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Implant and root canal treatment: Survival rates and factors associated with treatment outcome

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ABSTRACT

Objectives: To assess and compare the survival rates of implant and root canal treatment as well as to investigate the effect of patient and tooth related variables on the treatment outcome in a large-scale population-based study.

Methods: Dental records of patients who received root canal treatment and implant therapy were retrieved from the electronic records of the University of Minnesota School of Dentistry. Demographic characteristics, dental insurance status, socioeconomic status as well as medical history and tobacco use were recorded. The treatment outcome was included as a binary variable (survival/failure).

Results: A total of 13,434 records of patients who had implant (33.6%) or root canal therapy (66.4%) were included. The survival rate analysis and Kaplan-Meier table revealed the majority of the implants were removed within the first year (58.8%), while only 35.2% of the root canal treatments failed in the same time period. The overall survival rate was significantly ($p < 0.001$) higher for implant therapy (98.3%) compared to root canal treatment (72.7%). A statistically significant association was found between treatment ($p <$ n0.001), age ($p < 0.001$) and anxiety ($p = 0.004$) with treatment outcome

Conclusions: Implant therapy exhibited significantly lower failures when compared to root canal treatment, but the selection of either treatment should be based on multiple factors. Higher age and anxiety were also significantly associated with root canal and implant treatment failure.

Clinical significance: Clinicians are in an increased dilemma that affects the decision-making process due to the inadequate evidence in regards to the question of retention or extraction of a tooth in the natural dentition. This study demonstrated that both root canal and implant treatments are sound options with high survival rates; however, root canal therapy exhibited a significantly higher failure rate.

1. Introduction

A challenging dilemma in dental practice is when to maintain a natural tooth with extensive carious lesions and pulpal or periapical pathology with root canal treatment or when to replace it with a dental implant. Maintenance of the natural dentition is the ultimate goal of current evidence-based dentistry. Both implant and root canal treatment have shown high predictability. Properly treated teeth with extensive fixed prostheses surrounded by healthy or even compromised periodontal tissues have demonstrated survival rates close to 90% [1]. However, the increased survival rates for up to 97% of single-tooth implant supported restorations has resulted in considering implants as a viable option for managing non-vital compromised natural teeth [2]. A systematic review that evaluated the treatment outcome following endodontic therapy, restoration with implant-supported crowns, fixed dental prosthesis as well as extraction without replacement demonstrated that root canal treatment exhibited an 84% success rate, implant rehabilitation 95% and fixed dental prosthesis 81% [3].

The literature includes a wide range of definitions in regards to success of both implant and root canal treatments. The majority of the studies that examined implant outcomes have included survival as the only criterion which is similar to root canal therapy outcome when the endodontic literature is reviewed [4,5]. However, it is still difficult to compare data in regards to success rates between implant and root canal treatment. A number of independent factors have been reported to play a role in the predictability of implant and root canal treatment such as implant location in the alveolar arch, type of restoration, systemic medical conditions, occlusion, tobacco use and bone quality.

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Implant success rates are decreased when the number of parameters assessed is increased and there is lack of patient-centered parameters in determining implant success [6].

Both implant and root canal treatment modalities have shown failures and complications. The outcome of single-tooth implant restorations was examined in a study with matched root canal treated teeth that received a restoration [7]. Each treatment showed similar failure rates of approximately 6%, while the frequency of complications was found to be 18% for implants and 4% for root canal treatments. Peri-implantitis was the most commonly reported complication in implant treatment, while persistent apical periodontitis was highly prevalent following endodontic treatment [7]. Although both treatments are highly successful and predictable, root canal treated teeth have been considered inferior to implants with respect to long-term survival [8]. It is of paramount importance for the clinician to comprehensively evaluate pre-, intra- and post-operative factors that may affect the proposed treatment outcome [9,10]. The decision of whether to retain a natural tooth or to extract and replace it with a dental implant is based on a multi-factorial risk assessment [11].

Failure of root canal treated teeth has mainly been attributed to non-endodontic factors such as severe periodontal disease, recurrent carious lesions, prosthetic failures, and crown or root fractures that lead to non-restorability [12,13]. Other factors that may lead to root canal treatment failure include persistent or reintroduced intraradicular microorganisms, extraradicular infection, foreign body reaction and true cysts [14]. Implant failure, on the other hand, can be divided into early and late based on whether it occurs prior to or following the restoration [15]. Early implant failures are generally reported within the first 3–6 months and are associated with inadequate initial bone healing that results in poor osseointegration. In contrast, late failure is associated with failure to preserve the already achieved osseointegration [15]. Systemic medical conditions, tobacco use, periodontal disease susceptibility, poor plaque control, poor bone density and bone atrophy have been reported as risk factors of implant failure [16].

Due to the various methodologies and definitions used to evaluate and compare treatment outcomes following root canal and implant therapy as well as the currently inadequate evidence in regards to the question of retention or extraction of a tooth in the natural dentition [17], clinicians are in an increased dilemma that affects the decision-making process. Implant and root canal treatment failure may be associated with a multifactorial etiology. Several factors have been assessed for potential association with each implant or root canal treatment modality, while a limited number of studies have compared implant and root canal therapy. Therefore, the primary aim of the current study was to assess and compare the survival rates of implant and root canal treatment. Secondly, it was the aim of this investigation to identify possible site and patient related factors associated with implant and root canal therapy outcome in a large-scale population-based study.

2. Materials and methods

2.1. Subject population

This retrospective study is based on electronic dental records of patients who consecutively received root canal and implant treatment between 2010 and 2016 at the University of Minnesota School of Dentistry clinics. The study was approved by the Institutional Review Board of the University of Minnesota for medical record chart review. Patients were eligible for the study if they were at least 18 years of age with a complete demographic and medical history and had received root canal treatment or implant treatment in the dental clinics by dental students, residents or faculty. Datasheets were created utilizing the retrieved electronic dental records including patient's chart number, age at the time of the procedure, gender, ZIP code, presence/absence of dental insurance, medical and tobacco history, tooth/implant site and type of treatment provided.

2.2. Treatment

All root canal treatments were performed by dental students and graduate students in the Division of Endodontics or faculty at the University of Minnesota School of Dentistry, while implants were surgically placed by residents or faculty in the Division of Periodontology, Oral and Maxillofacial Surgery, Prosthodontics and Endodontics. All restorative treatments were completed by dental students, residents or faculty at the University of Minnesota School of Dentistry. Treatment failure was defined as removal of the implant or tooth for any reason since the most recent follow-up appointment.

Records of completed root canal and implant treatments were identified by utilizing the ADA codes. In particular, for root canal treatments, the following ADA codes were used: D3310 (endodontic therapy, anterior tooth), D3320 (endodontic therapy, premolar tooth), D3330 (endodontic therapy, molar three canal), D3330 B (molar four canal), D3346 (retreatment of previous root canal therapy – anterior), D3347 (retreatment of previous root canal therapy – premolar), D3348 (retreatment of previous root canal therapy – molar), D3351 (apexification/recalcification – initial visit), D3410 (apicoectomy – anterior), D3421 (apicoectomy – premolar), D3425 (apicoectomy – molar), D3450 (root amputation), D3470 (intentional reimplantation), D7270 (tooth reimplantation/stabilization). On the other hand, the D6010 code (surgical placement, endosteal implant) was employed to find all completed implant placements.

Implant failure was defined as the removal of a dental implant for any reason including loss of osseointegration, mobility, persistent pain, fracture and extensive bone loss. Implants remained in situ at the time of the most recent follow-up with no indication for removal were considered survived. Root canal treatment failure was defined as a root canal treated tooth that was extracted due to presence of sinus tract, periapical radiolucency, pain following percussion tests, widening of periodontal ligament, bone disturbance or loss, signs and symptoms of root resorption or apical periodontitis. Root canal treated teeth that remained in the oral cavity and were not planned for extraction at the time of the most recent follow-up were considered survived.

2.3. Patients' characteristics

Demographic characteristics of the sample population were recorded including gender (male/female), age at the time of the procedure, dental insurance status (presence/absence) and socioeconomic status as determined by a patient's ZIP code. The 2010–2014 American Community Survey 5- year estimates of the U.S. Census Bureau were used to estimate the mean annual household income and then each patient was classified with a lower socioeconomic status if the mean annual household income of the ZIP code where they live was below the mean value, whereas mean annual household above the mean value of the included population was categorized as a higher socioeconomic status [18]. Other examined patient's characteristics consisted of medical and tobacco history. Self-reported hypertension, heart attack, hypercholesterolemia, asthma, diabetes mellitus, thyroid disorder, kidney disorder, arthritis, artificial joint, osteoporosis, depression, anxiety, cancer and cancer treatment were recorded and included in the analysis. Site characteristics included information about the arch (maxilla/mandible) and region (anterior/posterior). Premolars and molars were considered posterior, while canines, central and lateral incisors were grouped as anterior teeth.

2.4. Statistical analysis

Means, standard deviations and percentages were presented as descriptive statistics. Demographic, site and patient characteristics were summarized between root canal and implant treatment including