

Factors Affecting Root Canal Treatment Outcomes: A Systematic Review

Yousif Abdullah Alsinaidi^{1*}, Tail Alhumaidi T Almotairi¹, Ibrahim Mohammed Alyami¹, Abdulmonem Abdulaziz Alsharif¹, Mohammed Zaben Alshammari¹, Alqahtani Abeer Saeed A², Ghaida Abdulrahman A Almithn²

¹General Dentist, Ministry of Health

²General Dentist in Private Clinic

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*Corresponding author: Yousif Abdullah Alsinaidi
General Dentist, Ministry of Health

Abstract

Background: Irreversible pulpitis occurs due to infection and other factors. Irreversible pulpitis needs root canal treatment to relieve the pain and achieve restoration of healthy teeth. The success rates of root canal treatment are based on adequate removal of the microorganism and the prevention of the re-growth of microorganisms. However, endodontic treatment isn't always successful. There are many factors affecting the outcome of root canal treatment. **Aim:** To identify the factors affecting the outcomes of root canal treatment by reviewing the previous studies conducted on this subject. **Methods:** PubMed, Google Scholar, and Research Gate databases were explored to search for articles related to our subject. The searching process involved using different keywords that were used in different combinations to obtain all possible articles focused on our subject. The inclusion criteria for studies were articles published in 2017 until now, English original and full-text articles. **Results:** A total of 158 articles were obtained, and only seven articles were eligible for the inclusion criteria. Four studies included treatment performed by dental students. The success rate of treatment ranged between 63.7% and 86.8%. The factors that affected the outcome of root canal treatment were categorized into factors associated with successful treatment, failure of treatment, and factors with no impact on treatment. **Conclusion:** The success rate of root canal treatment in our analysis was moderate. There were many factors affecting the root canal treatment outcome, including quality of filling, length of filling, and the absence or presence of a periapical lesion.

Keywords: Root canal, Factors, Determinants, Outcomes, Success, Failure.

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INTRODUCTION

The pulp of the teeth is the source of sensation; irreversible pulpitis can occur as a result of many causes, including caries, infection, and traumatic accidents. Irreversible pulpitis needs root canal treatment to relieve the pain and achieve restoration of healthy teeth [1]. Proper diagnosis and treatment are required for the success of endodontic treatment. The modern instruments used for endodontic treatment lead to a success rate of 86% to 98% [2]. Additionally, endodontic treatment can resolve periapical inflammation, which is an inflammatory response of the apical region toward the end of the root due to bacterial ingress into the periapical area [3]. However, endodontic treatment isn't enough alone when there is a large periapical lesion; therefore, surgical treatment is performed in combination with endodontic treatment [4].

The rates of root canal treatment success are based on adequate removal of the microorganism from

the canal system and the prevention of re-growth and recolonization of residual microorganisms by the placement of root filling that obturates the entire space, combined with a restoration that results in a satisfactory coronal seal [5]. Endodontic treatment isn't always successful [6]. The failure of endodontic treatment can be diagnosed based on clinical symptoms and signs as well as radiographs of the root canal. There are many factors that affect the failure of root canal treatment, such as necrotic pulp of periradicular infection, underfilling of the root canal, missed or unfilled canals, periodontal disease, broken instruments, root fractures, and mechanical perforation [7]. Also, the success of endodontic treatment is based on many factors. There is no recent systematic analysis that reported the factors affecting the outcomes of endodontic treatment; therefore, we conducted this systematic review.

METHOD & SEARCH STRATEGY

The PRISMA checklist guidance for systematic review and meta-analysis [8] was adopted to

write this systematic review. Scientific databases, including PubMed, Google Scholar, and Research Gate, were explored and used for searching for research articles eligible for our subject. Various keywords were used for the searching purpose; these keywords included "Root canal treatment, Success, Failure, Outcomes, Factors, Predictors, Determinants, Association." Such keywords were used in a variety of combinations in order to obtain all possible articles. All titles produced from the searching process were revised, and irrelevant titles were excluded.

Eligibility Criteria

The findings were examined to choose only research articles published from 2017 until now as well

as original articles. All articles reported the outcomes of root canal treatment were eligible. Only articles written in the English language were included, whereas articles written in other languages were excluded.

The second step involved reviewing the original articles that were written in English and evaluating the outcomes of root canal treatments. Abstracts were assessed manually to select the relevant studies for revision. Articles that didn't report factors associated with outcomes of root canal treatment were excluded. Also, articles that weren't available for full-text and those with overlapped or incomplete data were excluded. The full description of the search strategy is shown in figure 1.

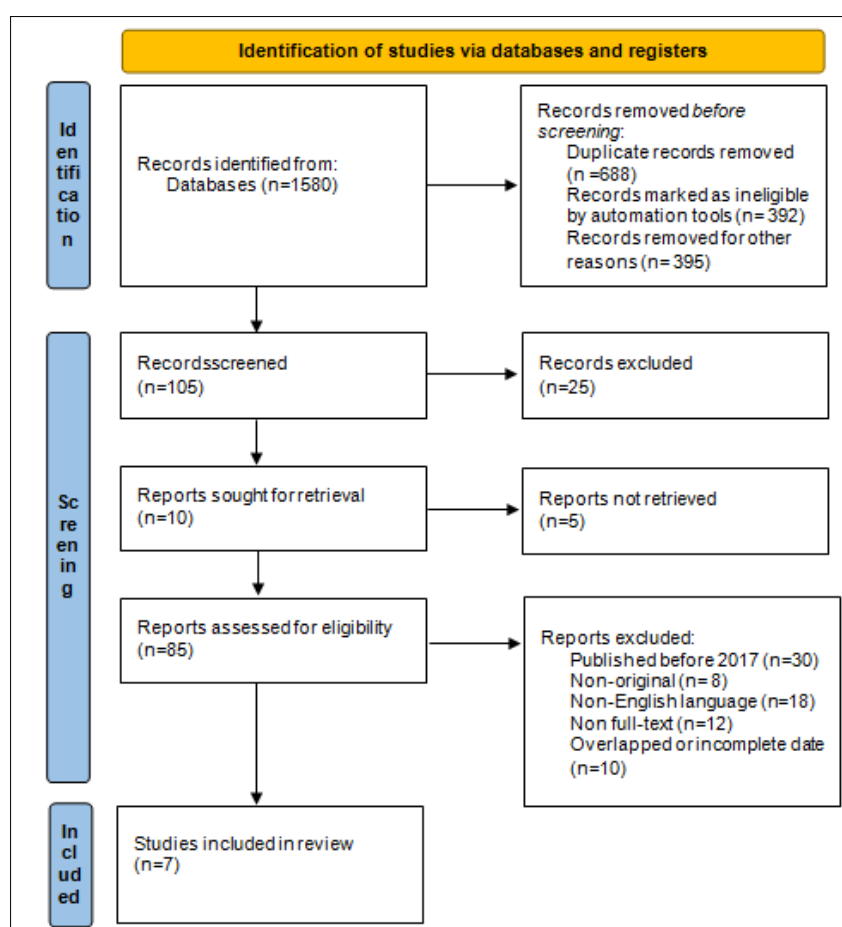


Fig. 1: Planning of Eligible criteria

Data Review and Analysis

The first stage in reviewing data included a preliminary review using a specially designed excel sheet for data extraction. The data of interest was extracted in the excel sheet, and the collected data included author and publication years, study design, sample size, intervention/criteria, results, and main findings. The chosen data was revised via the excel sheet and then transferred to a pre-designed table to summarize the collected data.

RESULTS

This systematic review included seven articles that met the eligible criteria [9-15] (table1). There were three studies that didn't state that study design [10, 11, 13, 15], whereas the remaining studies reported cross-sectional design [9], retrospective cohort [12], and retrospective [14]. There were five studies that reported the number of patients with a total number of 2387 [9-13, 15], whereas one study didn't report the number of patients [14], and one study was conducted on the older population [11]. The number of teeth included was

reported in three studies with a total number of 1863 teeth [11, 13, 14], whereas four studies didn't report the number of teeth [9, 10, 12, 15]. There were three studies that reported the number of root canals treated with a total number of 1160 treated roots [9, 12, 14].

Regarding interventional treatment, one study reported primary and secondary root canal treatment [9], root canal filling [10], treatment of mandibular second molar with C-shaped canals in older patients [11], and three studies reported non-surgical treatment [12-14], and one study reported root canal treatment in teeth with one or two-root canals [15]. There were four studies that reported that the treatment was done by undergraduate students [9, 10, 14, 15]. There were two studies that reported follow-up duration, which was 3-8 years in one study [10], and 2.8 years in the other study [15].

Regarding the criteria by which quality and success of treatment were determined, one study used ESE criteria, accepting (ASE) and not accepting (NSE) unintentional sealer extrusion for treatment quality and root canal treatment [9]. Another study stated that the treatment outcomes were based on strict clinical and radiological criteria to determine the success rate [10]. One study reported that the quality of the root filling was evaluated based on homogeneity, taper, and apical extension [12]. The fourth study used periapical index (PAI) to assess the radiograph and defined health and healing cases radiographically as successful [13]. The fifth study defined success as healed and defined failure as uncertain or unsatisfactory healing [14]. The last study considered the treatment as successful when the periapical radiographic normality was associated with the absence of clinical symptoms, whereas the treatment failure was considered in the presence of periapical radiolucency [15]. Only one study didn't report the criteria of success determination [11].

Regarding the results of the included studies, only two studies reported quality [9, 12]; one study reported technical quality and reported a satisfaction rate of 45.9% and 62.3% based on NSE, and ASE criteria, respectively. Unsatisfactory technical quality was associated with root canal filling length and root canal curvature (RCC) more than 7° and 12° according to NSE and ASE criteria, respectively, were associated with less satisfactory technical quality. In bivariate analysis, according to both NSE and ASE criteria, unsatisfactory technical quality was associated with tooth type. According to multivariate analysis, according to NSE criteria, root canal curvature ($P<0.001$) and apical root resorption ($P=0.028$) were associated with unsatisfactory technical quality. Based on ASE criteria, root canal curvature was the only predictor of negative outcomes of root canal treatment [9]. The other study reported poor filling quality, and it was found among 8.3% of roots. The failure of non-

surgical treatment was significantly associated with inadequate filling quality of the root [12].

The success rate was reported in six studies [10-15] and ranged between 63.7% [10] and 86.8% [12]. The factors associated with success included anterior teeth and premolar (compared to molars) ($OR=1.7$), female ($OR=1.9$) [13], absence of voids within the root filling ($P<0.001$), the absence of preoperative periapical lesions ($P=0.001$), the extension of root filling (length) material by 0-2 mm from the radiographic apex ($P<0.001$), and root type (premolar roots, anterior roots) [14].

The factors associated with failure included the presence of a periapical lesion on the postoperative radiograph ($OR=3.35$) [10], inadequate quality of the root filling, inadequate homogeneity and taper, the short length of filling ($>2mm$) [12], and apical periodontitis ($P<0.001$) [13]. One study revealed that carious lesions ($P=0.017$), gingival bleeding ($P=0.043$), and tooth motility ($P=0.022$) were significantly associated with the occurrence of periapical lesions [15].

The factors that were reported to have no significant impact on outcome included age, sex [11, 15], location of teeth, signs and symptoms, radiolucency, pulp vitality, caries, fracture, visit, shaping, sealer leakage, void, final restoration, hypertension, diabetes mellitus, cardiovascular disease [11], preoperative periapical lesion [12], teeth group (single or two-rooted), adjacent tooth, antagonist tooth, filling quality parameters (apical extension, homogeneity, taper, quality of filling), coronal restoration parameters (occurrence, quality of restoration, type, number of surfaces, extension, intra-radicular post, the void between post and gutta-percha, remaining gutta percha) [15].

DISCUSSION

The goal of the current systematic review is to identify the factors affecting the outcome of root canal treatment. In the current analysis, the success rate of root canal treatment ranged between 63.7% [10] and 86.8% [12]. In our analysis, there were four studies out of seven studies reported that the treatment was performed by undergraduate students and the success rate ranged from 60.7% [10] to 73.3% [15].

Many previous studies reported root canal treatment performed by dental students showed success rates of 68% for teeth with pre-existing periapical radiolucencies and 91% for teeth with no pre-existing radiolucencies [16]. Another study reported a success rate of 70% among teeth treated by undergraduate dental students [17]. These rates were similar to our rates, whereas one study reported a higher success rate of 84% of teeth that had root filling placed by postgraduate students and staff in dental hospitals [18].

These findings indicate that the success rate can be dependent on skills and experience; therefore, the success rate among undergraduate dental students was rather low.

However, in our analysis, there were different criteria used by the studies to determine the success of root canal treatment. There are many indicators for the success of endodontic treatment, which are subjected to individual variation. The American Association of endodontists has put the criteria for the success of endodontic treatment based on post-treatment clinical symptoms and signs [19]. However, these signs and symptoms are varied between cases [20]. The variation in signs and symptoms between cases and the criteria used to determine the success of the treatment may lead to variation in the success rates between different studies.

In our analysis, we could identify three categories of factors in relation to root canal treatment outcomes; the factors associated with the success of the treatment, factors that affected the failure of treatment, and the factors that had no impact on treatment outcomes. The factors associated with the success of treatment included anterior teeth, premolar, absence of voids within the root filling, absence of preoperative periapical lesions, the extension of the root filling, and the root type. On the other hand, the factors associated with treatment failure included the presence of a periapical lesion, inadequate quality of the root filling, inadequate homogeneity and taper, short length of filling, and apical periodontitis. Additionally, carious lesions, gingival bleeding, and tooth mobility lead to treatment failure indirectly as these factors are associated with the occurrence of periapical lesions, which in turn are associated with treatment failure.

The factors which had no effect on the outcomes of root canal treatment were various, and many, and they included age, sex, location of teeth, signs and symptoms, pulp vitality, caries, visit, shaping, radiolucency, sealer leakage, fracture, final restoration, hypertension, diabetes mellitus, teeth group, adjacent and antagonist teeth. Some factors were reported in one study to have no impact on the outcomes of treatment, such as homogeneity, taper, and quality of filling [15]; however, these factors were reported to affect the outcomes of treatment in another study in our analysis [12]. Also, it was reported that the absence of voids within the root filling was associated with the success of treatment in one study in our analysis [14]. On the other hand, another study in our analysis reported that void had no impact on the treatment outcomes [11, 15]. One study in our analysis reported that success of treatment was associated with females [13], whereas the other two studies reported no influence of gender [11, 15].

It was reported that improper shaping of the canals leads to short gutta-percha, which in turn allows bacterial growth and re-infection [21]. In our analysis, shaping was reported to have no impact on the outcome of treatment [11]. In our analysis, sealer leakage was reported to have no impact on the treatment outcome expressed in survival rate [11]. It was reported that sealing is the final and very important step in endodontic treatment as it prevents coronal bacterial invasion from the oral cavity [22]. Inappropriate sealing leads to bacterial invasion, and then bacteria can coronally ingress into the root canals after endodontic obturation leading to infection and then the failure of treatment [20].

In our analysis, age was reported to have no significant impact on survival and success rates [11, 15]. In contrast, a previous study concluded that the survival rate decreased with age as vertical root fracture was less common among younger patients as their teeth were more resilient to the masticatory force [23]. Also, from the previous study, the teeth being more resilient to the masticatory force, which indicates immobility of the teeth among young patients, was associated with a higher survival rate [23]. In our analysis, one study showed that tooth mobility was associated with periapical lesions, which in turn were associated with treatment failure [15].

It was stated theoretically, it was proposed that molar endodontics is more likely to result in failure when compared to simple one-canal root canal treatment due to the complex canal morphology [24]. In our analysis, this proposal was confirmed in two studies; one study reported that anterior teeth and premolar were associated with the success of treatment compared to molars [13], and the other study reported that the type of root, including premolar root and anterior roots, were associated with the success of treatment [14].

It was stated that the weighted success rate of treatment for teeth with pre-operative periapical lesions was lower than that for teeth without preoperative periapical lesions [25]. In our analysis, the success of treatment was associated with the absence of preoperative periapical lesions [14], which supports the previous statement [25].

It was reported that the number of visits has no effect on the success rates [26]. In our analysis, visits were reported to have no impact on the survival of root canal treatment [11].

It was reported that the technical quality of root filling is the main cause of clinical failure [5, 27]. In our analysis, one study reported that the failure of non-surgical treatment was significantly associated with inadequate filling quality of root [12]. Another study revealed that unsatisfactory technical quality was

associated with root canal curvature and apical root resorption [9].

CONCLUSION

In our analysis, we could conclude that most studies assessing the success and factors affecting the outcome of root canal treatment were conducted on undergraduate or postgraduate students. The success rate of root canal treatment in our analysis didn't reach 90%. There were many factors affecting the root canal treatment outcome. Some of such factors were associated with successful treatment, failure of treatment, and others had no impact on the treatment outcomes. The factors affecting the outcome of treatment include quality of filling, length of filling, and the absence or presence of a periapical lesion. However, the success rate and associated factors can be precisely determined due to the variation of criteria used for the determination of the success of treatment.

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