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RESEARCH ARTICLE

THE KEYS TO A SUCCESSFUL ROOT CANAL TREATMENT

Nashwan Abdullah Al-Afifi [1,*] and Samah Mohammed Al-Amery [2]

[1]*Dept. of Conservative, Faculty of Dentistry, University of Aden, Yemen*
[2]*Dept. of Dentistry, Faculty of Medicine and Health Sciences, University of Science and Technology, Aden, Yemen*

***Corresponding author: Nashwan Abdullah Al-Afifi; E-mail: nashwan.alafifi.dent@aden-univ.net**

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Abstract

Failure of root canal treatment (RCT) occurs when endodontic treatment falls short of standard clinical guidelines. An improper mechanical debridement (shaping and cleaning), persistence of bacteria inside the canals and apex, poor obturation quality, coronal leakage, and experience of dentists all probably influence the RCT success or failure. Although there is substantial success of RCT, failures take place in many cases, which usually could be related to the previously mentioned factors. So, it's considerably imperative to stop the foremost potential factors that cause RCT failure. This paper reviews how to increase the success rate of the RCT.

Keywords: Success, Failure, Root Canal Treatment, Access cavity preparation, Preparation of Root Canal System, Obturation, Coronal Seal.

Introduction

The root canal treatment (RCT) is aimed to maintain normal function of endodontically treated tooth as well as to remove root canal infection; therefore it stops or treats periapical inflammatory tissue lesions [1]. Failure of RCT occurs when endodontic treatment falls short of standard clinical guidelines [2]. The outcome of the RCT is drastically affected by the existence of bacteria inside root canals at the time of filling [3]. Lin, et al. [4] performed a study on two hundred and thirty-six cases of RCT failures, and found that the presence of bacterial infection inside the canals and/or the periradicular area and the presence of preoperative periradicular rarefaction are the principal factors associated with RCT failures. This means that persistent bacteria could very well stay in the treated root canals and therefore can stimulate or prolong periradicular tissue inflammation, thereby the elimination of bacteria from the root canal system is the conclusive aim of the RCT of teeth with apical periodontitis [3]. No cases give themselves a successful treatment without having a vital degree of debridement [5] and properly seal the root canal system with adequate obturation and proper coronal restroration to prevent the ingress of bacteria [6]. In addition, the instrumentation and technology used in treating and assessing the status of the affected root canal [7], and the expertise of the treating clinician [8].

So, one question remains: what steps should be taken to improve the RCT's success rate?

The next paragraphs will offer the crucial key elements that address this question:

1. Tooth isolation, Magnification, Radiography and Access cavity preparation

Complete isolation and good vision are prerequisites for a predictable, safe, and effective root canal treatment [9]. To isolate the treatment area and exclude moisture, dental practices today utilize both cotton rolls and rubber dams. The use of rubber dams in endodontic procedures has a positive impact on the outcomes of root canal treatment and reduces the higher risk that patients would swallow or aspirate instruments and materials [10, 11]. With some low-certainty evidence, a study performed by Wong, et al. [12] concluded that the use of rubber dams compared to cotton rolls may result in a decreased failure rate for restorations after six months.

Since the location of the canal orifices and their chemomechanical preparation represent a clinical challenge in the tooth with calcified canals, the American Association of Endodontics considers that the process involved in root canal treatment of calcified canals has a high level of difficulty and complexity [13]. Endodontic technology has advanced dramatically over the past few decades, moving from direct vision to magnification. Magnification aids in both increased and improved vision for the user. By using magnification, endodontists are able to locate canal orifices, detect microfractures, identify accessory canals, diagnose and treat patients more accurately, and recognize anatomic abnormalities in teeth and supporting structures. Due to their increased precision and accuracy, magnifying tools help create procedures of higher quality [14].

Radiographic examinations were initially utilized for diagnostic imaging but two-dimensional image cannot be relied upon to accurately show the location and specifics of the internal anatomy of the root canal system. Cone-beam computed tomography (CBCT) imaging examinations are crucial for proper diagnosis and planning of more difficult cases, such as severely calcified teeth, because they enable three-dimensional analysis [15, 16]. The intraoperative use of CBCT for locating the second mesiobuccal (MB2) canal, diagnosing resorptions, and fractures, and locating calcified canals has also been noted recently [17]. The literature emphasizes the value of CBCT in endodontics, particularly during the initial treatment period, for diagnostic imaging and treatment follow-up [13]. Preoperative Knowledge of the tooth anatomy and morphology is necessary in order to prepare an access cavity appropriately. Even two radiographs that taken at various angles are frequently adequate to create a 3D image of the tooth to be treated, a CBCT image may be justified and required to assess the presence of additional canals, complicated morphologies, curvatures, and/or dental developmental defects [18]. The root canal treatment's outcome is affected by the access cavity. For root canal therapy to be successful, internal anatomy must be understood and fully accessed [19]. Conventional endodontic access cavities usually involve the removal of caries and permanent restorations, and preserve as much of the intact tooth structure as possible. By removing the overhanging cervical dentine and enlarging the root canal orifices, these access cavities completely remove the pulp chamber roof, allowing direct access to the apical foramen or at least to the root canal's first curvature. Inadequate access cavity preparation may result in difficulty locating or negotiating the root canals [20]. The probability of such iatrogenic problems; ledge formation, zipping, perforation, and separated instruments can be decreased by proper access cavity preparation with a smooth, straight path to the apical foramen without modifying the root canal's original orientation [21]. Ultimately, these problems could result in unsuccessful RCT. Therefore, proper access cavity design and preparation are essential for high-quality endodontic treatment, prevention of iatrogenic problems, and prevention of endodontic failure [20]. Thus, according to the previously mentioned information, for appropriate access cavity preparation, proper tooth isolation, magnification, and good-quality radiographic images are crucial components that also serve in the proper diagnosis and planning of more difficult cases, which subsequently will improve the RCT success rate.

2. Preparation of Root Canal System

2.1. Working length determination

Accurate working length determination is among the essential formal steps to achieve the optimal cleaning and disinfection of the root canal system [22]. It is evident that when instrumentation is shorter than the correct working length of the canal, there is a risk of leaving inflamed tissue and infectious components in the root canal system. On the other hand, instrumentation that extends beyond the apical foramen may push infectious debris into the periapical tissue, causing periapical inflammation, a foreign body reaction, and incomplete regeneration of the supporting tissues. For this reason, it is believed that the apical terminus of the root canal instrumentation must be at the apical constriction [23]. The apical constriction is the apical part of the root canal, which has the narrowest dimension. Its position might vary but is generally between 0.5-1.0 mm short of the center of the apical foramen [24, 25]. Radiographs have traditionally been used to measure working lengths. However, the apical constriction's position varies greatly and cannot be detected on radiographs. So, the limitation of radiographs has led to the development of electronic apex locators [26]. Abidi, et al. [27] compared the accuracy of working length determination with endo motor having a built-in apex locator and with periapical radiographs and found that the endo motor having a built-in apex locator was a better measuring tool compared to the conventional periapical radiographs.

2.2. Shaping and cleaning of the root canal system

Shaping means preserving the original canal configuration while not forming any kind of iatrogenic errors, for example; instrument fracture, transportation, ledge, or perforation (Aguiar *et al.*, 2009). Schilder [28] mentioned the fact that successful cleaning and shaping of the root canal system is necessary for reaching the biological and mechanical goals of RCT. These goals are to eradicate all of the pulp tissue, bacteria, and their by-products while producing adequate canal shape to receive three-dimensional obturation of the entire root canal system [29]. Canal shaping requires the development of a continuously cone-shaped form of the root canal, which can be wide coronally and narrow apically, together with the apical foramen kept as small as is realistic [29, 30]. In recent years, there have been significant advances made in the development of Ni-Ti rotary instruments. The goal of this continuous improvement is to create files that are more effective and have qualities such as flexibility, efficiency, safety, and simplicity. Rajkhan, et al. [31] Compared rotary instrumentation to manual instrumentation techniques, and found that rotary instrumentation is thought to be more effective in shortening the instrumentation time and improving the quality of obturation. To get better results and reduce the related quality of work, the rotary endodontic files should be recommended for root canal filling settings [31]. Furthermore, a study performed by

Peralta-Mamani, et al. [32], concluded that, rotary instrumentation required less time to prepare root canals than manual instrumentation. However, the operator's experience had a significant influence. With rotary systems, significantly better results were also obtained in terms of canal transportation, the ability of the instrument to stay centered in the canal, altering the canal's curvature, and canal shape and smoothness. The manual instrumentation showed better performance regarding to the amount of smear layer and debris, the number of instrumented surfaces, and the number of dentin defects. Regarding the loss of working length, the amount of dentin that was removed, and what dentin was left after both techniques, the outcomes were comparable [32]. Because of the benefits of each of the previously listed systems, endodontic treatment success rates will increase through a comprehensive root canal preparation of the root canal system which can be achieved using both rotary and manual instrumentation techniques.

A thorough removal and disinfection of all bacteria and their byproducts from the infected root canal is necessary for an endodontic treatment to be effective. This is accomplished, in part, by shaping (instrumentation) the canal but mostly by using antimicrobial irrigants [33]. Root canal instrumentation produces a layer of organic and inorganic material called the smear layer that may also contain bacteria and their by-products [34]. A study performed by Siqueira Jr, et al. [35], indicated that around 70% much more debris appeared to remain in the root canals in cases where no irrigant was used at the time of instrumentation compared with irrigated canals. There is no single irrigation solution used in endodontics that concurrently cleans away the smear layer as well as, disinfects the whole root canal system [36]. The root canals should be irrigated with copious amounts of sodium hypochlorite (NaOCl) solution throughout root canal preparation. Following the finishing of the preparation, the canals need to be irrigated with a chelating solution such as Ethylenediaminetetraacetic Acid (EDTA) or Citric Acid. Every single canal should be irrigated no less than 1 min with 5-10 ml of chelating solution. Once the smear layer has been removed, irrigation with an antiseptic solution is useful. Chlorhexidine (CHX) is among the most promising solutions for final irrigation in this situation [37]. Iandolo, et al. [38] reported that modern endodontics demonstrated a successful endodontic irrigation procedure directly contributes to the clinical success of the endodontic treatment. The primary consideration is that there are a lot of irrigants, like NaOCl, EDTA, CHX, and distilled water, that may be combined with various activation techniques. These methods include laser procedures, heating, negative apical pressure, subsonic, sonic, and ultrasonic, as well as manual dynamic activation. The elimination of smear layers using heating, sonic, or ultrasonic technology is the most effective of the described methods. The literature suggests that irrigant activation has more advantages than its absence. However, it is impossible to suggest a reliable activation method [38, 39]. So, based on the facts previously mentioned, a high-quality root canal preparation requires accurate determination of working length, utilizing both manual and rotary systems as well as activation of irrigants that are used to disinfect the root canal system.

3. Obturation of Root Canal System

Obturation of the entire root canal system after thorough shaping and cleaning of the root canal system is essential for the successful outcome of endodontic treatment. However, the unique features of the root canal anatomy frequently make these steps challenging [40]. Obturation can be useful for preventing any contamination leakage or ingress of foreign material into the pulp canal system [41]. Root canal obturation is generally composed of core materials such as gutta-percha and sealer [42]. There are various core filling materials and sealers can be used in endodontics. Essentially, root canal obturation should seal all foramina connecting to the periodontium, be free of voids, adapt to the prepared root canal walls, and end at the working length [43]. Clinicians currently use gutta-percha and epoxy sealers as the gold standard for obturation procedures. According to a study performed by Al-Afifi, et al. [44], in which a variety of obturation techniques were used to evaluate and compare the obturation quality between canals obturated with gutta-percha/AH Plus sealer and resin-coated GP/EndoREZ® sealer, the latter was found to be superior in terms of maximizing the percentage of core filling material occupying the canal area with cold lateral compaction, warm lateral compaction, and single cone techniques. Therefore, using obturation materials that have adhesive properties will result in good root canal obturation even if a single cone technique has been used [44]. The antimicrobial properties of sealer and obturating materials can combat microorganisms in the dentin's tubules [45]. Recently, bioceramic sealers represent the most current advancements in endodontic sealing materials. Bioceramic sealers are safe, hydrophilic, expandable, biocompatible, and antibacterial [46]. An important point is that, at all times, you should remember not to underfill or overfill the root canal since the success rate of the obturation is high for those canals that end within 2 mm of the radiographic apex [47,48]. Canals with overfilled obturation had a fourfold failure rate more than canals with underfilled obturation of the radiographic apex [49].

4. Coronal Seal of Root Canal Treated Teeth

A well-sealing coronal restoration is important following the completion of root canal obturation mainly because it would probably avoid the ingress of any bacteria and their byproducts, which can be presented in the surrounding environment [50]. Generally, the coronal leakage can take place in the following situations: Delay in the placement of coronal restoration following RCT, a compromised or inadequate temporary filling, tooth fracture, leakage during post-placement, failure of the final restoration, and recurrent decay at restoration margins [51]. Consequently, the long-term prognosis of root canal-treated teeth needs a high-quality final restoration [52]. A clinical study performed by Ray and Trope [53] declares that a great RCT outcome could possibly be accomplished even in poorly filled root canals when the quality of the coronal restoration is certainly adequate. A meta-analysis study performed by Ng, et al. [54], mentioned that the teeth which have adequate coronal restorations get a success rate greater than those teeth with unsatisfactory restorations. In an attempt to improve the coronal seal, it has been suggested that orifice barriers be placed over canal obturation. Orifice barriers, sometimes referred to as "intra-orifice barriers," "coronal plugs," or "orifice plugs," are restorative materials that are placed into root canal orifices (at or just below canal orifice level) and used as a base to cover the pulp chamber floor once the root canal treatment is completed [55]. Different materials can be used such as Glass ionomer cement, Resin modified GIC, Composite resin, Mineral trioxide aggregate, and Cavit [56]. A recent systematic review and meta-analysis study in which orifice barriers were used to prevent coronal microleakage after root canal obturation concluded that orifice barriers are effective in preventing coronal microleakage and should be placed after the completion of root canal treatment [56].

5. The Experience of the Dentists

Alley, et al. [57] demonstrated that a lower success rate of RCT has been shown with general dental practitioners with a success rate of 89.7%, while a 98.1% success rate was presented when teeth treated by endodontists. The lower success rate of general dental practitioners could be related to training as practicing endodontists would be expected to have more clinical experience than generalists [57]. The most concerning is the low success rate in molars that are treated with general dental practitioners because of the low frequency of proper root fillings. General dental practitioners may view RCT more as a means of managing a patient's symptoms, while infection control should be the primary objective of RCT [58]. Furthermore, a lot of dentists find doing RCT challenging and difficult, which makes them willing to accept low-quality root fillings [59]. Dentists should always be learning new things. Equally significant is the potential for work sharing in more complex situations, such as molars, between endodontists and dentists [60]. So, the more RCT you do, the better you will be, which in the end improve the success rate of the RCT.

Conclusions

To sum it up, these “keys” should be taken into consideration during root canal treatment. Initially, adequate tooth isolation, magnification, and high-quality radiographic images are important to perform optimal access cavity preparation. Next, the preparation of the root canal system requires proper working length determination to avoid over or under-instrumentation, and shaping and cleaning of the root canal using the advantages of both manual and rotary systems with irrigants to remove all bacteria and their byproducts from the root canal system. Followed by adequate obturation and closure of the canal with a proper coronal seal. In addition, more training is needed for general dentists to improve the quality of RCT. Paying attention to details not only enhances root canal treatment quality but also increases success rate.

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مقالة بحثية

مفاتيح العلاج الناجح لقناة الجذر

نشوان عبدالله العفيفي[1,*] و سماح محمد العامري

[1] قسم العلاج التحفظي، كلية طب الأسنان، جامعة عدن، اليمن
[2] قسم طب الأسنان، كلية الطب والعلوم الصحية، جامعة العلوم والتكنولوجيا، عدن، اليمن

* الباحث الممثّل: نشوان عبدالله العفيفي؛ البريد الالكتروني: nashwan.alafifi.dent@aden-univ.net

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المُلخّص

يحدث فشل علاج قناة الجذر (RCT) عندما لا ترقى المداواه اللبية إلى مستوى الإرشادات السريرية القياسية. إن التنضير الميكانيكي غير السليم (التشكيل والتنظيف)، واستمرار البكتيريا داخل القنوات و ذروة الجذر، وضعف جودة السداده، والتسرب في حشوة التاج، وخبرة أطباء الأسنان كلها ربما تؤثر على نجاح أو فشل علاج قناة الجذر. على الرغم من أن هناك نجاحا كبيرا في علاج قناة الجذر، إلا أن حالات الفشل تحدث في كثير من الحالات، والتي عادة ما يمكن أن تكون ذات صلة إلى العوامل المذكورة سابقا. لذلك، من الضروري جدًا إيقاف أهم العوامل المحتملة التي تسبب فشل علاج قناة الجذر. تستعرض هذه الورقة كيفية زيادة معدل نجاح علاج قناة الجذر.

الكلمات المفتاحية: نجاح، فشل، علاج قناة الجذر، تحضير الغرفه اللَّبِيَّة، تحضير نظام قناة الجذر، السداده، حشوة التاج.

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