

Evaluation of the Outcomes of Root Canal Procedure Performed in Dogs - A Scoping Review

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ABSTRACT

This review explores the long-term effectiveness of root canal therapy in dogs. The main goals were to contrast evaluation methods, evaluate postoperative care, determine prognostic indicators, examine endodontic materials and procedures, and establish success rates. Research studies with follow-up of more than six months, including radiographic, histological, and clinical information from both experimental and clinical investigations throughout the world, were reviewed systematically. Analysis found success rates of over 80% in the majority of instances, but discrepancies in definitions of outcome and follow-up durations influenced comparability. Epoxy resin and calcium hydroxide-based sealers demonstrated favourable biocompatibility, yet the most suitable material remains debated. Cone-beam computed tomography was superior to conventional radiography in the identification of lesions. Prognostic indicators were integrity of coronal seal, root resorption, and preoperative Periapical radiolucency. Root canal treatment is a valid means of saving canine dentition overall, although better standardization and long-term follow-up are necessary to improve future clinical results and research initiatives.

Keywords: Root canal therapy, Canine, RCT in dogs, Veterinary dentistry, long term effects

INTRODUCTION

Because of the consequences for veterinary dental health and the preservation of functionally important teeth, research on the long-term effects of root canal therapy in dogs has become an important topic of the research. Depending on the tooth type and treatment methods, research have shown that success rates for root canal therapy (RCT) in dogs have ranged from roughly 70% to over 90% in recent decades ^[1]. RCT has clinical relevance - since it can save teeth that are impacted by pulp and periapical illnesses, minimizing the need for extraction and the difficulties that come with it. Understanding the long-term effects of RCT is crucial for improving treatment options and animal welfare, as tooth trauma and pulp exposure are common in canine patients ^[2,3].

It is still difficult to completely describe the long term biological and functional effect of the root canal therapy in dogs, even with advancements in endodontic materials and techniques. High success rates have been reported by a number of retrospective investigations; nevertheless, they also point to variations in preoperative periapical lesions, obturation quality and restoration techniques ^[1,4]. There are disagreements on how irrigation techniques, intracanal medications, and the need for prosthetic crowns affect the longevity of treatment ^[5,6]. Furthermore, the processes behind treatment failure or inadequate healing are called into question by the persistence of microbial

contamination and inflammatory reactions after therapy. The limited longitudinal data and differing definitions of success and failure in veterinary endodontics further exacerbate the knowledge gap. Prognosis and client communication may be impacted by this gap, which also impedes evidence-based clinical decision-making [7-10].

The biological mechanisms of periapical healing, microbial management, and mechanical restoration after root canal therapy are all integrated into the conceptual framework for this review. The most important principles are eradication of infection through biomechanical preparation and irrigation, the role of obturation materials in coronal seal of the canal system, and the influence of coronal restoration on survival of the tooth. All these factors interact to influence the structural integrity of treated teeth, periapical tissue repair, and inflammatory control [9,11]. Understanding these interactions is essential for assessing treatment results over time and directing clinical interventions. Focusing on treatment success rates, biological healing, and factors that affect outcomes, this scoping review aims to provide the latest data on the long-term effects of root canal therapy in dogs. By combining findings from various studies, this review seeks to address the identified gaps in knowledge and offer a detailed evaluation that guides veterinary dentistry. The added value lies in clarifying prognostic markers and pinpointing areas that require further study to improve treatment effectiveness and animal health [12].

The structured literature search included retrospective clinical studies, experimental research, and systematic reviews related to canine endodontics. Studies that reported radiographic, histological, or clinical outcomes and had follow-up periods longer than six months were prioritized according to the inclusion criteria. The organization of the analytical synthesis focused on biological responses, treatment success, and procedural factors impacting long-term outcomes [10-12].

METHODOLOGY OF LITERATURE SELECTION

Transformation of Query

The main research focus, “Long-term effects of root canal treatment in dogs,” was carefully developed into a series of specific search queries. This approach kept the literature search both thorough and accurate. By deconstructing the broader inquiry into specific sub-queries, the review minimized the risk of overlooking studies that used specialized terminology, while maintaining focus and manageability in the search outcomes.

The refined search questions developed from the primary topic are as follows:

1. Evaluation on the long-term consequences of dog root canal therapy
2. Comparative analysis on the long-term success rates for various materials and techniques used in dog root canal therapy
3. Analysis on the results and side effects of post-operative dog root canal therapy, and long-term recuperation
4. Evaluation on the long-term results and success rates of postoperative problems and management of canine root canal therapy
5. Examination of the long-term outcomes of root canal therapy in veterinary endodontics for dogs

SCREENING PAPERS

The Inclusion and Exclusion Criteria are used for each of the modified searches. This helps us gather a focused selection of potential publications.

Citation Chaining - Identifying additional relevant works

Backward Citation Chaining: To ensure comprehensive coverage, I examined the reference lists of each key paper to find earlier studies they cited. This backward search strategy helped capture foundational research and made sure that no essential background work was missed.

Forward Citation Chaining: Additionally, I conducted a forward citation search to see

how more recent studies have built on the core studies' results. This method revealed newer methodological improvements, replication studies, and developing controversies in the field. Through this process, an additional 68 relevant papers were identified

Relevance scoring and sorting

To ensure that the most relevant studies appear at the top of our final papers table, we apply a relevance rating to our pool of 114 candidate papers (46 from search queries + 68 via citation chaining). 113 publications that addressed the research question were located. Fifty of the 113 pieces were extremely pertinent.

RESULT

Descriptive Summary of the Studies

The research landscape of the literature on the long-term consequences of root canal therapy in dogs is mapped out in this part. It includes a wide range of clinical evaluations, experimental animal models, and retrospective and prospective studies. With approaches ranging from radiographic evaluations to histological and immunohistochemical analyses, the investigations primarily concentrate on treatment results, material efficacy, prognostic variables, imaging modalities, and complication management. A thorough grasp of root canal therapy in canine dentistry is reflected in the diverse geographic and disciplinary scopes, which include academic research and veterinary specialist practices. In order to resolve the disparity in reported success rates and pinpoint the variables influencing the durability of long-term treatment and clinical decision-making, this comparative investigation is essential.

Success Rate

More than 30 studies showed that root canal therapy for dogs had generally positive long-term results, with success rates ranging from roughly 60% to 100%, with the majority showing success rates above 80% [1,2, 13-17]. The length of follow-up had an impact on success rates; several studies revealed a drop over long durations, highlighting the significance of long-term monitoring [18-20]. The requirement for standardized outcome measurements was highlighted by the impact that variations in success definitions (strict vs. loose criteria) had on reported rates [9].

Material Efficacy

In many studies comparing sealers and obturation materials, calcium hydroxide-based and epoxy resin sealers frequently showed better biocompatibility and healing results [18-24]. There was no clear consensus on the best obturation material, despite the fact that some materials, for MTA Fillapex, showed promise in specific situations, including feline teeth [19,22,23]. Irrigation methods and intracanal medications impacted healing in a number of comparative studies, however they did not differ substantially [18,20].

Prognostic Factors

External inflammatory root resorption, grade of obturation, and preoperative periapical lucency were repeatedly found to be important predictors of treatment outcome according to Kuntsi-Vaattovaara et al 2002 [25]. The prognosis was also impacted by patient-related variables, including age, the presence of preoperative pain, and a history of systemic chronic pain [10-12]. Healing was impacted by technical parameters such as apical patency and coronal seal integrity, with coronal leakage significantly raising the chance of failure [17,22].

Table1: Descriptive Summary of the Studies

Study	Success Rate	Material Efficacy	Prognostic Factors	Imaging Accuracy	Complication Incidence
(Jucan et al., 2023)	93.3% success, 100% combined success/no failure	Not specifically compared; standard materials used	Preoperative and postoperative periapical lucency,	Intraoral radiography used; limited to 2D imaging	No failures reported; complications linked to root resorption

			root resorption significant		
(Morris & Hale, 2022)	100% crown stability over 2-9 years	No prosthetic crown placement evaluated	Fracture risk of untreated crowns noted	Intraoral radiography and clinical exam	17.2% enamel fractures managed post-treatment
(Adrian et al., 2022)	92.7% success, 1.8% failure	Various obturation materials assessed; no clear superiority	Preoperative periapical disease, obturation quality, no crown presence	Radiographic evaluation; quality of obturation assessed	Low failure rate; root resorption and apical periodontitis noted
(Lee et al., 2022)	71% success, 25% no evidence of failure, 4% failure	Advances in materials over 2 decades; success unchanged	Preexisting root resorption, periapical radiolucency, extrusion	Radiography with limitations; CT suggested for better assessment	Failures mainly due to root resorption and unresolved apical periodontitis
(Jesus et al., 2019)	~60% periapical healing after 180 days	No significant difference among irrigation protocols	Inflammatory mediator levels reduced post-treatment	Radiographic PAI scoring; histological confirmation	Persistent apical periodontitis in ~40%; inflammation varied by protocol
(Paula-Silva et al., 2021)	Periapical repair confirmed histologically	Calcium hydroxide dressing improved outcomes	Treatment protocol influenced healing	CT more accurate than radiography for lesion size	Root resorption and lamina dura integrity monitored
(Kuntsi-Vaattovaara et al., 2002)	79% favorable outcome, 21% failure	Not detailed	Preoperative lesion size and obturation quality	Radiographic follow-up	Failures linked to lesion progression and root resorption

Imaging Accuracy

Despite its limits in identifying modest failures and three-dimensional lesion shape, radiography is still the major assessment method [4,8,16]. Cone-beam computed tomography was found to be more efficient than standard radiography in detecting lesions. Preoperative Periapical radiolucency, root resorption, and coronal seal integrity were the prognostic factors. Complications postoperatively were infrequent and manageable using proper protocols. Overall, root canal treatment is a reliable therapy for the maintenance of canine dentition, even though standardization and long-term follow-up must be improved in order to cement future clinical outcomes and trends in research.

Complication Incidence

Postoperative complications like root fractures, enamel fracture, and chronic apical periodontitis were described but for the most part presented at low incidences [23-25]. Clinical management employing temporary plugs to avoid coronal leakage and irrigation methods to decrease inflammation were

successful in reducing complications [20,23]. Chronic pain in the face of radiographic healing was observed in one subset of cases, spontaneous resolution being a frequent occurrence with time [10, 11].

THEORETICAL AND PRACTICAL IMPLICATIONS

Theoretical Implications

The theoretical underpinning that endodontic treatment effectively preserves functionally relevant teeth by curing or stabilizing periapical disease is substantiated by the commonly high success rates of root canal treatment (RCT) in dogs, which are frequently higher than 90% according to liberal criteria [1,2,16]. This supports existing hypotheses about the biochemical mechanisms of periapical healing following adequate obturation and disinfection.

The pathophysiological models of apical periodontitis and root resorption are consistent with the identification of preoperative periapical radiolucency and external inflammatory root resorption (EIRR) as important prognostic factors. This illustrates the importance of pre-existing

inflammation and tissue damage in treatment outcomes [1, 2, 4]. The idea that any one material or technique is better is called into question by the similar success rates of various obturation materials and irrigation protocols, which imply that while material qualities are significant, the biological response and technical execution may be more crucial for long-term healing [2, 11].

The dynamic nature of periapical healing and possible late failures are highlighted by the findings that long-term follow-up beyond two years is necessary to appropriately assess treatment success. This information adds to the theoretical framework of chronicity and repair in endodontic pathology [4,6]. In 2018, Philpott et al, theoretical models of lesion detection and healing evaluation have been refined by the growing use of advanced imaging modalities like cone-beam computed tomography (CBCT), which offers a more sensitive and three-dimensional assessment of periapical healing than traditional radiography [8,12]. A new theoretical method for increasing precision in root canal access and instrumentation is introduced by the use of guided endodontics using 3D printing and finite element analysis. This could potentially lower iatrogenic errors and preserve tooth structure [26,27].

Practical Implications

Endodontic procedure is recommended for vets to perform and advance in clinical practice with the consistent high success rate of RCT in dogs, which warrants its use as a treatment of choice rather than extraction to restore fractured or endodontically fractured teeth [1,2,16]. To maximize results and address owner expectations, clinical decision-making, patient education, and individualized treatment planning need to be informed by the identification of prognostic factors like preoperative periapical lesions and EIRR [1,2,17].

The absence of marked differences in results between different sealers and irrigation regimens is an indication of flexibility in the selection of materials with respect to availability, cost, and clinician preference,

but placing due stress on careful technique and case selection [2,21,23]. Implantation of advanced imaging technologies like CBCT into veterinary dentistry can aid in better diagnosis and treatment evaluation, but availability and cost considerations can limit full utilization [8,12,27].

The development and clinical utilization of guided endodontic techniques through the application of 3D printing can increase the accuracy of the treatment, decrease the occurrence of procedural errors, and maintain more of the tooth structure, representing a most promising new venture in veterinary endodontics that definitely calls for more research and teaching [27]. An advancement for veterinary endodontics with the possibility to be explored and instructed more is the creation and clinical utilization of guided endodontic techniques via 3D printing, which could increase treatment accuracy, lessen procedural complications, and retain more tooth structure [27].

SUMMARY AND CONCLUSION

Studies in veterinary dentistry show that root canal treatment in canine patients is mostly very successful, with long-term success rates mostly as high as 80–90%. This is a trustworthy way of saving teeth essential for mastication and overall function. With the passage of time, however, the success rate may decline, which is the reason for follow-ups. Both clinical observation and imaging findings are often utilized to determine success, where healing or stabilization of infections around the tooth's root is the main indicator. Results are affected by a variety of various factors—like whether the tooth was already infected or had root resorption before treatment, how good the seal of the root canal was, and even patient-specific factors like age, overall state of health, and pre-treatment pain levels. The method also matters: having a good coronal seal and leaving the tip of the root open to heal are both essential since bacteria that pass down through an inferior seal are one of the more common reasons for failure.

Materials of calcium hydroxide and epoxy resin sealers have most commonly been used and show good tissue compatibility. They support healing; however, the material that has ever claimed to be the "best" has never been there. The irrigation system could suppress the inflammation and promote healing with the current advances, such as in negative pressure systems, albeit subtle in effect. Work carried out across two visits with a medicated dressing in between tends to yield better results than when all treatment is carried out in one visit. In other situations, teeth may be stable without placing an additional crown but with some degree of risk of enamel fractures. Imaging also helps in further follow-ups of result outcomes. Conventional X-rays may find some place in diagnosis, yet they do not picture lesions in their actual extension or track how healing is evolving. Cone-beam CT is more sensitive and will trap symptoms earlier. Histological evaluation and tissue studies serve in research and give broad data on the mode and course of healing. However, this is seldom used in clinical practice. Incidences of complications-from root or enamel fractures to chronic infections-are rare and when occurred, can all be cured. Interested in preventive measures included application of temporary seal against leakage by bacteria and aggressive irrigation decrease the chances of these complications. Some dogs will continue to be a bit uncomfortable even when the X-rays become normal, but the vast majority improve with time.

The above notwithstanding, the existing studies are reasonably heterogeneous in design, follow-up, definition of success, and are thereby hardly comparable with each other. Most of the evidence comes from small or retrospective studies, and larger, good-quality trials are yet to come. Nonetheless, root canal treatment remains a safe and sound procedure in dogs, with the successful long-term result being dependent not only on materials and technique but also on individual health of the dog and care in case management. Nomenclature needs to be standardized, choice of materials optimized,

and after-care practice further guided by studies to reach even higher standards of success in the future.

Declaration by Authors

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