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Alternative treatments to endodontic failure at different stages

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Abstract

Introduction: The main objectives of root canal treatment are to provide comfort, function, aesthetics and long-term prevention of re-infection. Endodontic treatment has success rates of between 86% and 98%. Treatment options after initial unsuccessful treatment include non-surgical retreatment, endodontic surgery, dental autotransplantation, intentional reimplantation and extraction.

Objective: To review the literature on possible treatments to be performed following conventional endodontic treatment.

Methodology: Information was searched in PubMed, SCOPUS and Google Scholar. Key words were used to search for information such as: "non-surgical retreatment", "apical surgery", "apicoectomy", "autotransplantation", "intentional reimplantation". Results: Endodontic retreatment is a non-surgical procedure that involves the removal of previous filling materials, followed by cleaning, shaping and filling the canals. Apicoectomy involves surgical treatment of a tooth with a periapical lesion that cannot be resolved by routine endodontic treatment. Autotransplantation is the repositioning of an autogenous tooth at another site to replace teeth. Intentional replantation involves purposefully removing a compromised tooth and replanting the tooth in its socket.

Conclusion: The first choice when dental treatment fails is non-surgical retreatment, which will allow the previously treated canal to be cleaned and better results to be obtained. Intentional reimplantation, although not the most appropriate treatment, has been shown to be successful and is considered one of the last treatment options.

Keywords: Non-surgical retreatment, apical surgery, apicoectomy, self-transplantation, intentional re-implantation.

1. Introduction

For patients who have had pulp and periapical diseases caused by caries or trauma, the main goals of root canal treatment are to provide comfort, function, aesthetics, and long-term prevention of re-infection. These goals are achieved through thorough cleaning and shaping, filling the canals and restoring the affected teeth ^[1].

Endodontic treatment is a reasonably predictable procedure with success rates between 86% and 98%. The success or failure of this treatment is evaluated by the clinical signs and symptoms, as well as by the radiological findings of the treated tooth ^[2].

Factors that may be attributed to endodontic failure include persistent bacteria, inadequate filling of the canal, over-extension of the filling material, incorrect coronal seal, untreated canals, iatrogenic procedural errors such as poor access cavity design, and complications of instrumentation such as perforations or separate instruments ^[2].

The main reason for endodontic failure is the presence of some species of bacteria within the root canal system, such as *Enterococcus faecalis*. These bacteria are more resistant to disinfection agents, causing persistent intraradicular or extraradicular infection ^[3,4]. Treatment options after initial unsuccessful treatment include non-surgical retreatment, apicoectomy, dental autotransplantation, intentional re-implantation and extraction. From the perspective of health care economics, the alternative to retaining the natural tooth should result in lower total

lifetime costs or provide greater lifetime function, absence of disease, comfort or acceptability to a patient^[5].

It is important that initial root canal treatment be performed to high standards to reduce the risk of future failures. The first treatment option after root canal treatment failure is not tooth extraction and replacement with a fixed prosthesis or a single tooth implant^[6].

Patients choose non-surgical root canal treatment to retain teeth and preserve the natural aesthetics of their smile and to relieve pain^[7].

The high survival rates of dental implants have created a paradigm shift in treatment planning that has sometimes resulted in the unnecessary extraction of these teeth^[1].

There is no comprehensive review in the literature on the different treatment alternatives to the failure of the initial endodontic treatment, which are presented in an orderly fashion according to the sequence in which they are performed and mention their success or failure rates.

The aim of this review is to analyze the literature about the treatments to be performed after a conventional endodontic treatment that was not successful, which are non-surgical re-treatment, apicoectomy, autotransplant and intentional replantation.

2. Materials and methods

Articles on the subject published through the PubMed, SCOPUS and Google Scholar databases were analyzed, with emphasis on the last 5 years. The quality of the articles was evaluated using PRISMA guidelines, i.e., identification, review, choice and inclusion. The quality of the reviews was assessed using the measurement tool for evaluating systematic reviews (AMSTAR-2).

The search was performed using Boolean logical operators AND, OR and NOT.

It was performed with the words "non-surgical re-treatment", "apical surgery", "apicoectomy", "autotransplantation", "intentional replantation".

The keywords were used individually, as well as each of them related to each other.

Initially, the titles of all the articles were selected, the abstract of each one was evaluated and the articles were chosen for a complete reading review.

3. Results & Discussion

3.1 Non-surgical re-treatment

In root canal therapy, the infected pulp is removed from a tooth, the root cavity is disinfected and the root canal is filled with a sealing material. However, if the microorganisms that caused the infection are not completely eliminated, after a while they can cause a disease at the apex of the root, called periapical lesion^[8].

The treatment for this requires a second operation, which can be performed in the same way as the first treatment, from the crown to the root canal, to remove the existing filling and clean and disinfect it as best as possible before resealing^[3].

Retreatment of the root canal is a non-surgical procedure that involves the removal of previous filling materials from the tooth's root canal, followed by cleaning, shaping and filling the canals^[9].

The removal of filling materials from the root canal system is a primary objective in root canal retreatment procedures as this would allow instruments and irrigation solutions to reach a larger portion of the root canal system, which would consequently promote better cleaning and disinfection^[10].

Several studies have examined the ability of manual, rotary

and reciprocal nickel-titanium (NiTi) and stainless steel systems to optimally achieve this goal^[11].

Removal of the filling material can be achieved by different techniques, such as the use of manual endodontic files, nickel-titanium reciprocating and rotary files, and Gates Glidden and Peeso burs. Heated instruments, ultrasound and solvents can also be associated with this procedure^[12].

It has been investigated that manual instrumentation is associated with longer retreatment times than those treated with rotary/reciprocating systems. However, no procedural errors were reported with the former. NiTi retreatment files have no advantages over conventional techniques. Reciprocating and rotary systems exhibit similar capabilities in removing root filling material^[13].

When used in the initial penetration stage, solvents can improve the root canal penetration of the files, but can make cleaning difficult and, if used after instrumentation, can reduce residual filling material^[14].

Recent studies reported a 95% success rate after conventional root canal treatment in cases of irreversible pulpitis. Eighty-five percent of necrotic teeth were successfully treated using non-surgical endodontic treatment^[15].

Endodontic treatments may not be able to solve the problem because of the complex anatomy of the root canal system, such as the reticular structures of the lateral and accessory canals, as well as the oval root canals, which make complete cleaning and shaping difficult^[16].

Untreated areas of the root canal allow bacterial growth, and the remaining pulp tissue, necrotic tissue and microorganisms are considered the main cause of non-surgical retreatment failure^[17].

It is concluded that after a conventional root canal treatment, the total amount of bacteria may not have been eliminated, so that in the future that treatment may fail, in which case the primary option for solving that problem is non-surgical retreatment, which will allow the previously treated canal to be cleaned more thoroughly and to obtain better results.

3.2 Apicoectomy

Surgical and non-surgical endodontic treatments have a high success rate in the treatment and prevention of periodontitis apicalis. However, periapical endodontic lesions remain in some cases and additional treatment should be considered when periodontitis apical persists^[18].

Apical surgery or apicoectomy has been considered one of the last attempts to save teeth that cannot be treated with a conventional endodontic approach^[19].

Apicoectomy involves surgical treatment of a tooth with a periapical lesion that cannot be resolved by routine endodontic treatment^[20].

The goal of apical surgery is to obtain tissue regeneration, creating a barrier between the root canal system and the periradicular tissues. This goal should be achieved by resection of the root end, preparation of the root end cavity, and a bacterial tight closure of the root canal system at the end of the cut root with a retrograde filling, complete debridement of the periapical pathology by curettage to eliminate any source of infection^[19, 21].

Factors associated with a better chance of success with apicoectomy include patients under 45 years of age, upper anterior or premolar teeth, cases without preoperative pain, lesions without periodontal compromise, absence of perforating lesions, and teeth with only one periapical surgery. In the case of apicoectomy failure, the tooth may need to be extracted^[22].

A 2016 study compared the clinical effectiveness of the surgical (apicoectomy) or nonsurgical (root canal retreatment) approach for healing apical lesions and found no evidence of superiority of either approach at one year, four years, and 10 years of follow-up^[9, 23].

The success rate of apical surgery has been reported to range from 37% to 91%. The wide range and inconsistency of results can be attributed to variation in treatment planning, surgical technique, methodology, and follow-up period^[24].

The generally recommended surgical level of root-end resection is 3 mm; however, there are articles that have recommended a 3.6 mm resection, and in other studies, a higher percentage of lateral canals have been removed with a resection level of 3.5 mm compared to 3.0 mm (92.59% vs 74.07%). These findings suggest a modified resection level of 3.5 mm^[25].

Modern microsurgical techniques have increased the success rate of apicoectomy relative to traditional approaches. In previous studies, assisted apical resection has been performed using a computer-assisted design three-dimensional printed template. Guided apicoectomy allowed precise root resection, suggesting that this technique can be advantageous in complex anatomical situations^[26].

Success rates have improved considerably thanks to the minimally invasive technique of retrograde filling under a dental microscope. Because orthograde retreatment has been shown to significantly improve the results of apical surgery, it has been recommended before the operation to promote high success rates^[27].

In conclusion, we know that apical surgery is the first option to be performed after non-surgical retreatment was not as successful as expected. Innovations have been made in the area of apical surgery, such as the implementation of the microscope or the use of surgical guides that allow accuracy in the procedure and therefore a less invasive and conservative treatment.

3.3 Autotransplant

Autogenous tooth transplantation refers to the repositioning of an autogenous tooth at another tooth extraction site or at a surgically formed recipient site. This procedure is used to replace teeth that are, for example, congenitally missing or involve ectopic eruption, severe decay, periodontal disease, trauma, or endodontic failure when a suitable donor is available^[28].

By using the patient's own tooth, self-transplantation presents a number of advantages compared to other treatment options (i.e., dental implants or fixed partial dentures), such as greater resistance to occlusal loading, maintenance of the periodontal ligament (PDL) and surrounding bone, and the potential for improved aesthetics^[29].

This treatment is indicated in situations where congenital teeth are missing, movement of impacted or severely ectopic teeth, premature loss of permanent teeth (severe caries, trauma, iatrogenic damage, developmental abnormalities), periodontal disease, endodontic failure, growing patients correcting arch discrepancies, and when a suitable donor is available^[30, 31].

This is a viable treatment option for replacing missing teeth, but as with any surgery, complications can arise including pulp necrosis, inflammatory and replacement resorption, poor periodontal healing and ankylosis. These are complications that can be prevented or lessened by proper planning and following the correct protocols^[32].

Success rates for this procedure are as high as 96% and

survival rates of up to 98% for self-transplanted teeth^[33, 34, 35]. Reported complications of autotransplantation include pulp necrosis, root resorption, and hypermobility^[31].

The clinical application of a computer-aided rapid prototype model (CARP) for autotransplantation was first introduced in 2001 using 3D computerized tomographic (CT) image acquisition, followed by the manufacture of a 3D impression copy model^[36].

This technique allowed surgeons to simulate the contour of the recipient bone using full-size CARP models of the donor teeth and recipient alveolar bones prior to the operation. The use of CARP models for autotransplantation has the advantage of minimizing extraalveolar time and trauma to the donor tooth, which increases the success rate of the surgery^[37].

The CARP models improve the survival rates of teeth with mature roots to 88.1% and 68.2% at 3 and 12 years, respectively. In addition, self-transplants improve the maintenance of naturally attached gums, leading to good aesthetic results^[37].

Recently, high success rates have been reported for cases with mature teeth, and self-transplantation is becoming a predictable option in contemporary restorative dentistry^[38]. The main factor for successful autogenous tooth transplantation is the vitality of the PDL attached to the transplanted tooth^[31]. Although simple in concept, autotransplantation remains a controversial treatment option; however, it has been suggested as the treatment of choice in selected cases. A successfully transplanted tooth erupts with growth and can also be moved orthodontically. If a transplant fails at a later stage, a well-maintained ridge can be prepared for an implant when more appropriate. For a successful outcome, preservation of the periodontal ligament of the transplanted tooth is the key to successful self-transplantation through prevention of ankylosis^[39].

As a conclusion we have that autotransplantation is a long-established surgical technique that has a high success and survival rate, making it a good alternative treatment for endodontic failure when other procedures have already been tried and were not successful.

3.4 Intentional replantation

Intentional replantation is a procedure that involves the extraction of a tooth and its almost immediate replacement, with the aim of apically filling the canals, while the tooth is out of the cavity^[40].

Although intentional replantation is considered a treatment option of last resort, it was reported that the treatment had a 90% success rate in the first 6 months^[41].

Between 6 and 12 months, the survival rate decreased from 85% to 80%, and after 48 months, the survival rate of replanted teeth stabilized^[42].

A meta-analysis of 6 studies also showed a high success rate of 89.1% of intentionally replanted teeth^[43]. The success of this procedure is influenced by several factors, including the extent of periodontal disease and the presence of root fracture. However, it is a fairly simple procedure that is less expensive than dental implants and has minimal morbidity for the patient^[44].

Although the survival rates of replanted teeth do not compete with those of classic periodontal treatment and endodontic treatment, survival is remarkably high and is a conservative option that may be viable for some patients^[45].

Intentional replantation is the atraumatic extraction of a tooth, a resection and extraoral filling of the root, followed by

replacement of the tooth in its original socket. Endodontic microsurgery to treat recurrent infection is still preferred because of its high success rate, but in several situations, this is not feasible and an extraction/reimplantation should be considered^[46].

Amalgam has been used to seal root-end preparations; however, more recent studies have incorporated the use of newer materials such as MRI, Super EBA, MTA, and Endocem^[47].

An intentionally re-implanted tooth can cause certain complications, namely ankylosis, external root resorption, persistent periradicular infection, and periodontal decay. Under certain circumstances, extraction is unavoidable in a tooth with severe external root resorption, ankylosis, or severe periodontal breakdown^[48].

The main reason for failure in re-implanted teeth is root resorption, specifically ankylosis. Although the success rate is not always high, intentional replantation may be a treatment alternative that deserves consideration to maintain the natural dentition and avoid tooth extraction^[49]. Root resorption was reported as an adverse outcome in all of the included studies, with an overall prevalence of 11%^[50].

It is the last treatment option, used for cases that present with root canal obstruction due to a cemented post, complicated drilling, or separate instrument. It is also used when surgical complications are more likely^[51].

Several case reports suggest that intentional replantation is a reliable procedure and the rate of tooth retention after replantation is high even after more than 10 years of follow-up^[48].

Higher success rates have been reported for those replanted teeth where the overtime was 15 minutes or less compared to those that were kept out for more than 15 minutes^[37].

We conclude that intentional replantation is an alternative to tooth extraction, which despite not being the most appropriate treatment has proven to be successful in situations where other more conservative procedures have already been tried. The time that the tooth spends outside the alveolus is of vital importance because the longer it is the less success rate can be obtained. Today, successful results have been obtained in this procedure.

4. Conclusions

In conclusion, we know that after a conventional root canal treatment, the total amount of bacteria may not have been eliminated, so that in the future this treatment may end in failure. In this case, the first option to treat the tooth and conserve it is the non-surgical retreatment, which will allow the previously treated root canal to be cleaned more thoroughly and to obtain better results. The second option in case of unsuccessful re-treatment is apicoectomy, which results in the resection and cleaning of the apical third, which allows the elimination of bacteria from areas that are difficult to treat. Self-transplantation is another surgical technique that has a high success and survival rate, making it a good alternative for treating endodontic failure when other procedures have already been tried. Intentional reimplantation is an alternative to tooth extraction, which despite not being the most appropriate treatment has proven to be successful in situations where other more conservative procedures have already been attempted.

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