodontically treated tooth depends on the quality of both the root canal procedure and the final restoration, underscoring the need for integrated management. Coronal microleakage, leading to contamination or recontamination of the endodontic space, frequently results from an improperly fitted crown restoration or delayed completion of the final restorative procedure. Incorrect or unjustified use of temporary restorations can also contribute to these issues.

Factors influencing clinical decision-making and research motivation

Clinical decision-making processes exhibit significant variability and dentists often study only superficially the limitations of dental practice methods, instruments and equipment. This can lead to a level of confidence that exceeds the actual sensitivity and specificity of these tools. Critical analysis of scientific data is an essential skill in today's dental practice, characterized by intense publication activity and vast databases. Dentists need to continuously develop critical appraisal skills to select, interpret and apply relevant data, differentiating valid scientific sources from those lacking a sound basis. Without these skills, therapeutic approaches based on incomplete or inaccurate information risk negatively impacting healthcare quality.

This reality highlights the importance of this research, which aims to assess dentists' cognitive and practical mechanisms in interdisciplinary decision-making to optimize clinical care quality. These elements, combined with personal observations from dental practice, motivated the choice of this research topic and the establishment of a working hypothesis. The three research directions chosen aimed to draw conclusions regarding diagnostic methods, microbiology and minimally invasive practice in endodontics. The final study integrated the concept of interdisciplinarity and decision-making algorithms.

I. Current State of Knowledge

1. Contemporary Perspectives in Endodontics and the Role of Diagnostic Imaging

Diagnostic terminology developed by the American Association of Endodontists (AAE) was globally recommended and adopted to promote international consistency in clinical interpretation and treatment planning for irreversible pulpitis, pulp necrosis, symptomatic and asymptomatic apical periodontitis, acute and chronic periapical abscess, and condensing osteitis [1, 2]. However, a 2022 study found significant variations among specialists and general dentists in understanding and using this terminology, especially in complex or inconclusive cases. Recommendations include updating the AAE terminology with terms like “Non-responsive regenerated pulp”, “Responsive regenerated pulp” and “Inconclusive pulp condition” to enhance clinical communication and accuracy [3].

Advanced imaging methods like Cone-Beam Computed Tomography (CBCT), Magnetic Resonance Imaging (MRI) and ultrasonography have been developed and integrated into dental diagnosis to provide more detailed investigation of dento-maxillary anatomy and overcome limitations of conventional methods [4-10].

Accurate diagnosis and precise differentiation of periapical lesions are difficult under standard dental practice conditions and without advanced training in complementary imaging techniques [11-15]. Despite numerous publications, the actual clinical need to establish a histological diagnosis of periapical lesions using imaging methods remains uncertain. Determining a differential diagnosis between periapical granuloma and apical radicular cyst based on imaging results is unreliable and can lead to confusion in clinical practice and interdisciplinary communication [11-15].

The incidence of cystic lesions among periapical lesions is reported to be between 15% and 20% [6, 11, 16, 17]. While there is no consensus on the necessity of determining the histological nature for appropriate treatment planning, granulomas and pocket cyst lesions are considered significantly more likely to heal following orthograde endodontic treatment than true cyst lesions, for which surgical retreatment is often considered inevitable [6, 16].

Serial sectioned histological examination of periapical lesions remains the only definitive method to confirm the presence of a continuous epithelial membrane in an apical cyst structure [6, 7, 11, 15, 16]. While CBCT significantly improves exploratory capacity compared to periapical or panoramic radiography, histology remains the method of choice for confirming a differential diagnosis [4, 8, 13]. Rational and clinically justified use of CBCT is recommended, avoiding overuse due to increased patient exposure to ionizing radiation, compared to traditional radiography [4]. CBCT is recommended exclusively in complex clinical cases where conventional imaging does not provide sufficient information for an optimal therapeutic strategy.

Advanced imaging findings should be interpreted critically and cautiously to ensure accurate diagnosis. Understanding the limitations of paraclinical investigations, acquiring thorough theoretical knowledge and performing a detailed clinical examination are fundamental for developing effective diagnostic and therapeutic strategies.

2. Microbial Aetiology in Endodontic Disease

Dental caries serve as a primary route for pathogenic microorganisms to access the endodontic system, triggering inflammation [18]. Untreated, bacteria, identified as the main etiological factor, advance into the root canal, forming an endodontic microflora that influences pulp inflammation and periapical pathologies [17, 19, 20]. Bacterial contamination can also occur through other pathways like cracks, leakage or periodontal disease. Bacteria release virulence factors such as lipopolysaccharides (LPS) from Gram-negative species, inducing inflammation and stimulating the production of pro-inflammatory mediators like cytokines [20]. The severity of inflammation and tissue damage correlates directly with the presence and virulence of these bacterial products [21, 22]. Apical periodontitis develops as the inflammatory process spreads to the periapical space, causing periodontal ligament inflammation and bone resorption, which is amplified by bacterial cytokines [17, 21].

Endodontic infections are often polymicrobial, involving a wide variety of bacterial species that form complex, predominantly anaerobic communities [21, 23]. Among the commonly identified bacteria are Enterococcus faecalis, Porphyromonas gingivalis, Prevotella intermedia, Fusobacterium nucleatum and Actinomyces spp., which are directly involved in the development and persistence of infections [20, 23]. While planktonic

bacteria are present, the primary cause of persistent infections is the ability of many species to form biofilms [23, 24].

Biofilms are structurally complex bacterial communities organized in three-dimensional structures, adhering to dentinal surfaces and embedded in an extracellular matrix [24, 25]. This structure protects bacteria, significantly increasing their resistance to antimicrobial agents and advanced disinfection protocols used in endodontic treatments [25]. The persistence and recurrence of endodontic infections are largely attributed to this increased bacterial resistance acquired through biofilm organization [20]. Enterococcus faecalis is frequently implicated in persistent infections due to its robust survival capabilities and enhanced resistance within biofilms [20, 23, 26]. Extraradicular biofilms, particularly involving Actinomyces and Propionibacterium propionicum, can also form on the root surface and are associated with persistent periapical lesions [23, 27].

The management of endodontic infections focuses on advanced antimicrobial strategies to eliminate bacterial biofilms and achieve high-level disinfection [20, 21]. Current approaches involve chemo-mechanical treatment, combining mechanical removal via instrumentation with the use of specific antiseptic and chelating irrigation solutions like sodium hypochlorite (NaOCl) and EDTA [17, 24]. Sodium hypochlorite demonstrates antimicrobial and biofilm disruption activity, enhanced by methods like ultrasonic irrigation [21, 23]. However, some irrigants like chlorhexidine (CHX) have limitations when used alone [21, 25]. The goal is to remove bacteria and their biofilms through thorough cleaning and shaping before sealing the root canal system. Despite advancements, removing bacterial biofilm remains a challenge, representing a central factor influencing treatment prognosis and therapeutic strategy. A thorough understanding of these bacterial processes is essential for developing effective therapeutic management.

3. Mechanical Complications and Management of Separated Instruments in Endodontic Treatment

Fracture of endodontic instruments is a common procedural complication in endodontics, impacting the predictability and long-term prognosis of treatment. Studies indicate the prevalence ranges from 0.4% to 23% [28]. The incidence is influenced by various factors, including the type of instrument, the complexity of root canal anatomy and the clinician's experience and technique [28-31]. Complex root canal morphology,

particularly curvature and narrowness in regions like the apical third, presents significant challenges and increases the risk of fracture [28, 30-32]. Furthermore, insufficient clinical training and excessive pressure during procedures contribute to errors. The presence of a fractured instrument can obstruct access to the entire root canal length, preventing adequate chemo-mechanical treatment, hence, if not removed, the probability of treatment failure increases [33-35].

Managing fractured instruments is challenging and requires adapting the clinical approach based on the fragment's location and canal anatomy. Techniques for removal include mechanical, chemical and surgical methods, each with specific advantages and limitations. Conventional mechanical techniques, such as the Instrument Removal System (iRS) and Masserann techniques, involve grasping the fragment, but often necessitate excessive removal of hard tooth structure to expose the instrument, increasing the risk of root perforation [32, 36, 37]. Other mechanical methods relying on grasping devices typically require creating a staging platform and circumferential groove around the instrument, which can be difficult or risky in complex anatomy [30, 32, 33]. Chemical techniques aim to dissolve the instrument using solvents [28].

The success rate of removing fractured instruments varies considerably depending on the fragment's location and length within the canal [33, 34, 38]. Fragments located in the coronal and middle thirds show a higher removal success rate (91.2%) compared to those in the apical third (79%) [33]. Similarly, fragments located before a canal curvature have a higher success rate (92%) than those located after the curvature (50%) [34]. Longer fragments are generally more difficult and time-consuming to remove [29, 39].

The use of an operating microscope is also crucial for enhancing visibility and improving the success of removal techniques [35].

4. Integrating Prosthetic Considerations into the Endodontic Decision-making Process

An interdisciplinary approach involves evaluating remaining tooth structure, restorability, selecting the optimal restorative method and considering the patient's occlusal, periodontal and systemic context [40-43]. A core principle is to maintain the tooth within the dental arch for as long as possible, which requires preserving hard tooth structure during both endodontic therapy and the subsequent restorative plan [44].

Neglecting restorative considerations early on can lead to negative consequences, including reduced tooth fracture resistance, compromised long-term prognosis, coronal microleakage and recontamination of the endodontic space [45-47]. Biomechanical analyses support the use of indirect prosthetic restorations such as full crowns, endocrowns, onlays and overlays for teeth with extensive coronal destruction due to their superior mechanical strength and reduced fracture risk compared to direct composite restorations [48-50]. The necessity and appropriate use of posts remain subjects of debate [42, 51, 52]. Ultimately, carefully planned integration of restorative considerations is crucial for preventing biological and biomechanical complications and ensuring long-term therapeutic success [44, 45, 53].

However, the integration of prosthetic considerations shows considerable variability in clinical practice, influenced by factors like educational background, clinical experience and access to advanced technology [41, 52, 54]. There is a notable absence of clearly defined clinical guidelines and a unified decision-making algorithm specifically tailored to an interdisciplinary approach [45, 55, 56].

II. Personal Contributions

5. Main Hypothesis and General Objectives

Main hypothesis: "Assessment volatility, lack of interdisciplinary guidelines and dissentient integration of restorative-prosthetic principles into endodontic decision-making influence treatment outcome and foster disruptions".

The foundation of this thesis arose from my clinical experience and my professional interactions with referral dentists across various age groups. The research aims to study inconsistencies in daily clinical practice regarding endodontic diagnosis, perception and decision-making, focusing on interdisciplinarity and integrating restorative considerations. Extensive knowledge of the endodontic-restorative interface and analysis of inconsistencies can highlight clinical and scientific vulnerabilities, raise awareness and contribute to solutions for improving outcomes and tooth retention.

General objectives: The main objective was to address the hypothesis by identifying and analyzing the reasons behind variability in assessment and clinical decision-making at the endodontic-restorative interface.

Along with this main objective the research included four other milestone objectives:

- Conduct a high-level evidence-based research to study the limitations of current imaging tools in periapical diagnosis.
- Perform a comprehensive literature update and analysis on the main ethiological factor in endodontic disease: bacteria.
- Develop and clinically validate a minimal invazive technique that conserves healthy dentine within the endodontic complications management.
- Assess and confirm clinicians' perception and decision-making patterns through an in-depth analysis, validating personal clinical observations and identifying disruptions.

6. General Research Methodology

This PhD thesis was designed following a three-path research protocol integrating systematic reviews, a clinical case-report study presenting an innovative technique and a detailed cross-sectional survey analysis, addressing clinical inconsistencies encountered in daily practice under the interdisciplinary umbrella of endodontics and restorative dentistry.

Two systematic reviews were conducted to critically analyse and synthesize current literature and provide evidence-based data addressing two of the four study objectives: the limitations of dental imaging investigations and the role of bacteria as the primary etiological factor in endodontic pathology.

The separation of endodontic instruments represents a contemporary topic influencing the perception, decision-making processes and clinical approaches among endodontists, prosthodontists and general dental practitioners (GDPs). This unfavorable clinical accident can compromise treatment outcomes; therefore, a new technique was developed to help clinicians minimize tooth structure loss and predictably regain access to the root canal anatomy, allowing a clear disinfection protocol. This method described in a case-report study enhances treatment outcomes and increases tooth retention probability by addressing two important factors: bacterial removal and preservation of dental tissues.

Finally, a cross-sectional survey was conducted, providing quantitative and qualitative data on dental practitioners' perceptions and decision-making approaches in clinical situations involving endodontic diagnosis, bacterial involvement and procedural complications. Advanced statistical analyses were performed to investigate dependencies, patterns and associations.

Results from these four studies were analyzed and critically discussed within this thesis, leading to scientifically and clinically significant conclusions.

7. Study 1: “The Limitations of Periapical X-ray Assessment in Endodontic Diagnosis—A Systematic Review”

Secondary hypothesis: "Limitations of periapical radiography and imaging differential diagnosis generate erroneous and divergent interpretations among dentists, directly affecting treatment planning".

7.1. Introduction

Knowing the capacity of periapical X-ray and pragmatically assessing the nature of a periapical lesion is important, but attempting a differential diagnosis of cyst, granuloma or epithelial cells on a periapical X-ray might be an assumption. A consensus exists that a periapical cyst follows chronic apical periodontitis [15]. One argument for diagnosing a cyst via periapical X-ray is the observation of the epithelial lining defining clear margins. However, while 52% of periapical lesions contain organized epithelial cells, the incidence of cystic lesions is only 15% [15]. This aligns with the 85% success rate in orthograde retreatments, as periapical cysts may require a retrograde endodontic approach [57]. Assessing epithelial cells on a periapial X-ray can appear over-elaborated due to imaging dissimilarities, questioning the ability to differentiate.

It is crucial for clinicians to know the extent to which a tool can be trusted to use it properly. Periapical X-ray is a 2D image projecting a 3D anatomy with potential detail superimposition. While CBCT offers a new perspective, it should be used only when further investigation is needed and its own limitations considered. The presence or absence of lamina dura can be assessed by periapical X-ray, but no correlation is found with histological diagnosis of a cyst [15]. Lesion dimension had weak correlation with histology even for CBCT, advising biopsy analysis [10]. Density measurements do not provide feasible and reliable results predictably linked to histological aspects [58]. A review of 104 cases found no common aspects between periapical X-ray and histology to develop a diagnostic pattern [59].

The aim of this review was to compare the histological diagnosis of apical cyst to periapical X-ray characteristics based on high-quality studies.

7.2. Materials and Methods

This systematic review was registered in PROSPERO (CRD42023406854) and followed PRISMA guidelines using the PICO framework. The clinical questions were: “To what extent is a clinician able to diagnose a periapical pathology using periapical imaging investigation and how would this detailed assessment impact the clinical approach?”. P: Patients with apical periodontitis. I: Periapical X-ray diagnosis. C: Histological examination. O: Correlation between X-ray and histological findings to avoid misdiagnosis and overtreatment.

Five electronic databases were searched: Ovid Medline, PubMed, ScienceDirect, Mendeley and Scopus using keywords like “periapical periodontitis” AND (X-ray OR Radiography) AND “diagnosis” AND “histology”. Search results were narrowed by subject, abstract and methodology.

7.2.1. Inclusion Criteria

• Articles published in English or using English as a second language.

• Articles using histopathology as a gold standard for periapical diagnosis.

• Articles using periapical X-ray as the main or comparative imaging technique.

7.2.2. Exclusion Criteria

• Book chapters, personal opinions, letters, narratives, commentaries, conference abstracts.

• Studies not published in English.

• Studies using other imaging techniques (OPG/CBCT) without clear differentiation.

• Studies with induced pathology.

7.2.3. Study Selection

Titles and abstracts were screened independently by two calibrated reviewers, with disagreements resolved by a third author. Full-text analysis followed based on eligibility criteria.

7.2.4. Data Collection Process

Data was collected by two independent reviewers using a datasheet during full-text analysis. Duplicates were removed and studies were excluded if inclusion/exclusion criteria

were not met or methodology/objective was unclear. Risk of bias and quality were assessed. A flowchart illustrated the process.

7.3. Results

Initially, 52 articles were included, with one duplicate removed. After full-text reading of 51, 14 more articles were added from extended searches, resulting in 65 studies for review. Forty-nine publications were eliminated for various reasons: 22 used other imaging techniques, 9 lacked applicable information, 7 were on cadavers, 3 had induced pathology and 2 didn't differentiate imaging types. 16 studies matched the criteria and were included.

A quality score was calculated for each included study using an adapted table from McGrath et al. (2009), with scores ranging from 11 to 20.5.

A 22-year retrospective study found that while 68.4% of cases were diagnosed as cysts on X-ray, only 15.6% were histologically confirmed cysts, the rest being granulomas [59]. Sensitivity and specificity were measured in another study, which found that in 63% of cases, the level of inflammation assessed by periapical X-ray related correctly to the histological category [60]. This study concluded that further research is needed and periapical X-rays and CBCT information should be mindfully considered. Another article demonstrated a weak correlation between periapical X-ray and histologic diagnosis (kappa = 0.104) [10]. It also found that CBCT overestimated radicular cyst diagnosis by 8% compared to 2D. Assessing periapical cysts using periapical X-ray can only be considered "tentative".

A study investigating imaging findings and histological inflammation levels found 45% of lesions described as granulomas and 55% as cysts radiologically, but histological assessment reported 81.6% granulomas and 18.3% cysts [61]. A study analyzing 221 digital X-rays found agreement between radiogram and histopathological diagnosis around 60%, suggesting that distinguishing cysts and granulomas using density indexes is plausible to some extent, but not always applicable due to anatomical superimpositions [58].

The capacity of digital radiometric analysis to discern between cysts and granulomas was investigated, suggesting it could be realistic if visual accuracy (no superimpositions) is present [62]. However, another study contradicted this, finding no differentiation in radiometric measurements between granulomas and cysts, even with a larger sample size

[63]. This study found that histologically diagnosed cysts tend to be larger than granulomas, but the median grey level didn't change considerably between the diagnoses. A comparative descriptive study found similar prevalence of periapical cysts (28.5%), but no data on correlation between X-ray diagnosis and histopathological assessment [64]. Despite calibration and standardization efforts, no relationship between macroscopic and radiologic size was found.

A retrospective study investigating radiographic features of persistent periapical radiolucencies and histological diagnosis found a higher incidence of granulomas (72%) and lower incidence of radicular cysts (21.5%) [11]. While some lesions presenting radiopaque lamina on X-ray were histologically cysts, others were epithelialized granulomas. The case study by Ricucci et al. found that out of 57 lesions, 10 (18%) were histologically cysts, 35 were granulomas and the rest were abscesses. Comparing X-ray and histology, only 3 out of 10 radiological images with radiopaque lamina were cysts, while 7 out of 47 lesions without a cyst-like image were histopathologically confirmed cysts. The authors advise avoiding "cyst" or "granuloma" terminology based on imaging alone, recommending "periapical radiolucent lesion".

A study by Ricucci et al. linked bacterial biofilms to persistent chronic pathology, including large periapical lesions and cysts [15]. It aimed to analyze biofilm presence and potential connections with radiographic size and histopathological diagnosis. Questioning the predictability of periapical imaging has existed since early research. One study found successful correlation between biological diagnosis and X-ray assessment in 12.7% of cysts and 58.7% of granulomas [65]. It concluded that periapical imaging should only locate the pathology and clinicians should not base their approach on imaging features; textbooks describing roentgenographic characteristics differentiating cysts from granulomas should review their statements.

A comparative study assessing ultrasound, conventional and digital periapical radiography found remarkable accuracy (86.7–100%) for ultrasound compared to the gold standard, though sample sizes were small [66]. The power of research depends on the sample size, influencing confidence level and margin of error.

7.4. Discussion

This review, based on strict inclusion/exclusion criteria, is limited by the number of included articles and samples. Evaluating whether a clinical diagnosis can be related to histological diagnosis using periapical X-ray requires agreed terminology, which was used in this review. It is confusing to find divergent classifications, even for skilled researchers. Available clinical tools do not perfectly translate the true histological status, leading to various clinical diagnoses for the same presentation over time. The AAE proposed terminology to standardize definitions for everyone in the field [1].

Many publications have correlated histological status with clinical signs and symptoms [64, 67-70], however, available clinical diagnostic tools do not truly assess histopathology.

An argument exists for the irrelevance of determining exact histological status since the advocated orthograde treatment is often the same. However, some authors suggest a pocket cyst might heal after orthograde treatment, while a true cyst may require surgical intervention [11].

The review highlights evidence that periapical imaging lacks predictable features for granulomas and cysts, and the need for surgical intervention cannot be ascertained by X-ray alone. Persistent apical pathology is influenced by factors like refractory intracanal infection, host immune response, foreign body reaction, extraradicular infection, or cystic lesions [40, 71]. The etiology is endodontic and clinicians must be aware of variables influencing long-term outcome and adopt a comprehensive assessment. The incidence of cysts ranges from 6% to 55%, dropping to 15% when serial section histology is used, limiting its relevance [15].

Ultrasound shows promising accuracy for differential diagnosis [9, 72, 73]. However, the sample sizes analyzed in these studies are small, limiting scientific conclusiveness. External validity is also limited by practitioners' knowledge and access to machinery.

Given that studies were conducted in strict conditions, achieving better performance in private practice with varied quality X-rays is unlikely. Many variables make complete reliance on dental X-ray interpretation difficult. CBCT was introduced, although even 3D

imaging can have discrepancies. For differential diagnosis between cyst and granuloma, no current clinical imaging tool is as accurate as histopathology.

A study comparing periapical X-ray and CBCT for apical periodontitis diagnosis concluded comparable accuracy, however, radiopaque lamina feature is not sufficient for cyst diagnosis and caution is needed for both periapical X-rays and CBCT [59, 60]. A review of 1108 cases found 16.8% cystic lesions, classifying any sample with epithelial lining (even fragmentary) or large lesions with inflamed fibrous capsules as cysts [74]. Another study found a 20% incidence of cystic lesions related to internal apical resorption [75].

7.5. Conclusions

While not establishing guidelines, this review aids in comprehensive assessment of endodontic situations to avoid overtreatment and promote conservative approaches. The radiological diagnosis is inaccurate, requiring improvement. The patient's decision and outcomes influence the approach and dentists should explain options, including specialist referral when limited by training, skills, experience or confidence. Further well-designed research is needed. Awareness campaigns should help clinicians understand periapical X-ray limitations and develop coherent treatment plans without misconceptions.

8. Study 2: ”Dental pathologies of endodontic origin and subsequent bacterial involvement – a literature review”

Secondary hypothesis: "Bacterial biofilm is the main etiological factor in endodontic pathologies and its effective control through a rigorous disinfection protocol is decisive for treatment success".

8.1. Introduction

Dental pathologies of endodontic origin typically begins with injuries like caries or trauma, allowing microbial invasion, primarily by oral bacteria, into the dental pulp. This leads to pulpal inflammation (pulpitis), which can progress from reversible to irreversible, culminating in pulp necrosis [76]. As the infection advances into the root canal system, bacteria form complex, predominantly anaerobic communities, leading to root canal infection [76].

8.2. Review

Polymicrobial infections, involving a diverse range of bacterial species, are common. Bacteria, identified as the primary cause of endodontic diseases, release virulence factors and byproducts that trigger inflammation and contribute to tissue destruction in the periapical region, leading to conditions like periapical granulomas, cysts and abscesses [77-79]. Common bacterial generally involved include Enterococcus [80], Porphyromonas [81], Prevotella [81], Fusobacterium [82] and Actinomyces [83]. Enterococcus faecalis, in particular, is frequently associated with persistent infections after endodontic treatment due to its resilience [84, 85].

A key characteristic of endodontic bacteria is their ability to organize into biofilms, which are complex three-dimensional structures adhering to dentinal surfaces and embedded in an extracellular matrix. This biofilm organization provides significant protection from host defenses and antimicrobial agents, contributing to the persistence and recurrence of endodontic infections, especially in areas difficult to access with instruments [86-88]. Extraradicular biofilms can also form on the root surface and are associated with persistent periapical lesions [89].

8.2.1. Updates in the Management of Endodontic Infections

The management of endodontic infections focuses on chemo-mechanical treatment to remove infected tissue, bacteria and their biofilms, aiming for high-level disinfection [90]. This involves mechanical instrumentation combined with the use of irrigating solutions like sodium hypochlorite (NaOCl), considered the gold standard for its tissue dissolution and biofilm disruption capabilities, often used alternately with EDTA [24]. While various irrigants and activation techniques like passive ultrasonic irrigation (PUI) and laser-based methods are used to enhance disinfection and biofilm removal [24], some, like chlorhexidine (CHX), have limitations against mature biofilms and can even increase their resistance [91]. Intracanal medications like calcium hydroxide also offer complementary antimicrobial effects, particularly in persistent cases [92]. However, complete elimination of bacterial biofilms remains a significant challenge in endodontic therapy, representing a central factor influencing treatment prognosis and strategy. Understanding the role of bacterial biofilms is crucial for developing effective diagnosis and management strategies for endodontic infections.

8.3. Conclusions

In conclusion, bacteria play an important role in the pathogenesis of endodontic infections, alongside other contributing factors. The management of endodontic infections should take into consideration novel methods of local treatment, addressing the presence of bacterial biofilms alongside planktonic bacteria.

9. Study 3: “The Platformless Technique (PFLT): A Minimally Invasive Technique for Removing Separated Instruments: Case Report Study”

Secondary hypothesis: "Preservation of dental hard tissues by minimally invasive techniques such as Platformless Technique (PFLT) allows predictable extraction of separated instruments, regaining root canal patency and optimizing interdisciplinary therapeutic success".

9.1. Introduction

Removing fractured endodontic instruments from root canals is often challenging, requiring adaptation based on fragment location and canal morphology [93]. Various techniques exist, including mechanical, chemical and surgical [28, 94].

Traditional mechanical techniques, using grasping devices, often require creating a staging platform and circumferential groove around the instrument [28, 32, 38, 95]. This is often difficult in complex anatomy due to iatrogenic risk. Chemical techniques use solvents to dissolve the instrument, but have limitations like prolonged time and adverse effects on tissues [28]. The choice of technique remains at the clinician's discretion, considering instrument type, length, location, accessibility and canal morphology.

The difficulty of removing fractured instruments is influenced by factors like tooth anatomy, position and size of the fragment, available equipment and operator skills. The fundamental aspect of the therapeutic approach is preserving healthy dentine to avoid weakening the tooth and increasing fracture risk.

A new technique, the "Platformless Technique" (PFLT), was developed to reduce healthy dentin removal by eliminating the platform stage. This technique was described in a case report study with three cases showing imaging follow-up from 2 to 5 years, indicating stability and predictability.

9.2. Materials and Methods

The concept of PFLT is to reduce healthy dentin removal by eliminating the platform stage. The use of a microscope is mandatory for correct and minimally invasive application, avoiding iatrogenic risks. PFLT involves creating a bypass using a stainless-steel ultrasonic file after using a final shaping mechanical file to reveal the separated fragment, avoiding the creation of a platform with cutting burs, Gates Glidden or modified Gates Glidden drills used in other techniques.

The approach depends on the fragment's position. If coronal and not needing exposure, a pre-bent ultrasonic K-file 15 ISO (U-file) is used with an ultrasonic device at the lowest intensity, following the available canal space. Constant irrigation with sodium hypochlorite 3-5% is mandatory for debris evacuation, cooling and disinfection. EDTA 17% solution is recommended as an irrigant during removal.

The procedure requires patience, controlled force and a delicate touch. Ultrasonic intensity can be increased cautiously if the U-file separates, maintaining irrigation.

A key aspect is the elimination of the platform. A simple pre-flaring technique using a final shaper (e.g., 0.6 taper ISO 25 mechanical file) is sufficient to enlarge the space and detect the separated instrument. When the file reaches the instrument, it might stop or bypass; if it bypasses, the clinician should stop and use the ultrasonic file. Tactile feedback and experience enable removal even without visual identification. A direct bypass with U-files can be guided by pre-operative CBCT for anatomy and an apex locator attached to the U-file to reduce iatrogenic risk.

9.3. Cases Presentation

9.3.1. Case 1

A-52-year-old female patient diagnosed with symptomatic apical periodontitis (SAP) presented a fractured instrument in the middle/apical third of the mesial root canal, a large apical lesion involving both root apices and a screwed metal post in the distal canal under a crown. After crown and post removal, a 25/0.6 instrument was used to reveal the fragment in the mesiobuccal canal. Bypass was guided towards the internal curvature with abundant sodium hypochlorite irrigation and a 15 ISO U-file. After removing the fragment, patency was re-established and obturation was performed.

9.3.2. Case 2

A 20-year-old male with pain on biting associated with a left mandibular first molar, presenting multiple fractured instruments. CBCT allowed visualization of fragments for minimally invasive management. The fragments were removed using the PFLT protocol safely. Shaping, cleaning and sealing were done, addressing secondary anatomies. A 5-year follow-up showed complete remission of the lesion. Five-year follow-up and microscopic images of fragments before and after removal.

9.3.3. Case 3

A 43-year-old female referred with fractured instruments. After cleaning the pulp chamber, no pre-flaring was performed since the referral dentist's failed intent was carried out using a platform stage with excessive healthy dentine sacrificed already. The instrument was directly removed using U-Files. Although a favourable outcome, unnecessary pericervical tissue was removed prior to the "Platformless" approach and no complications or adverse conditions had to be reported. Fiber post was placed in the distal canal and post-endodontic restauration was performed. After 2 years, a complete healing of the periapical lesion can be noted.

9.4. Results

In all three cases shown, the symptoms disappeared immediately after treatment, allowing the patients to regain chewing function. The immediate resolution and long-term stability of the works produced positive feedback from patients and satisfaction in having been treated with the use of a conservative and minimally invasive technique.

9.5. Discussion

From a clinical perspective, factors such as fragment length, instrument type, location, accessibility and canal morphology influence both the difficulty of the procedure and its success rate. The operating microscope significantly improves the process.

Compared to surgical management, the PFLT aims to be an orthograde mechanical removal technique that preserves original endodontic anatomy and maintains conservative shaping. It avoids the removal of healthy tissue around the coronal portion of the fragment, thus not creating a platform. The creation of a 360° platform with trephine burs requires significant sacrifice of dental structure to allow extractor placement, which is excessively invasive in many situations, increasing iatrogenic risks.

Comparing PFLT with other ultrasonic techniques, using a pre-bendable stainless-steel ultrasonic K-file 15 ISO is more conservative. While some light tissue removal might be needed for fragments in the middle or apical third, this occurs via conservative pre-flaring with final shaping files, not Gates Glidden burs. The main advantage of PFLT is reduced healthy dentine loss, lowering the tooth weakening effect. Post-operative radiographs can show minimal alteration of canal anatomy.

9.6. Conclussions

In conclusion, the developing of this new technique may give clinicians a new perspective on how to improve clinical skills and provide a patient centered approach that ensures predictability and minimal invasiveness.

10. Study 4: “A Cross-Sectional Survey Assessing the Factors Influencing Dentists’ Decisions on Post-Endodontic Prosthetic Crown Restoration”

Secondary hypothesis: "The lack of a unified decision-making algorithm affects the coherent integration of prosthetic considerations into endodontic therapy, reducing predictability and interdisciplinary success".

10.1. Introduction

Endodontic therapy aims to preserve teeth with pulpal and periapical diseases [96]. Successful outcomes depend on the quality of root canal procedures, however, variability exists in clinical approaches, decision-making and outcomes with potential drawbacks of multidisciplinary approaches [97].

This study aimed to assess Romanian dentists' decision-making regarding prosthetic considerations in endodontic practice to bridge knowledge gaps. By identifying disparities in post-endodontic crown placement decisions, it provides evidence for national policy reforms, including standardizing timing protocols and defining interdisciplinary referral criteria. The study evaluated diagnostic imaging preferences, factors influencing restorative decisions and the perceived role of prosthetic planning. Findings could inform future guidelines and education, supporting an integrated approach.

10.2. Materials and Methods

A cross-sectional electronic survey was conducted among Romanian dentists. Ethical approval was obtained from the Carol Davila University Ethics Committee. Participation in

the survey was voluntary, anonymous and an informed consent was obtained electronically, being included in the Google Forms document.

This survey is part of a larger multicentric study, but this research focused exclusively on responses from Romania. The structured questionnaire included demographic data, diagnostic imaging preferences and restorative decision factors. Questionnaire content validity was reviewed by endodontists and prosthodontists (CVI > 0.7). Pilot testing assessed clarity and relevance. A second pilot test assessed internal consistency (Cronbach's alpha > 0.7).

Dentists were recruited via professional networks and associations. Inclusion criteria: valid license, active practice in Romania, fluency in Romanian. Reminders were sent to maximize participation. 238 complete responses were collected; 20 students were excluded, leaving 218 for analysis, meeting the minimum sample size for statistical relevance (margin of error ±6.6% at 95% confidence). No missing data handling was needed. Data analysis used descriptive statistics and inferential analyses (Chi-square, logistic regression).

10.3 Results

Periapical radiography was the most frequently used imaging modality (83.49%), followed by CBCT (53.67%) and panoramic radiography (48.17%). A high confidence level (over 70%) was reported for CBCT accuracy in differentiating between periapical cysts and granulomas, perceived as significantly higher than periapical X-ray accuracy.

However, this perceived high accuracy of CBCT did not significantly drive preferences towards immediate invasive treatments like apicoectomy or extraction, even when a fractured instrument was present. Dentists generally preferred conservative options such as retreatment and monitoring or specialist referral. Endodontists, specifically, were significantly less likely (approximately five times) to choose an invasive approach compared to other dental specialties. The availability of a hypothetical minimally invasive histological diagnostic tool strongly shifted preferences towards conservative decisions (81.65%) across all specialties, suggesting a general inclination towards less invasive treatment when definitive diagnosis is certain.

Regarding restorative timing, a strong preference (69.3%) was observed for postponing definitive restorations until complete radiographic healing in cases with ongoing periapical lesions. While endodontists showed no statistically significant preference for

postponing, other specialties exhibited a strong preference for delay. Factors influencing decisions for restoring versus extracting teeth were prioritized differently among specialists. Endodontists notably prioritized the "Feasibility of successful restorative outcomes" and, compared to other specialists, placed greater importance on the "Complexity of the root canal system", "Radiographic characteristics of the lesion" and "Presence of a fractured instrument" when deciding between preservation and extraction. Non-endodontic specialists, conversely, assigned relatively greater importance to "Financial considerations" and "Patient preference". The risk of tooth fracture was rated as highly important by all groups.

10.4. Discussion

The findings highlight a discrepancy between dentists' perceived diagnostic capabilities of imaging tools, particularly CBCT, and the actual scientific evidence. This overestimation of imaging accuracy carries a risk of misdiagnosis and inappropriate therapy [10-12, 15, 60]. Clinical decisions appear influenced by factors beyond diagnostic accuracy, including specialty training, clinical experience, patient context, treatment philosophy, cognitive biases and potentially a defensive dentistry mindset, especially concerning invasive approaches. The preference for delaying definitive restorations, despite evidence of risks like coronal leakage and tooth fracture, may reflect this cautious or defensive approach [98, 99].

10.5 Conclusions

Findings reinforce the necessity for comprehensive, evidence-based guidelines and ongoing interdisciplinary education. Recommendations include developing national/international guidelines for optimal crown placement timing (e.g., within four weeks for premolars), implementing targeted professional training for radiographic interpretation skills and standardizing electronic health record templates to facilitate integrated endo-prosthodontic planning. Ongoing interdisciplinary professional education and structured clinical protocols are essential to reduce decision-making discrepancies, enhance treatment predictability and ultimately improve tooth survival.

11. Conclusions and Personal Input

Clinical assessment algorithms are often built on intuition and personal experience, leading to subjectivity and inconsistency. The substantial volume of accessible publications and their updating tempo are notable [100]. However, the under 20% evidence level described in some studies is concerning [101-103]. It is a cognitive challenge for clinicians to accept that relying on vision and radiological imaging may be inaccurate compared to direct clinical examination or histology [104-106]. Confirmation bias reinforces selectively searching for consistent information [107]. This should be interpreted cautiously, as low evidence is not no evidence [108]. Personal experience (case reports, expert opinions) provides expertise worth considering [108, 109].

The human brain uses verbatim and gist representations [98, 110]. Reliance on gist (essence, main points) develops with experience but is subject to bias; even with accurate verbatim data, fuzzy memories can influence decisions [110].

Drawing on the study findings, the chapter notes discrepancies: despite evidence showing imaging tools like periapical X-rays and CBCT have limitations in differentiating periapical lesions, a significant percentage of dentists surveyed believed otherwise regarding CBCT accuracy. The research also revealed that while lesion characteristics influenced the decision-making of non-endodontic specialists regarding tooth restoration and preservation/extraction, they had less influence on endodontists. Furthermore, contrary to evidence supporting the importance of timely coronal sealing to prevent bacterial leakage, a majority of dentists reported they would postpone definitive crown restoration in cases with ongoing apical healing. Endodontists showed less statistical preference for this delay compared to other specialties, though the overall difference wasn't statistically significant across professional roles.

Interdisciplinary approaches and collective intelligence are presented as crucial for improving clinical assessment and outcomes, particularly in complex cases [98, 111-115]. However, challenges exist, including communication barriers, conflicting opinions and increased costs [113]. The increasing trend towards specialized care also raises concerns about affordability and accessibility [112]. This volatile context risks shifting practice towards defensive dentistry, driven by fear of complaints, potentially leading to delayed treatments despite known risks [99].

The endo-restorative interface needs addressing and further guidelines should be developed. The cross-sectional study showed endodontists prioritize restorability when deciding to conserve or extract, while non-endodontic specialists consider imaging characteristics. These results emphasize the need for clear, evidence-based interdisciplinary guidelines to reduce incoherent decision-making and clinical approaches.

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