

Original Research

Analyzing Diverse Factors Contributing to Failures in Root Canal Treatments: A Comprehensive Study

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ABSTRACT:

Background: Endodontic therapy, also known as root canal therapy, is a series of treatments aimed at addressing the infected pulp of a tooth. The goal is to eliminate the infection and safeguard the thoroughly cleaned tooth from potential microbial invasions in the future. The objective of the current study was to evaluate the factors contributing to failures in endodontic procedures. **Methods:** The research was conducted by involving 156 patients of diverse genders. The study encompassed a total of 280 teeth that had undergone endodontic treatment. Evaluation focused on various factors, such as missed canals, dislodged or fractured restorations, and iatrogenic issues, including perforations, file separations, and ledges. **Results:** A prevalent cause of endodontic failure was identified, with inadequate obturation accounting for 45%, missed canals for 20%, and fractured coronal restorations for 35%. The observed differences were found to be statistically significant ($P < 0.05$). **Conclusion:** Endodontic failure can stem from a variety of reasons, with the most frequent culprits being a missed canal, inadequate obturation, and fractured coronal obturation.

Keywords: Pulp, Root canal, Restoration, ledges, obturation.

Received: 11 November, 2023

Accepted: 13 December, 2023

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This article may be cited as: Sandhu JK. Analyzing Diverse Factors Contributing to Failures in Root Canal Treatments: A Comprehensive Study. Int J Res Health Allied Sci 2023; 9(6):12-16.

INTRODUCTION

Endodontic therapy, commonly known as root canal therapy, represents a sophisticated and systematic approach to address the intricate challenges presented by an infected tooth pulp. Beyond its fundamental objective of eradicating the existing infection, this comprehensive treatment aims to fortify the decontaminated tooth, creating a resilient barrier against potential microbial invasions in the future. The versatility of endodontic therapy is evident in its application to a spectrum of dental conditions, including apical periodontitis, periapical abscess, granuloma, and cysts.¹ This underscores its pivotal role in managing diverse and often complex oral health issues, emphasizing its importance in modern dentistry.² The crux of the success of endodontic therapy lies in the meticulous execution of each procedural step. Commencing with the precise access opening, navigating through the intricacies of biomechanical preparation, ensuring thorough obturation of the root canal system, and concluding with the meticulous restoration of the tooth—all these stages contribute synergistically to the overall

favorable outcome. A diligent and comprehensive approach to endodontic therapy not only addresses the immediate concerns associated with infection but also promotes the long-term health and viability of the treated tooth. By navigating the intricate landscape of the root canal system and addressing the multifaceted challenges presented by dental pathology, endodontic therapy stands as a cornerstone in preserving natural dentition and enhancing the overall well-being of dental patients.

The growing emphasis on dental patient education and awareness, coupled with advancements in dental technology, has significantly contributed to fostering the perspective that maintaining one's natural dentition is crucial throughout their lifetime.³ This cultural shift towards prioritizing oral health has, in turn, led to a notable surge in the demand for conventional non-surgical root canal therapy. However, it's imperative to acknowledge that despite its widespread application, endodontic treatment is not without its challenges and can exhibit varying rates of success. The increased awareness about the importance of preserving natural teeth has prompted

individuals to seek interventions like conventional non-surgical root canal therapy to address dental issues. This procedure, which involves treating the infected pulp of a tooth without resorting to surgical methods, has become a cornerstone in modern dentistry.⁴ Nevertheless, it's essential to recognize that endodontic treatment, like any medical intervention, is not infallible, and the success rates may vary. Factors contributing to the success or failure of endodontic therapy can include the complexity of the dental pathology, the thoroughness of the treatment process, the skill of the practitioner, and patient-related variables. Ongoing research and advancements in endodontics aim to further improve the success rates of these procedures. Continuous education for both dental practitioners and patients, along with the integration of innovative technologies, contribute to refining and enhancing the outcomes of endodontic treatments. As the field progresses, it remains crucial to strike a balance between promoting the preservation of natural dentition and acknowledging the potential complexities associated with endodontic interventions.

Root canal failures present a multifaceted landscape of challenges within the realm of endodontics, and among the plethora of factors contributing to these setbacks, three salient issues come to the fore: missed canals, inadequate obturation, and fractured coronal restoration.^{5,6} Despite the well-established efficacy of non-surgical root canal treatment, a subset of endodontically treated teeth exhibits responses that deviate from the desired favorable outcome, necessitating a deeper understanding of the intricacies involved. In a comprehensive study conducted by A et al., the prevalence of missed canals took center stage, unraveling a significant 48% incidence among 266 previously treated teeth. This underscores the imperative for practitioners to possess a nuanced understanding of root canal anatomy, emphasizing the need for meticulous exploration and treatment to ensure a thorough and successful procedure. Zooming in on the specifics of missed canals, the distribution across different tooth types revealed intriguing patterns. Maxillary second molars exhibited an 11% incidence, while the impact on maxillary first molars was more pronounced at 44%. An in-depth analysis of the latter unveiled a remarkable concentration of missed canals, with an overwhelming 93% identified in the mesio-buccal root. This asymmetry in distribution persisted in mandibular second molars, where 29% of missed canals were located in the distal root and a substantial 71% in the mesial root.^{7,8} These nuanced findings underscore the critical importance of precision and attention to detail in endodontic procedures, particularly in the identification and treatment of canals. The current study endeavors to contribute meaningfully to the ever-expanding body of knowledge in endodontics by conducting a

comprehensive assessment of various causes of endodontic failures. By unraveling the intricacies of these contributing factors, the aim is to pave the way for refinements in non-surgical root canal treatments, thereby elevating the overall success rates and ensuring optimal patient outcomes in the dynamic and evolving field of endodontics.

MATERIALS AND METHODS

The study unfolded within the specialized domain of Endodontics, a critical branch of dentistry devoted to the diagnosis and treatment of dental pulp and periapical tissues. The research cohort comprised a diverse group of 156 patients, inclusive of individuals of both genders. A thorough examination was conducted on a total of 280 teeth that had undergone endodontic treatment, reflecting the study's comprehensive scope. Ethical considerations were paramount, and as such, ethical clearance was diligently sought before embarking on the study, underscoring a commitment to upholding the highest standards of research integrity and patient welfare. To ensure transparency and respect for individual autonomy, the research team adhered to the ethical principle of informed consent. Each patient was provided with a detailed explanation of the study's objectives and procedures, and written consent was obtained as a testament to their voluntary participation.

The data collection process involved capturing general information such as the patient's name, age, and gender, fostering a holistic understanding of the demographic context. The Intraoral Periapical (IOPA) radiograph emerged as a pivotal diagnostic tool, enabling a nuanced assessment of various parameters. These included the presence or absence of periapical radiolucency, the quality of obturation, and the identification of specific endodontic challenges, such as missed canals, dislodged or fractured restorations, as well as iatrogenic problems like perforations, file separations, and ledges. The wealth of data gathered from these assessments was systematically tabulated, laying the groundwork for a meticulous statistical analysis. Rigorous statistical scrutiny was employed to extract meaningful insights from the data, ensuring that observed trends and patterns were not merely anecdotal but held statistical significance. The adoption of a P value less than 0.05 as the threshold for significance underscored the commitment to robust statistical validation, providing a solid foundation for the interpretation of findings. In essence, this methodical and ethical approach in the study design and execution not only aligns with the highest standards of research conduct but also ensures that the results contribute meaningfully to the evolving body of knowledge in the specialized field of Endodontics.

RESULTS

Table I: Distribution of patients

Gender	Males	Female
Number of patients	76	80
Number of teeth	120	160

Figure I: Distribution of patients

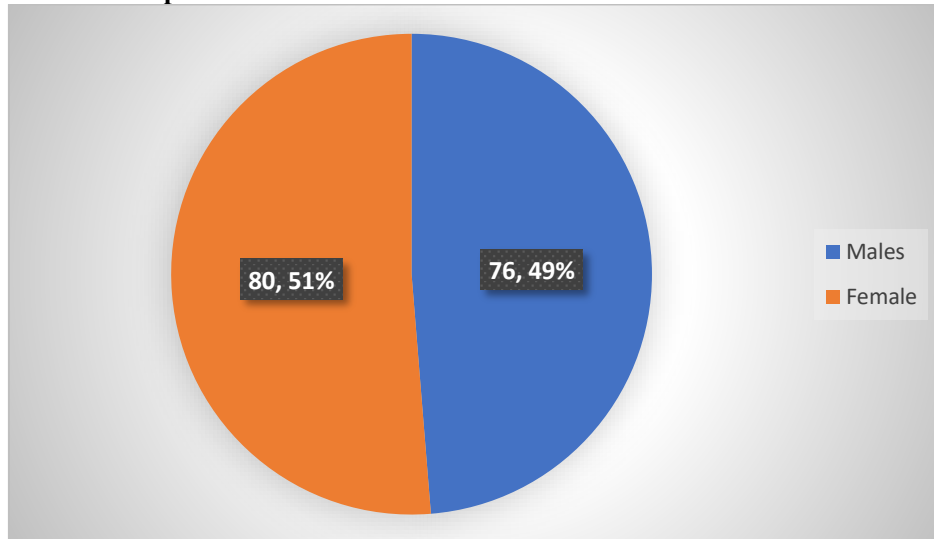


Table I presents a demographic breakdown of the study participants, revealing a distribution of 156 patients, with 76 being male and 80 female. This gender distribution is further reflected in the allocation of teeth, where males accounted for 120 teeth, and females had 160. This clear and concise representation provides an overview of the gender distribution within the sample population and the corresponding number of teeth assessed for the study.

Table II Causes of endodontic failures

Reasons	Males
Inadequate obturation	45%
Missed canals	20%
Fractured coronal restoration	35%

Figure II Causes of endodontic failures

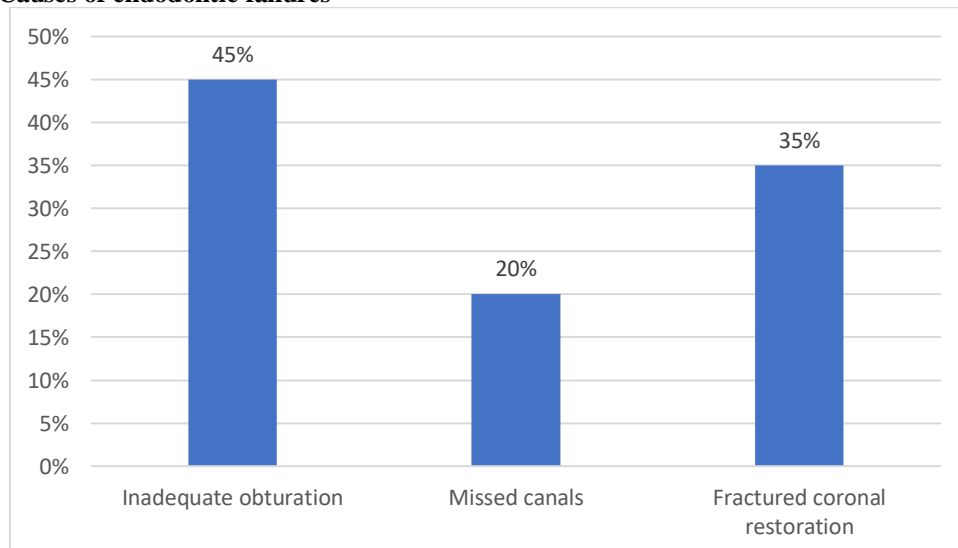


Table II succinctly outlines the primary reasons for endodontic failure within the study cohort. The most prevalent contributing factor was inadequate obturation, accounting for 45% of the cases, followed by missed canals at 20%, and fractured coronal restoration at 35%. The observed differences in these failure causes were statistically significant, with a P value of less than 0.05. This statistical significance underscores the importance of these factors in influencing the outcomes of endodontic treatments within the study population.

DISCUSSION

Endodontic failure, marked by clinical signs, symptoms, and radiographic evidence of periapical bone destruction, prompts the imperative need for re-intervention. The intricate process of addressing endodontic failure begins with a meticulous exploration into the root causes, which can span a spectrum of factors. These etiological contributors are broadly classified into persistent or reintroduced intra-radicular microorganisms, extra-radicular infections, foreign body reactions, and the development of true cysts.^{9,10} The persistence or reintroduction of microorganisms within the root canal system is a primary consideration. In some instances, despite initial treatment efforts, microbial remnants may persist or be reintroduced, leading to continued inflammation and compromised healing. The recognition and elimination of these microorganisms become paramount in achieving a successful re-treatment outcome. Beyond the confines of the root canal, extra-radicular infections can pose challenges. These infections extend beyond the root apex and may require targeted interventions to address the source of the persistent pathology. Successful management often involves a combination of endodontic procedures and potential surgical approaches to effectively eliminate the source of infection. Foreign body reactions represent another potential cause of endodontic failure. This may involve the body's response to materials introduced during the initial treatment, such as obturation materials or restorative components. Identifying and addressing these reactions require a careful evaluation of materials used and, if necessary, their removal or replacement. True cysts, characterized by epithelial-lined cavities containing fluid or semi-solid material, can also contribute to endodontic failure. These cystic lesions may develop as a consequence of chronic inflammation and require a comprehensive approach, often involving surgical intervention to excise the cystic tissue and promote healing. In the face of endodontic failure, a thorough understanding of these varied etiological factors is crucial for clinicians to formulate an effective re-treatment plan. This may involve a combination of endodontic procedures, surgical interventions, and a keen awareness of the patient's individual circumstances. The pursuit of successful outcomes in such cases demands a tailored and multidimensional approach that addresses the root causes, ensuring long-term dental health and patient satisfaction.¹¹ The occurrence of a file segment left behind during endodontic treatment reflects a complex interplay of factors within the intricate landscape of dental care. In situations where achieving an optimal level of cleaning and shaping poses challenges, a pragmatic decision may be made to retain the file segment rather than risking potential damage to the tooth structure. While this circumstance may evoke concerns in patients, it is essential to contextualize such occurrences within the broader

spectrum of routine dental procedures involving various metallic elements. Metal components within teeth are a routine aspect of dental interventions, encompassing elements like metal posts, amalgam fillings, gold crowns, and porcelain-fused-to-metal crowns. Recognizing that metal is a common and accepted part of dental restorations helps provide reassurance to patients who may encounter the inadvertent presence of a file segment during their endodontic treatment journey.¹²

The likelihood of file separation is influenced by a myriad of factors, including the anatomy of the tooth being treated—factors such as narrowness, curvature, length, calcification, and the number of roots all contribute to the complexity of the endodontic procedure. These variables underscore the necessity for dental practitioners to navigate each case with meticulous precision, adapting their techniques to the unique anatomical features of each patient. Complications arising from incomplete canal cleaning due to blockage from a separated file segment can be effectively addressed through surgical root canal treatment. This intervention provides a controlled environment for accessing the affected area, allowing for the safe removal of the file segment and thorough cleaning of the canal system. Surgical root canal treatment serves as a valuable tool in the dental practitioner's arsenal for managing unforeseen challenges during endodontic procedures. The overarching objective of the present study is to delve into the multifaceted causes of endodontic failures, casting light on scenarios such as file separation and their broader implications.¹³ By systematically analyzing these challenges, clinicians can refine their approaches, enhancing the overall success rates of endodontic procedures and contributing valuable insights to the collective knowledge base of the dental community.

In the context of the ongoing study involving 156 patients, a nuanced examination of demographic details reveals a gender distribution with 76 males and 80 females. Delving into the tooth distribution within this cohort, it is noteworthy that males accounted for 120 teeth, while females had 160. These demographic insights provide a comprehensive foundation for understanding the study population, paving the way for a more detailed exploration of endodontic outcomes. Drawing parallels with A et al.'s study introduces a valuable comparative dimension. Their investigation, which focused on 96 patients with 180 mandibular premolars, identified missed canals as the most common cause of failure, constituting 40% of cases.¹⁴ Additionally, fractured coronal restoration emerged as a significant factor, accounting for 32% of failures. This comparative reference not only enriches the findings of the present study but also highlights patterns and trends that could contribute to a more holistic understanding of endodontic challenges. Moreover, recognizing the pivotal role of follow-up studies is crucial in contextualizing the

longevity and functional retention of endodontically treated teeth. These longitudinal assessments provide insights into the enduring impact of initial treatments, helping to gauge the potential for sustained healing and functionality. The literature consistently emphasizes the multifaceted nature of endodontic failure related to microorganisms. Anatomical intricacies, such as apical ramifications, isthmuses, and morphologic irregularities, present challenges. Simultaneously, procedural errors, encompassing missed canals, root perforation, ledge formation, and instrument separation, contribute to the complex landscape of endodontic complications. This comprehensive understanding, derived from both the ongoing study and existing literature, underscores the multifactorial nature of endodontic outcomes.¹⁵ It emphasizes the need for clinicians to navigate a diverse array of anatomical and procedural challenges in their pursuit of enhancing the potential for successful endodontic treatments. By integrating these insights, clinicians can refine their approaches, ultimately contributing to the long-term healing and functional retention of treated teeth, thereby advancing the field of endodontics.

CONCLUSION

Endodontic failure may occur due to various factors, reflecting the complexity of dental interventions. Common reasons for such failures include missed canals, inadequate obturation, and fractured coronal obturation. A missed canal refers to the unintentional oversight of one or more branches or extensions of the root canal system during treatment. The intricate anatomy of the root canal system presents challenges, and overlooking canals can lead to persistent infection and compromised treatment outcomes. Inadequate obturation involves deficiencies in filling and sealing the cleaned root canal space. Proper obturation is critical for preventing bacterial re-entry and ensuring the long-term success of endodontic treatment. Inadequate sealing can result in persistent infection and subsequent failure. Fractured coronal obturation occurs when the restoration placed on top of the filled root canal becomes damaged or fractured. This compromises the integrity of the treated tooth, potentially allowing for bacterial re-entry and undermining the overall success of the endodontic procedure. Addressing these common causes of endodontic failure necessitates a comprehensive understanding of root canal anatomy, meticulous treatment planning, and precise execution of each step in the endodontic process. Regular follow-ups and the use of comprehensive diagnostic tools are also essential for promptly identifying and addressing potential issues. By targeting these common reasons

for failure, clinicians can strive to enhance the predictability and long-term success of endodontic treatments.

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