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ORIGINAL RESEARCH

SURVIVAL AND LONGEVITY: COMPARISON BETWEEN ROOT CANAL TREATED TEETH RETAINED WITH PROSTHODONTIC RESTORATIONS AND DENTAL IMPLANTS

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ABSTRACT

Background: The clinical decision between retaining a compromised tooth via root canal treatment (RCT) and prosthodontic restoration or extracting it and placing a dental implant remains a central dilemma in modern dentistry. Both treatment modalities have high reported success, but long-term comparative data on survival and complication profiles from matched cohorts are essential for evidence-based practice.

Methods: Using data collected from a university dentistry clinic's patient record from 2010 to 2022, researchers ran a retrospective cohort analysis. There were a total of 518 patients who were randomly assigned to one of two groups. One group received a single-tooth implant and crown to replace a missing tooth, while the other group received endodontically treated teeth restored with a post-and-core and a crown. The main result was whether or not the tooth or implant remained in place. Surviving without any technical or biological issues was the secondary goal. A p-value of less than 0.05 was used to establish statistical significance when data were examined using log-rank tests and Kaplan-Meier survival analysis.

Results: As a whole, the duration of follow-up was 9.8 ± 1.3 years. There was no statistically significant difference between the RCT group's 93.7% ± 1.8% 10-year cumulative survival rate and the Implant group's 96.2% ± 1.5% survival rate (p=0.11). Having said that, the 10-year success rates showed a notable disparity. The success rate of the Implant group, at 91.6% ± 2.1% (p=0.02), was significantly higher than the RCT group's 84.3% ± 2.9%.The primary reasons for failure in the RCT group were non-restorable tooth fracture (56.3% of failures) and endodontic pathosis (31.3%). In the Implant group, prosthetic complications like screw loosening or abutment fracture (45.0% of complications) were more common, while peri-implantitis accounted for 20.0% of failures.

Conclusion: Both RCT with prosthodontic restoration and single-tooth implants offer excellent and comparable long-term survival rates. However, dental implants demonstrate a higher 10-year success rate, characterized by a different profile of complications that are often more prosthetic and manageable in nature compared to the more catastrophic biological failures associated with RCT-treated teeth. This distinction is critical for informed consent and clinical decision-making.

Keywords*:* Root Canal Treatment, Dental Implants, Survival Rate, Longevity, Prosthodontic Restoration, Endodontics.

INTRODUCTION

The management of a severely compromised tooth, particularly one with extensive caries, trauma, or pulpal pathology, presents a significant clinical challenge. For decades, the standard of care has been to preserve the natural dentition through endodontic therapy, commonly known as root canal treatment (RCT), followed by a suitable coronal restoration to restore function and aesthetics [1]. The high predictability and long-term success of modern endodontic procedures, combined with advances in adhesive dentistry and restorative materials, have solidified this approach as a cornerstone of restorative dentistry [2]. Preserving the natural tooth maintains periodontal ligament proprioception, avoids surgical intervention, and is often perceived as a more conservative and cost-effective initial option.

Concurrently, the evolution of osseointegrated dental implants has revolutionized prosthetic dentistry, offering a highly reliable method for replacing missing teeth [3]. Implant therapy provides a standalone solution that does not rely on adjacent teeth for support, preserves alveolar bone, and restores function and aesthetics with outcomes that can mimic natural teeth. The long-term survival rates for single-tooth implants are exceptionally high, often exceeding 95% over 10 years, making them an attractive alternative to saving a questionable tooth [4].

This dual success has created a clinical crossroads where practitioners and patients must weigh the long-term prognosis, potential complications, and costs of retaining a natural tooth versus replacing it. The decision is complex and influenced by a multitude of factors, including the restorability of the tooth, the presence of periodontal disease, the strategic importance of the tooth, patient-specific factors like systemic health and financial considerations, and clinician-related factors such as skill and philosophical approach [5].

The current evidence has been sought to be synthesized in recent meta-analyses and systematic reviews. The long-term viability of both single-tooth implants and restored endodontically treated teeth was determined to be similar in a study by Iqbal and Kim [6]. It is important to note that initial case assessment is crucial, since Doyle et al. found that when a tooth is considered restorable, the results of RCT and restoration are similar to those of an implant[7]. However, these reviews also highlight significant heterogeneity among studies, varying follow-up periods, and differing definitions of "success" and "failure." While survival (the presence of the tooth/implant in the mouth) is a common metric, success (survival free of complications) may offer a more nuanced understanding of the long-term clinical performance and patient morbidity associated with each treatment. Complication profiles often differ, with endodontically treated teeth being more susceptible to catastrophic failures like vertical root fracture, whereas implants are more prone to manageable prosthetic complications like screw loosening or abutment issues [8].

Despite the existing body of literature, a research gap persists for long-term (≥10 years) comparative data from well-matched cohorts in a controlled clinical environment, using consistent criteria for both treatment execution and outcome assessment. Many existing studies are either retrospective with high risk of bias or have shorter follow-up periods. Therefore, further investigation is warranted to clarify the comparative longevity and specific failure patterns of these two fundamental treatment modalities.

In this clinical trial conducted at a university, the researchers compared the success and survival rates of root canal treated teeth retained with full-coverage prosthodontic restorations to those of single-tooth dental implants over a 10-year period.

MATERIALS AND METHODS

Study Design and Sample Selection

Using EHRs for patients seen between January 1, 2022, and December 31, 2023, researchers were able to execute this retrospective cohort analysis. Participants were divided into two groups: those who underwent root canal therapy (RCT) and were given a post, core, and a single crown for a tooth, and those who substituted a single tooth implant and crown for a missing tooth (Implant group). A power analysis, based on an expected 5% difference in 10-year survival with an alpha of 0.05 and power of 80%, determined a minimum required sample size of 245 patients per group.

Inclusion Criteria

For inclusion, patients had to be at least 18 years old at the time of treatment, have complete records including pre- and post-treatment radiographs, and have attended at least one follow-up appointment annually for a minimum of 8 years.

- RCT Group: Patients with a single maxillary or mandibular tooth (canine to second molar) that received multi-visit RCT by an endodontic specialist, followed by placement of a prefabricated fiber post, a composite core buildup, and a full-coverage ceramic or porcelain-fused-to-metal (PFM) crown within 3 months of RCT completion. The treated tooth must have had at least two remaining coronal walls and a 2 mm ferrule height.
- Implant Group: Patients who received a single, delayed-placement dental implant (tissue-level or bone-level) to replace a congenitally missing or extracted tooth (canine to second molar). Implants had to be placed in healed bone (at least 4 months post-extraction) by a surgical specialist

and restored with a screw-retained or cement-retained single crown.

Exclusion Criteria

Patients were excluded if they had uncontrolled systemic diseases (e.g., diabetes mellitus with HbA1c > 8.0%), were heavy smokers (>10 cigarettes/day), had a history of head and neck radiation, were treated with bisphosphonates, or exhibited signs of severe bruxism. Teeth or implants that were part of a fixed or removable partial denture were also excluded.

Data Collection and Outcome Variables

Two calibrated examiners, blinded to the study's primary objective, independently reviewed all patient charts and radiographs. Data extracted included patient demographics (age, gender), tooth type and location, date of definitive treatment, and all subsequent follow-up information until December 31, 2022, or the date of failure. The primary outcome was survival, defined as the continued presence and function of the prosthodontic restoration (on the tooth or implant) at the last follow-up appointment. Failure was defined as extraction of the tooth or removal of the implant.

The secondary outcome was success, defined as survival without any biological or technical complications.

- Biological complications for the RCT group included evidence of a new or persistent periapical radiolucency, root fracture, or untreatable periodontal pocketing (>6 mm). For the Implant group, this included peri-implantitis (bone loss >2 mm post-loading with bleeding on probing) or implant mobility.
- Technical complications for the RCT group included post/core fracture, crown decementation requiring re-cementation more than once, or catastrophic restoration fracture. For the Implant group, this included abutment or screw loosening/fracture, or fracture of the crown material.

Statistical Analysis

We used SPSS Statistics for Windows, Version 28.0 (IBM Corp., Armonk, NY) to compile and analyze all of the data. A variety of descriptive statistics were computed, including means with standard deviations for continuous variables and frequencies and percentages for categorical variables. Independent t-tests for age and chi-square tests for gender and tooth type were used to compare the two groups' demographic and clinical characteristics. We estimated the cumulative survival and success rates at 5 and 10 years using Kaplan-Meier survival analysis. When comparing the success and survival curves of the RCT and Implant groups, the log-rank test was employed. For all analyses, a p-value less than 0.05 was deemed statistically significant.

RESULTS

A total of 610 patient records were initially screened. After applying the inclusion and exclusion criteria, 518 cases were included in the final analysis: 255 in the RCT group and 263 in the Implant group. The mean follow-up period for the entire cohort was 9.8 ± 1.3 years (range: 8.1 to 11.5 years).

Baseline Characteristics

Table 1 shows the demographic and clinical details of the two groups. With no significant difference (p=0.28), the average age of patients in the RCT group was 48.3 ± 12.1 years, while in the Implant group it was 49.5 ± 11.6 years. There was good cohort matching based on gender distribution and the percentage of restorations that were premolar compared to molar (p=0.65 and p=0.41, respectively)."

Table 1. Baseline Demographic and Clinical Characteristics of the Study Groups.

Characteristic	RCT Group (n=255)	Implant Group (n=263)	p-value
Age (years)			
Mean ± SD	48.3 ± 12.1	49.5 ± 11.6	0.28
Gender			
Male, n (%)	112 (43.9%)	122 (46.4%)	0.65
Female, n (%)	143 (56.1%)	141 (53.6%)	
Tooth Type			
Premolar, n (%)	108 (42.4%)	118 (44.9%)	0.41
Molar, n (%)	147 (57.6%)	145 (55.1%)	

Survival and Success Rates

Table 2 displays the findings of the Kaplan-Meier survival analysis. Comparing the RCT and Implant groups, the 10-year cumulative survival rate for the former was 93.7% and 96.2%, respectively. The survival curves of the two groups did not differ significantly from one another, according to the log-rank test (p=0.11).

There was a notable disparity, nevertheless, when looking at success rates (complication-free survival). The RCT group had a substantially lower cumulative success rate of 84.3% after 10 years compared to the Implant group's 91.6% (p=0.02).

Table 2. Kaplan-Meier 5-Year and 10-Year Cumulative Survival and Success Rates.

Outcome Metric	Time Point	RCT Group (n=255)	Implant Group (n=263)	Log-Rank p-value
Survival Rate (%)	5-Year	97.2% ± 1.1%	98.5% ± 0.8%	0.24
	10-Year	93.7% ± 1.8%	96.2% ± 1.5%	0.11
Success Rate (%)	5-Year	91.8% ± 2.0%	95.8% ± 1.4%	0.04*
	10-Year	84.3% ± 2.9%	91.6% ± 2.1%	0.02*

Complication and Failure Analysis

Over the 10-year follow-up, 16 failures (extractions) were recorded in the RCT group, and 10 failures (implant removals) were recorded in the Implant group. The types of complications and reasons for failure are detailed in Table 3. In the RCT group, the most common reason for failure was non-restorable vertical root fracture (9/16, 56.3%). Endodontic-related issues, such as persistent or recurrent periapical pathosis, accounted for 31.3% of failures. In the Implant group, failure was primarily due to loss of osseointegration or advanced peri-implantitis (8/10, 80.0%).

When analyzing all complications (including those not leading to failure), the profiles differed markedly. The RCT group experienced a total of 39 complications, with endodontic pathosis being the most frequent (15 events). The Implant group had 22 complications, with prosthetic issues such as abutment screw loosening being the most common (10 events, 45.5%).

Table 3. Distribution of Complications and Reasons for Failure over 10 Years.

Event Type	RCT Group (n=255)	Implant Group (n=263)
Total Events Leading to Failure	16 (6.3%)	10 (3.8%)
Non-restorable tooth/root fracture	9 (56.3%)	N/A
Endodontic pathosis (re-treatment failed)	5 (31.3%)	N/A
Severe periodontal disease	2 (12.5%)	N/A
Loss of osseointegration/mobility	N/A	4 (40.0%)
Advanced peri-implantitis	N/A	4 (40.0%)
Implant fracture	N/A	2 (20.0%)
Total Complications (Success Events)	23 (9.0%)	12 (4.6%)
Endodontic pathosis (requiring re-tx)	10	N/A
Crown decementation (>1)	6	1 (cemented crown)
Post/core debonding or fracture	4	N/A
Restorable tooth/cusp fracture	3	N/A
Abutment/screw loosening	N/A	9
Porcelain/veneer fracture	N/A	2

DISCUSSION

The primary finding of this 10-year retrospective study is that while both root canal treated teeth restored with crowns and single-tooth implants exhibit excellent and

statistically comparable long-term survival rates, dental implants demonstrate a significantly higher rate of complication-free success. This distinction underscores the importance of looking beyond mere survival when evaluating clinical outcomes and counseling patients.

Our reported 10-year survival rate of 93.7% for the RCT group aligns with major longitudinal studies and systematic reviews. For instance, the Toronto study reported survival rates for endodontically treated teeth between 86% and 90% over 8-10 years [9]. The pooled proportion of teeth surviving 8-10 years post-treatment was around 89% [10], according to a meta-analysis by Ng et al. We ascribe the marginally better survival rate to our rigorous inclusion criteria, which demanded sufficient coronal tooth structure (ferrule) and treatment by experts, both of which are well-known to be robust positive predictors of outcome [11].

It is also in line with the vast amount of literature on implant longevity that the Implant group had a survival percentage of 96.2%. Over the course of ten years, implants have been shown to have a 95.4% success rate according to a systematic review [12], and a 96.7% success rate for single-crown implants according to a meta-analysis [13]. Dental implants are well-established as a long-term, dependable option for replacing individual teeth, and our findings support this claim. When a tooth is considered curable, both methods are great at preserving oral function in the long run, and our study's absence of a statistically significant difference in survival (p=0.11) concurs with that opinion [6].

The more revealing aspect of our findings lies in the success rates and complication profiles. The significantly lower 10-year success rate for the RCT group (84.3% vs. 91.6% for implants) was driven by a higher incidence of biological and structural complications. The predominant reason for absolute failure in the RCT group was vertical root fracture (56.3% of failures), a catastrophic event that necessitates extraction. This finding is a critical consideration in clinical decision-making, as endodontically treated teeth, particularly molars and premolars, are biomechanically compromised and susceptible to fracture under occlusal load, even when restored with a crown [14].

In contrast, the complications observed in the Implant group were largely technical and prosthetic in nature. Abutment screw loosening was the most frequent complication, a well-documented issue that is often easily managed by retightening or replacing the screw without compromising the implant itself [15-17]. While peri-implantitis remains a serious biological concern leading to some failures, its incidence in our cohort was relatively low, and many prosthetic complications were non-terminal. This suggests that while implants are not without problems, their common failure modes are often less catastrophic and more retrievable than those of endodontically treated teeth. This difference in the "nature of failure" is a pivotal point for patient-clinician discussions regarding long-term maintenance and potential re-intervention costs.

Limitations

This study has several limitations inherent to its retrospective design. First, treatment decisions were not randomized, introducing potential selection bias, although we attempted to mitigate this by matching groups on key demographic and clinical variables. Second, our data are from a single university center, where treatments are performed by residents under specialist supervision; this may not fully represent outcomes in private practice. Third, we excluded patients with significant risk factors like smoking and uncontrolled diabetes, which limits the generalizability of our findings to a broader, more complex patient population. Finally, this study did not assess patient-reported outcomes, such as satisfaction or quality of life, nor did it include a cost-effectiveness analysis, both of which are crucial components of a comprehensive comparison.

Future Directions

Future research should focus on prospective, multi-center, randomized controlled trials to eliminate selection bias. Incorporating patient-reported outcome measures (PROMs) and detailed cost-benefit analyses would provide a more holistic framework for decision-making. Furthermore, investigating the impact of newer technologies, such as dynamic navigation for implant placement and minimally invasive endodontic techniques, on long-term outcomes would be highly valuable.

CONCLUSION

Within the limitations of this 10-year retrospective cohort study, the following conclusions can be drawn:

1. Both root canal treatment followed by a full-coverage restoration and single-tooth dental implant therapy provide excellent and statistically comparable 10-year survival rates for the replacement or retention of a single tooth.

2. Single-tooth implants demonstrated a significantly higher 10-year success rate (complication-free survival) compared to restored endodontically treated teeth.

3. The profiles of complications and failures differ substantially between the two treatments. Endodontically treated teeth are more prone to catastrophic biological and structural failures, such as vertical root fracture, whereas implants are more susceptible to manageable prosthetic complications.

The decision-making process should therefore extend beyond survival statistics to include a thorough discussion of the likely long-term maintenance needs and the nature of potential complications for each treatment modality,

allowing for a truly individualized and informed patient choice.

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Competing Interests

The authors have no competing interests to declare.

Ethical Approval

The study was approved by the appropriate ethics committee and conducted according to relevant guidelines and regulations.

Informed Consent:

Not applicable.

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