Review Article

EDTA Vs CITRIC ACID DECALCIFYING SOLUTIONS: A SYSTEMATIC REVIEW TO COMPARE THE CLINICAL EFFICACY

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ABSTRACT

Decalcification is defined as the process of reducing the minerals from the bone or any other kind of calcified tissue. Several root canals exhibit an excessive amount of mineral content and are found to be blocked. There are six major types of decalcifying agents such as EDTA, 5% trichloracetic acid, 5% nitric acid, 10% formic acid, formalin–nitric acid, and citric acid. The purpose of this systematic review was to determine the efficacy of EDTA and Citric acid in decalcifying the root canals. A systematic literature review from 2010 to 2022 was performed using databases such as PubMed, Medline, and ScienceDirect. The keywords used were "EDTA", "Citric acid", and "root canal decalcification". PRISMA flowchart was used to describe the selection process of searched articles. The Cochrane risk of bias assessment method was used to assess the quality of the studies included. The majority of the included studies could not establish a clear comparison between EDTA and citric acid. More experimental studies need to be conducted to distinguish between these two materials.

Key words: EDTA, Citric acid, Decalcification, Blocked canal.

Introduction

Root canal treatment aims to sterilize the canals leading to the root canal space. Mechanical instruments, in conjunction with chemical techniques, can accomplish this. In addition to using hand or mechanical equipment, the dentin root canal surface develops a layer known as the smear layer, which is amorphous, uneven, and granular. Moreover, several canals exhibit an excessive amount of mineral content and are found to be blocked [1, 2].

Decalcification is defined as the process of reducing the minerals from the bone or any other kind of calcified tissue. There are six major types of decalcifying agents such as EDTA, 5% trichloracetic acid, 5% nitric acid, 10% formic acid, formalin–nitric acid, and citric acid. From the research, it has been determined that EDTA is one of the fewer decalcifying acids than the others as this contains EDTA disodium salt, distilled H2), 200gm, 950 ml, ~50ml, and 10N NaOH [3, 4].

While on the other hand, citric acid is also an effective decalcifying agent [5]. From the research, it has been determined that it has become the decalcifying agent that is most studied among the six agents of decalcification due to its ability of cleansing as well as decalcify in the root canal [6].

A study showed that there was no difference between EDTA and EGTA that was observed. Both of them remove more calcium significantly than the citric acid and CDTA at the pH of 7.4 ($p < 0.05$). Furthermore, there was no difference seemed in the saline solution and citric acid at the pH of 7.4. The result shows that citric acid at a pH of 1.0 is a more practical alternative like an irrigating solution to remove the layer that was smeared and give some opportunities for the procedure of biomechanical [7, 8].

Kumar *et al*. (2014) conducted a study to determine the impact of some of the significant decalcifying agents, mainly focusing on the EDTA and citric acid solutions [9]. The author states that the layer of the smear is a negative trait that prevents the adhesion of material filling to the walls of the dentine. Chelating agents are being used for different purposes, such as during cleaning as well as shaping the canals of roots to eliminate the layer of smear. From the research, it has been determined that Citric acid decreased the overall process of the microhardness of the root canals more than the other decalcifying agents. While on the other hand, EDTA caused the minimum reduction in microhardness as compared to all other irrigants [10].

Apelblat (2014) and Ivica *et al*. (2019) discussed citric acid in which the author examined all the significant steps included in the production of Citric Acid as well as explored its effectiveness [11, 12]. Research shows that citric acid is one of the most effective agents among the six agents that are being used in decalcification.

PICO question

P= Patients with calcified canals
I= EDTA
C= Citric acid
O= Successful outcome in the form of decalcification of canals

Study hypotheses
Citric acid is a more effective decalcifying agent as compared to EDTA.

Aims of the study
This meta-analysis set out to compare the performance of EDTA and citric acid as root canal decalcifiers.

Clinical applications
The findings of this systematic study will help clinical practitioners to evaluate which decalcifying agent among these two could be preferred in their practice.

Materials and Methods

A systematic literature review from 2010 to 2022 was performed using databases such as PubMed, Medline, and ScienceDirect. The keywords used were "EDTA", "Citric acid", and "root canal decalcification" **(Table 1)**. PRISMA flowchart was used to describe the selection process of searched articles **(Figure 1)**.

Table 1. Inclusion and exclusion criteria

№	Inclusion criteria	Exclusion criteria
1.	Controlled trials and case-control studies	Systematic reviews or meta-analyses or expert opinions or narrative reviews
2.	Published between 2010 and 2022	Not within the given time
3.	Studies including EDTA and citric acid	Irrigants other than EDTA and citric acid
4.	English language of publication	Language other than English
7.	In vivo (humans)	In vitro

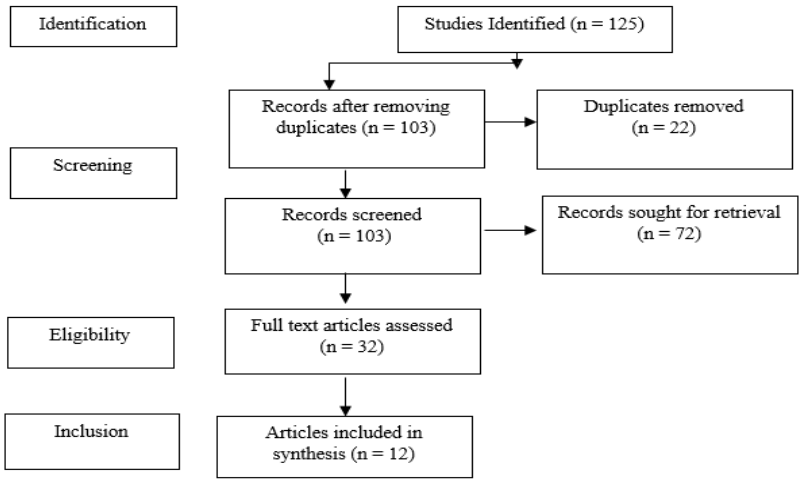

Figure 1. PRISMA Flow Diagram

Risk of bias assessment
All studies were evaluated for quality using the Cochrane risk of the bias assessment tool **(Table 2)**.

Table 2. Summary of Cochrane Risk of Bias Assessment

Study	Selection Bias/Appropriate control selection/baseline characteristics similarity	Selection bias in randomization	Selection bias in allocation concealment	Performance-related bias in blinding	Reporting bias/Selective reporting of outcomes	Detection bias Blinding outcome assessors	Accounting for confounding bias

Cruz-Filho *et al*., 2011 [13]	+	+	+	+	+	+	-
Pitoni *et al*., 2011 [14]	+	+	+	+	-	+	+
Prado *et al*., 2011 [15]	+	+	+	-	+	+	+
Poggio *et al*., 2012 [7]	+	+	+	+	+	+	-
Wu *et al*., 2012 [3]	+	-	+	+	+	+	+
Keyur *et al*., 2014 [16]	+	+	+	-	+	+	+
Turk *et al*., 2015 [17]	+	+	+	-	+	+	-
Poggio *et al*., 2015 [18]	+	+	+	+	+	+	+
Ajeti *et al*., 2018 [19]	+	+	+	+	+	-	+
Gandolfi *et al*., 2018 [20]	+	+	+	+	+	+	-
Unnikrishnan *et al*., 2019 [21]	+	+	+	+	+	-	+
Varshitha and Sharma, 2019	+	+	+	+	-	+	+

Results and Discussion

The microhardness of the dentin smear layer in the root canal lumen was measured, and the influence of several chelating solutions was assessed by Cruz-Filho *et al*., 2011. There was no statistically significant difference between the effects of EDTA and citric acid, which both caused a drastic decrease in dentin microhardness. Both EDTA and citric acid performed best among the solutions used.

After endodontic cleaning and final irrigation with different techniques, Pitoni *et al*. (2011) evaluated the micromorphology of the dentine walls of primary anterior teeth using scanning electron microscopy, paying special attention to the presence of the smear layer [14, 22-24]. The outcomes were similarly positive for both decalcifying agents. Prado *et al*. (2011) examined the efficacy of 17% EDTA and 10% citric acid for removing the smear layer [15]. The results showed that neither EDTA nor citric acid effectively removed the smear layer in less than a minute. When the canal was examined in 3 minutes, however, both were able to scrape off the smear layer. Accordingly, the results were consistent between the two.

In vitro, the decalcifying ability of several irrigating solutions on root canal dentin was compared by Poggio *et al*., 2012. Samples treated with Tetraclean, a citric acid-based solution, showed much stronger decalcifying capacity, as seen by the larger release of Ca2+. Findings indicated that Tetraclean might be utilized to facilitate easier smear layer removal and enhanced biomechanical instrumentation techniques.

Wu *et al*., (2012) compare the efficacy of smear layer removal of 17% ethylenediaminetetraacetic acid (EDTA) and 20% citric acid [3]. It was concluded at the end of the investigation that EDTA was found to be highly effective in removing the smear layer as compared to citric acid. Keyur *et al*., (2014) assessed and compared ex vivo the decalcifying effect of 17% EDTA and 15% citric acid during three different time intervals [16]. In all three periods, 17% EDTA and 15% citric acid were the most effective at removing calcium.

The effectiveness of 5% EDTA and 2.5% citric acid in removing the smear layer in the root canal was studied by Turk *et al*., 2015. According to the above findings, there was little to no difference in the efficacy of various decalcifying agents in eradicating the smear layer. The decalcifying efficacy of several irrigating solutions, such as 17% EDTA and Tetraclean, was evaluated and compared by Poggio *et al*., 2015. (a citric acid-containing agent). Except for the citric acid-based treatment (Tetraclean), which induced a larger and still growing calcium release even after 10 min of contact time, the greatest quantity of Ca2+ was eliminated from root canal dentin samples after this period. Citric acid-based irrigants may be employed to obtain a competent decalcifying activity on dentin and to streamline the biomechanical processes.

Ajeti *et al*., (2018) determined the amount of mineral extraction caused by EDTA and citric acid in root canals [19]. One-Way ANOVA exhibited a high substantial difference when comparing employed agents in various duration periods. Results revealed that the highest amount of ions was removed with EDTA 10%. According to pH, Ca2+ ions were removed mostly with EDTA 10%. It was established that EDTA is a superior chelating agent as compared to citric acid. The decalcifying action of these solutions is associated with the extent of exposure, pH, and concentrations.

Gandolfi *et al*. (2018) looked at the effects of several decalcifying chemicals used as Irrigant solutions in endodontic therapy on dentin's collagen and mineral components [20]. It was discovered that 10% EDTA and 10% citric acid produced the most effective demineralizing results. Except for the 1% EDTA treatment, all others caused collagen rearrangement. Reports showed that 1% EDTA is the most effective remineralization, whereas 10% citric acid is the least. Thus, there was no statistically significant difference between EDTA and citric acid.

Varsity and Sharma (2019) studied root canal dentin smear layer removal using a combination of 10% citric acid and 17% EDTA. Citric acid was shown to have nearly equal decalcifying qualities as EDTA, leading researchers to conclude that using citric acid at a concentration of 10% might be a viable alternative to EDTA as a root canal irrigant. Citric acid has fewer negative side effects than other solutions, including lower cytotoxicity, antimicrobial activity, and reduced root canal dentin softening.

Finally, a study by Unnikrishnan *et al*. examined ethylene diamine tetra acetic acid (EDTA) at 17% and citric acid at 10% at root canal decalcification (2019). After using 2.5% NaOCl during instrumentation, they found that rinsing with 5 mL of 17% EDTA solution for 1 minute was more effective at removing the smear layer and reduced dentin microhardness to less than 10% citric acid.

This systematic review was conducted to assess the influence of two commonly used decalcifying agents EDTA and citric acid. We focused on the studies that included these two solutions to retrieve an accurate comparison done by various authors. It can be noted from the results that the majority of studies could not find a significant difference between the two agents. However, a few studies did find some differences and established that EDTA was slightly ahead of citric acid as far as its ability to decalcify and toxicity are concerned.

Due to its good biocompatibility qualities, EDTA has been recommended by several studies. After 14 months, the results showed no evidence of periapical tissue harm from the EDTA that had been pushed through the apical foramen and into the periapical tissues. In addition, it was reported that removing calcium hydroxide from the root canal with 15% EDTA or NaOCl alone was ineffective, but utilizing both irritants together, in conjunction with hand instrumentation, was effective. Moreover, it was determined that smear layer and debris removal in the apical area of the root canal could be attained with the combined use of EDTA and ultrasonics for 1 minute [6, 25].

The biocompatibility of an irrigation solution is an important consideration. This is known as chemical damage when a crucial tissue is exposed to substances inappropriate for cell respiration. Magnesium, manganese, iron, copper, zinc, calcium, and other divalent cations are co-factors to several enzymatic reactions and may be chelated by EDTA and citric acid, respectively. Researchers arguing for EDTA's safe use have used a variety of approaches to examine their results at 24, 48, and 96 hours, and they have concluded that using EDTA reduces the inflammatory response. Therefore, it may be established that, with no exemptions, all acidic agents should be employed safely, valuing the periapical tissues [26].

Conclusion

- No clear comparison between EDTA and citric acid could be established.
- EDTA was found to be slightly ahead of citric acid as a decalcifying agent, but this difference was not significant.
- More experimental studies need to be conducted to distinguish between these two materials.

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