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Comparison of Root Canal vs. Dental Implant: Outcome and Success Rates

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ABSTRACT

Tooth decay (cavity) has the potential to affect all parts of the tooth, which include enamel, dentin, and the pulp (nerve of the tooth). Tooth decay is caused by poor hygiene which leads to different sugars accumulating in the mouth, producing bacteria. As the cavity grows in size and when the cavity has reached the pulp, more extensive treatment may be needed. Because dental cavities is the most common non-communicable disease worldwide, knowing the effectiveness of several treatments is very important to maintain good oral-health. In adult patients with detrimental cavities or infections, a root canal or implant are two possible treatments that follow the standard of care. A systematic review will be conducted to evaluate whether root canal treatment or implant placement has a higher success and better outcome. Information will be gathered from multiple research articles to draw a conclusion. A root canal option requires the patient to maintain a much stringent oral hygiene routine and follow up with maintenance visits at the dental office. However, an implant is a surgical procedure that may take time to osseointegrate and thus requires more patience and follow up visits from the patient. Although a root canal or an implant are two ways of successfully treating a cavity or infection, our research shows a root canal has a higher success rate and thus should be explored more carefully as a viable treatment option by a patient.

I. INTRODUCTION

The prevalence of edentulism in older adults is rapidly declining and thus, the necessary maintenance of teeth or replacement of teeth is required to improve function and aesthetics in this population. Tooth decay, a major disease prevalent in the world today, negatively affects the oral health of over 92% of adults, aged 20 to 60.[1] Poor hygiene and rapid bacteria lead to tooth decay worsening over time and may deem the tooth non-restorable. Fast-spreading bacteria, plaque, and many other factors are believed to play an important role in decay. Although the species *Streptococcus Mutans* has been identified as a prominent bacteria in plaque, a study from Jørn A. Aas et al. investigated different species that are also associated with tooth decay.[2] *S. Mutans* takes sugars such as sucrose, a disaccharide, and uses parts of it to attach onto the tooth. The study also found *S. Mutans* was not detectable in 10% of the subjects, suggesting other bacterial species are also prominent in tooth decay. Acid-producing bacteria such as *Veillonella* and *Actinomyces* are believed to play a role in caries and also the initiation of decay. Tooth decay starts as acids from plaque that constantly attack the enamel, the outermost part of the tooth. The tough nature of the enamel covers and protects the insides of the tooth, supporting forces from chewing and preventing damage to further layers. After openings in the enamel are created through time from tooth decay, it spreads to the dentin, which is the layer below the enamel. The dentin is a dense tissue, covering the pulp and making up much of the tooth's mass. The pulp is the final, innermost layer where important tissue holds vital nerves, blood vessels, and special cells. These cells include odontoblasts, fibroblasts, plasma cells, and other various cells. It functions for the formation and nutrition of the dentin as well as defense for the tooth through localized immune response. If tooth decay reaches the pulp chamber (where the nerve is housed), severe pain and discomfort is inflicted, requiring a need for thorough treatment. Different methods are rising in the field, through technological and medical growth. Either a root canal treatment from an endodontist or a dental implant by a surgeon are among the options of clinically acceptable, standard of care treatments.

Root canal treatment, or RCT, is the process in which the tooth is restored instead of extracted. It focuses on cleaning the nerve, a necessary step when the pulp becomes inflamed or infected. Endodontists will apply anesthesia, commonly through infiltrations of a maxillary tooth or inferior alveolar nerve (IAN) blocks of a mandibular tooth. The IAN block anesthetizes the lingual nerve, the mandibular teeth until the midline, the body of the mandible, soft tissues, parts of the tongue, and the floor of the mouth. From there, after the pulp is accessed, commonly sodium hypochlorite is poured into the pulp chamber, which kills dangerous bacteria and eliminates all unnecessary substances. Sometimes, other solutions can be used to amplify the disinfection and improve the purpose of irrigation. Using small tools and instruments, the root canal is shaped and cleaned, where endodontists will use gutta-percha to seal the tooth. Usually, there will be space left for a filling and a proper restoration after treatment, which is required, either by a crown, amalgam, or other restorations.

In contrast, a dental implant is also a clinically acceptable treatment option. A dental implant is a titanium post that replaces the roots of a lost or extracted tooth. After a seriously infected tooth is extracted (or is already lost), every case must be observed and researched because of the different conditions every patient experiences. First, the entire mouth, including the jaws and all of the teeth, are scanned for the specialist to identify possible complications. If there is a need for bone grafting since there may not enough bone to support the implant, the process may take many months for the graft to osseointegrate, depending on the extent of bone graft and adjacent tooth health. If no bone graft is needed, different sizes, location, and the types of implants to be placed are determined after careful evaluation. Conscious sedation may be used for the patients' comfort as the procedure may take a long period of time. First, the surgeon reveals the bone by cutting through gingiva. From there, an opening is made through the bone which helps the implant fit perfectly. A denture or temporary crown may be used if necessary, throughout healing. During this process of osseointegration, the implant biologically connects with bone and tissue for many months. After the healing period, another scan is needed for the fabrication of a permanent crown. Finally, a permanent abutment and crown are placed above the implant, giving the appearance of a "real" tooth.

Patients are faced with important choices and need to first study the process and outcome of both treatments before preferring one treatment over the other. The aim of this paper is to evaluate the setbacks, advantages, and outside factors, including elements that influence failure or success rates of root canal treatments and implants. It also discusses the impact of time and regular follow-up times after the treatments, how and where different material, location, and condition of diseases will help to decrease the complications of treatment. A patient should be aware of all options and their obstacles based on their different situations.

II. METHODS

This systematic review focused on the following question: In adult patients with a detrimental cavity or infection, does treating the tooth with a root canal lead to higher success and better result over removing the tooth and placing an implant? The definitions of population, intervention, comparison, outcome, and study design (PICOs) were developed based upon the focused question as follows:

Population: adult patients with a severe cavity or infection

Intervention: treatment of cavity/infection with root canal therapy

Comparison: extracting tooth and implant placement

Outcomes: more effectiveness and success of one versus the other

III. RESULTS & DISCUSSION

There are multiple factors that may affect the outcome of root canals and thus lead to varying success rates after treatment. After a review of multiple endodontic related studies, it was concluded that age and gender did not affect the outcome of root canals. Gender, however, affected postoperative pain, which will be discussed later in this section. A major factor shown to lessen success rates of root canals is smoking. A study by E.A. Krall et al evaluated past and current smokers, showing the effect smoking had on oral health in general.[3] Patients that previously or currently smoked had an increase in tooth loss, and had greater alveolar bone loss than patients who did not smoke.[3] Although there were varying ways of evaluating the effect of smoking, the study concluded that between smokers and nonsmokers, patients who were smokers had 30% more endodontically treated roots than non-smokers.[3] Moreover, the study also concluded that since smoking affects immune response to disease or infection, antibodies and different cells were present in fewer quantities in those who smoked which suggests that smokers may be vulnerable to oral diseases. Another factor that could affect the success of root canal treatment is the level of experience of the dental provider. In a study by Alley et al, endodontically treated teeth had a higher survival rate when it was treated by endodontists compared to general dentists.[4] The study found root canals treated by endodontists had a survival rate of 98.1% while root canals performed by general dentists had a 89.7% survival rate. Another factor that affects success rate is retreatment, a procedure done after the failure of the first root canal treatment. Fabio G. M. Gorni et al. evaluated the extent to which previous endodontic treatment affected retreatment in a span of 2 years.[5] There were two groups: root–canal-morphology respected (RCMR), where calcification, an apical stop, broken instruments, or underfilled canals were included, and the root–canal-morphology altered (RCMA) group which included perforation, stripping, and internal resorption. Perforation would be a hole in the root canal region, stripping is the perforation caused by too much instrumentation during treatment, and resorption which was pulp left unsealed after treatment.[5] The process of retreatment is similar to that of original root canal treatment, with the addition of removing all complicative substances. A thorough cleansing of the pulp chamber would be executed, along with the removal of posts and broken instruments, and finally removing the gutta-percha with various chemicals. The process would solely be based on the endodontic morphology of the patient. From there, new gutta-percha is used and a sealer is then applied, finishing this all in the span of one to two visits. After 30 days, direct or indirect coverage to the endodontic access cavity was applied to prevent coronal leakage, which could start more infection. The results of retreatment proved to be very different between both groups. The RCMR group had a 83.3% overall success rate compared to 48.7% for the RCMA group.[5] This data shows a significant difference, hinting towards how retreatment conditions and results are favored towards the RCMR group. The results may have been concluded because of outdated or an inefficient type of material used in previous endodontic treatment. A limit to this study is that it was conducted approximately 20 years ago, which suggests that over time treatment has improved as well as success rates, for many concepts have influenced oral health. The overall results demonstrate how previous complications with RCT heavily affects possible success of a second endodontic treatment.

Lastly, a successful root canal includes a proper coronal restoration. In a study by Moti Moskovitz et al, stainless steel crown, composite resin, amalgams, and a temporary filling (if the patient did not return for a proper, full coverage restoration) were compared.[6] The capsulation of the endodontically treated teeth would prove necessary, as success and failure were compared up to 6 years and 5 months, with a mean follow-up time of 21 months. The stainless steel crown had the most success, with a 95.9% success rate, surpassing the amalgam/resin with 92.3%, and the temporary filling material at only 28.6%. The data shows that even a composite restoration would work, leaving the temporary filling restoration option as an outlier. The results also support many other articles that state RCT has a high success rate. These numbers can be achieved only when a proper restoration is attached after treatment.

Similarly to the root canal treatment, numerous factors can influence the outcome of dental implants. According to Morris et al, smokers had an 11.28% failure rate against a 4.76% failure rate for non-smokers.[7] It is a dangerous habit for many that is detrimental to both treatments, as well as the health of other body parts. Another major factor linked to implant failure is alcohol and tobacco consumption, measured to see the impact in a long-term period of time. Galindo-Moreno et al. concluded that with the daily consumption of more than 10 grams of alcohol

and tobacco, more bone loss would occur.[8] This was evaluated with 185 patients and 514 implants, with a follow up of 3 years. There would ultimately be more gingival inflammation and tooth decay, with very high incidences of plaque levels.[8] Additionally, diseases such as periodontitis, osteoporosis, and peri-implantitis also had a negative effect on the success of dental implants. Periodontitis was linked with more complications and implant loss. In a study by Gabriela Giro et al, osteoporosis, which causes decreased bone mass and fragile bone tissue, was linked to higher rates of implant loss, although there were no definitive results for bone-to-implant contact measurements and the negative effect on bone healing osteoporosis caused.[9] Lastly, peri-implantitis was present in about 23.5%-25% of patients examined and is increasing in prevalence, which is why it should be taken into consideration when deeming a tooth non-restorable.

Do Gia Khang Hong and Ji-hyeon Oh evaluated internal factors that may cause failure/success including sinus lifting, immediate/conventional loading, and implant size.[10] Sinus lifting is the technique in which the membrane is opened and lifted in a careful manner, where bone grafts can then be placed in the sinus.[10] Autogenous bone grafts have been revealed to be one of the most convenient points of supply as its osteoinductive and osteoconductive properties are unmatched.[11] Although this procedure is a solution to reinforce weak bone and replace insufficient bone levels for implants, sinus lifts still takes a significant time to heal and integrate- approximately 6 months or more depending on the severity of the case. Another complication with sinus augmentation is the development of sinusitis, causing delayed healing and inflammatory regions. To combat this, a non-traumatic approach to this procedure could be used to reduce the chance of tearing the membrane.[10] Implant size has also been a questionable risk factor. Standard sized implants cannot be placed at some sites, whether because of bone deficit or tight spaces from adjacent structures or adjacent teeth. Procedures such as bone augmentation and bone grafting were created to avert these situations, but they cost a significant amount of money and time. Short implants are made to withstand these different amounts of complications, but its controversial background is disputed among many articles. The size of short implants are not specifically defined, with articles ranging its size from 10mm and less, or even 8mm and less. Ranging from 86.7% to even 100%, the success rates were different in all articles.[10] Another study stated that short implants had a higher fail rate than normal sized implants, which contrasted another study that revealed that there was no significant difference in success rates.[10] One certain point in an article stated that standard implants tended to have higher marginal bone loss. Short implants usually had a higher success rate of 97-100% success when compared to implants with previous surgical operation such as sinus augmentation. Although the numbers have ranged without a specific conclusion, it should still be contemplated by clinicians as their final choice is crucial. This choice also includes immediate and conventional loading. Standard implants can be left to heal after being placed in order for osseointegration to occur. A danger of this process is the risk of tissue interfering with the implant.[10] Instead of this conventional approach, immediate loading has risen in popularity for its reduction of treatment duration and increase in patient acceptance. Instead of waiting to restore the implant after various months, the crown could be placed very quickly after implant placement, even up to 48 hours after implant placement. There were many articles that had various differences regarding immediate loading. In a study by Jie Chen et al, there was a significantly lower survival rate in immediate loading implants than conventional implants, but there was no significant difference in marginal bone loss, gingival inflammation, and probing depth.[12] Additionally, many patients' questionnaires revealed that there were very high scores regarding general function, esthetics, and treatment procedures, which opposed other studies that revealed that immediate loading would lead to more postoperative pain than conventional loading. Through 27 different studies, only 8 studies showed no implant failure.[12] A previously mentioned study referenced several findings. One of the findings revealed in the immediate group having a 98.3% survival rate for conventional implants and 96.7% survival rate for conventional implants over 4.7 years.[10] Another article, a systematic review, had a 99.6% survival rate in the conventional method and 98.2% survival rate in the immediate method with 29 different studies included.[10] These results oppose the previous claim that there was a significant difference in success. In conclusion, immediate loading is comparable to conventional loading as it has proven to be a workable method, but all options including patient compliance must still be analyzed because of different situations.

Discomfort may be unconsidered by many prospective patients, but is vital for maximum comfort during or after surgical procedure. The natural fear of dental-associated procedures is universally common. M. C. Wang et al discussed in a study how patients can lessen their anxiety before surgery.[13] Four main concepts were included: preparation, teamwork, trust, and a clear plan. It included being fully transparent with the patient, going through the procedure step-by-step, and preparing patients with a cooperative team while gaining trust. Demonstration with instrumentation might have also proved to be effective as patients wanted to see first-hand what they needed to experience. The studies also showed that many patients did not want to see any x-rays or certain materials like the color "red" as it could resemble blood and increase their nervousness.[13] In relation to postoperative pain, a review by Alaa W. AlQutub analyzed the discomfort experienced after implant procedure and also compared it to tooth extraction, a procedure that may be needed before implants.[14] In 40 patients who went through both procedures, the irritation over time from implant surgery decreased much more rapidly than with tooth extraction as monitored from 12-70 hours after operation. Also, there was only moderate pain and little inflammation. This conclusion supported many other studies like H. González-Santan's investigation discussing the duration of pain and extent of inflammation.[15] Experience in dentistry may also affect pain, with more experienced surgeons having much fewer reports of pain compared to junior surgeons. The amount of modification before implants (sinus augmentation and bone grafting), longer surgical duration, and consistent smoking also may add to post-operative pain exhibited in the patient. The location of the implant may cause different amounts of pain as the patient's perception may vary based on where the implant is screwed. Based on outside factors before or during operation, postoperative pain may increase but is generally low and decreases after a few days. Likewise, root canal treatment may have varying amounts of postoperative pain. Three articles recorded their results in light, moderate, and severe levels. Luis-O. Alonso-Ezpeleta et al studied the postoperative pain in one-visit root canal treatments, and ended up with 83% of patients experiencing a type of discomfort or pain.[16] 44% of patients mostly felt light pain, compared to 6% of patients having intense pain. Also, the pain was experienced mostly from 6 hours to a day, decreasing in intensity until about a week after treatment. Another article by Mothanna K. AlRahabi studied the results from RCT regarding pain and different causative factors.[17] In 2 days, postoperative pain occurred in 3% to 69.3% of patients. Although most pain had disappeared in 24-48 hours, there were still reports of pain up to 9 days, which supports the results found in the previous study. Damage and inflammation to tissue during operation are factors causing pain, as well as gender, and poor shaping or cleaning of the canal.[17] The hormone difference causes females to experience more pain after treatment, as articles included that there were many more reports of pain specifically from females.[17] The study concluded by comparing the results from one-visit treatment to multiple-visit treatments. Lastly, M. Gotler et al compared the intensity of pain between vital pulp, necrotic pulp, and retreated teeth.[18] It was found that treatment in vital pulp had a significantly higher incidence of pain at 63.8% over 6 hours after treatment. The intensity mean was also higher than the other groups. Furthermore, the management and preparation before treatment was recommended. Prescribing medicine and discussing the procedure could increase the patient's confidence in their current treatment and even future dental or endodontic operations. Although postoperative pain is a hassle, patients should realize the importance of understanding it and methods to endure it.

The economical and psychological status of patients may also affect the two treatments. For example, a study concluded that endodontically treated teeth cost about half of implant treatment, parts and crowns included.[7] The cost is a significant difference, with the cost of implants averaging from $2798–$3060 and root canals averaging from $1468–$1741.[7] These estimates do not include operations that are needed before implant placement, including fees for bone grafting and sinus augmentation. The need for efficiency in the least amount of time used is universally desired. The root canal treatment generally takes between 2-3 visits, each with its own procedure, while dental implants may need at least 4 visits to be completed. Even more may be needed if augmentation needs to be performed before the post is placed.

Additionally, psychology plays a role in patient's lives. The feeling of an unnatural tooth may irritate a patient. While root canals may give off the same perceptions as a normal tooth, implants fail to copy the function of

the periodontal ligament, which supports teeth in their sockets and resist the results of mastication. Karl F Woodmansey et al. compared the mastication between both implant and root canal treatment, which revealed that implants had lower bite forces and chewing efficiency, which is vital to any patient.[19]

All of the articles had a very similar trend of high success rates and low failure rates when comparing the treatments all-round. In a study mentioned before by Michael F. Morris et al, a large investigation studied over 1.4 million patients over 8 years, and concluded that root canal treatment success was very high with 97% of teeth retained.[7] Other treatments and retreatments would be performed within 3 years. Although other studies had varying results, those results were influenced by either the type of coronal restoration or the size of the filling. Y. L. Ng et al divided the criteria into 2 sides when defining "success." [20] A strict criteria would be the fully restored tissue near the apex, while the loose criteria would be a smaller amount of apical lesion restored. Both criterias guided the success rates as rates ranged from 31% to 100% overall. The general "strict" criteria success rate was 74.7% from 40 studies. Similarly, the general "loose" criteria success rate was 85.2% from 36 studies, which did not represent a massive difference. Only a few studies out of the original 63 observed the cases for at least 4 years after treatment, and the median follow up percentage was 52.7% over 39 studies.[20] Also, the functionality of teeth was reserved at 94.44% with the follow up time of 3.5 years. Likewise, dental implants have seen high success rates. There was an average of 98.9% with a follow up time of 61 months.[7] Many other articles consistently continued with a trend of high success rates, as a study by V. Moraschini et al concluded with an average of 94.6% over 20 years.[21] Lastly, partial to fully edentulous patients were evaluated in a study from Sharon M. Compton et al.[22] The study group included patients who differed in condition, such as extent of periodontal disease, amount of smoking, choices such as immediate loading, augmentation before surgery, and type of restoration, from crowns to dentures. With all these components, implants still had a survival rate of 92.9%.[22] Even though follow up times can be as long as 10 or more years, implant survival was exceedingly high. Its sustainability and longevity proves to be healthy as its osseointegrated properties are demonstrated, with the conclusion that very little implants failed in even 16 years.[22] It establishes the idea that implants have the capability to survive through aging. Although the success rates for both treatments are promising, outside components must still be evaluated, not just the success rates.

IV. CONCLUSION

Through multiple research articles and clinical studies, both treatments have proved to be successful and sustainable. With all factors taken into account, root canal treatment should be the first solution considered because it allows the patient to keep their own teeth. However, restoring teeth may not always be possible and thus dental implants are comparable to RCT in efficiency and success. If tooth decay is at a point where a tooth is unrecoverable, implants should be the treatment of choice. Further research may call for clinical studies evaluating deeper into how, why, and which tooth decay prompts uncommon situations before choosing treatments. Additionally, research may be executed on factors for causing complete edentulism, which could result in multiple dental implants. Nevertheless, root canal treatment and dental implants are successful and are clinically accepted to meet the standard of oral care.

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