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Effect of various endodontic irrigants on the microhardness of root canal dentine - A systematic review

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Abstract

Removal of the organic and inorganic components of the smear layer in the course of the endodontic treatment is achieved by the use of different endodontic irrigants. Despite their favorable disinfection abilities, they are reported to alter the biomechanical properties of root canal dentin. The aim of this article is to critically review published in vitro studies comparing effects of different irrigation regimes on dentinal microhardness and to identify, synthesize, and analyse the data available over the ten-year period from 2010 to 2020. The literature search was done on PubMed - MEDLINE, The Cochrane Library and Science Direct database. A total of nineteen papers out of 40 titles met the eligibility criteria. All studies reported reduction of root dentin microhardness after treatment with various endodontic solutions except green tea extract, tea tree oil and saline which did not decrease the microhardness significantly also 0.2% chlorhexidine did not affect microhardness of root canal dentin.

Keyword: Endodontics, Root Canal, Microhardness

Introduction

Chemical disinfection during the endodontic treatment aims to clean the complex root canal system. There are a number of irrigants available for endodontic treatment, and many others are being tested; however, none of them meet all the requirements needed to be considered as an ideal irrigant[1]. However, each solution has unique properties. For example, sodium hypochlorite (NaOCl) and chlorhexidine (CHX) exhibit a broad antibacterial spectrum, but NaOCl is a potential irritant of periapical tissues. Conversely, CHX does not dissolve the pulp tissue but is less cytotoxic to the periapical tissues than NaOCl[2]. Accordingly, it is sometimes necessary to use the irrigant solution combinations or alternate with chelators to address some disadvantages.

However, this combination can exhibit detrimental alterations in the chemical composition of dentin. The change of Ca/P ratio affects the original proportion of organic to inorganic components, thus modifying dentin's microhardness, solubility, permeability and surface roughness. According to some researchers these effects are time and concentration dependent [3,4].

Microhardness testing is a comprehensive, non-destructive and easily performed method utilized for investigation of the fine scale changes in the hardness of the non-homogenous dentin structure[5]. It is determined as material's resistance to local deformation which is measured on the basis of the permanent surface deformation that remains after removal of a given load[6]. The effect of microhardness on the overall outcome of the endodontic treatment has yet to be evaluated clinically. Nevertheless, *in vitro* tests that determine the hardness profile of root dentin can provide indirect evidence of any change of its mineral composition[7]. Such changes could influence the adhesive properties of the root dentin surface and decrease the root strength and its resistance to fracture. Irrigants and chelating agents may cause changes in the microstructure of the dentine and in the ratio of calcium to phosphorus. Panighi and G'Sell reported a positive correlation between hardness and the mineral content of the tooth.

Material and Method

The current systematic review is reported following the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) statement.

Research Question

What is the effect of one irrigant(I) vs another irrigant(C) on microhardness (O) on extracted human teeth(P) when assessed in in-vitro studies.

Criteria in the Selection of Studies

We selected studies in dentistry that considered the effect of irrigant solutions on the mechanical properties of endodontically treated teeth.

This included studies that evaluated the study design and the effect of at least one irrigant solution on dentin, regardless of origin (human or animal), but only studies written in English were included.

The studies were initially selected for the title and abstract according to the following inclusion criteria:

1. SRs
2. Related to the effect of irrigants on microhardness.

Articles without an abstract or those without an adequate description were included for full-text evaluation. Eligibility was confirmed after access of the full text by following the defined exclusion criteria.

Articles that failed to meet any of these criteria were excluded.

Literature Search and Data Extraction

The data was collected from three search engines which are:

1. PubMed
2. Cochrane
3. Medline
4. Google Scholar

Search was conducted for articles published in the year 2010 – 2020.

The language was restricted to English. The combination of terms used for the database search is described in Table 1.

Table 1: Combination of Terms Used for Database Search

Database	Subject	Combination of terms used
PubMed	Microhardness	(‘‘microhardness’’[All Fields] OR ‘‘Microhardness’’[All Fields] OR ‘‘effect of irrigants’’[All Fields] OR ‘‘irrigants’’[All Fields] OR (Irrigants[All Fields] AND Microhardness[All Fields])) AND [All Fields] OR ‘‘effect on microhardness’’[All Fields]
Cochrane	Microhardness	(‘‘Microhardness’’ OR ‘‘Irrigants’’ OR ‘‘effect of microhardness’’ OR ‘‘Effect of irrigants’’)
Google Scholar	Microhardness	((((((microhardness) ((root canal) OR irrigants)))

The reference list from included studies, published reviews and standard endodontic textbooks were screened. An additional hand search was performed from endodontic specialty journals, namely Australian Endodontic Journal, International Endodontic Journal, Iranian Endodontic Journal, Journal of Endodontics,

Titles and abstracts were evaluated, and the relevance of each study to the criteria was determined. Then, the full texts of the selected articles were obtained and reviewed.

From the selected studies, the following data were extracted and included in the data sheet:

Studies about effect of irrigants: type of samples, sample size, type of irrigants used, methods used for evaluation, and results (microhardness)

Data Extraction

The data extraction form was created with the following contents: first author, year of publication, study type, sample size, type of sample, instrument used, kinematics, method of evaluation and results (which performed best). Data were extracted independently and any disagreement was resolved by discussion

Results

Study selection

A systematic review methodology was followed and database searching was done which yielded **40** records. Records from year **2010-2020** were taken into consideration.**3** duplicate record was removed from total of **37**. Total 37 records screened on the title; records did not meet the inclusion criteria **2**. **35** records were further reviewed and **16** records were excluded. A total of **19** studies were further evaluated on the basis of inclusion criteria. Total studies to be systematically reviewed came out to be **19.**

Study Characteristics

1. Studies about microhardness
2. Type of samples
3. Sample size
4. Type of irrigants used
5. Methods used for evaluation of microhardness

Discussion

Irrigation solutions used during cleaning and shaping may affect the physical and chemical properties of radicular dentine, including hardness. Determination of microhardness can provide valuable evidence of mineral loss or gain in the dental hard tissue, with special regard here, to the effects of irrigating solutions on root dentin hardness. Kinney et al. suggested that the decrease in hardness is caused by a decrease in stiffness of inter tubular dentin matrix caused by heterogeneous distribution of mineral phase within the collagen matrix. The microhardness of dentine depends on the physical properties of the solution (i.e. pH and concentration), and structure of dentine (i.e. tubular density, location, age).[8]

About sectioning of roots in different studies

Earlier investigation of *Cruz-Filho et al.* revealed that cutting the root into buccal and lingual half represent the clinical situation more accurately[9]. Almost all of the studies preferred longitudinal over the transverse sectioning of the intact roots into discs except a few in which transverse section was done (oliviera et al, Pimenta et al, Yaseen et al, Marcelino et al, Taneja et al)[10,11,12,13]. A relatively small canal diameter in the apical one-third exposes the dentin to a lesser volume of irrigants and hence compromising the efficiency of smear layer removal. Therefore, tooth specimens were split longitudinally to ensure complete distribution of irrigants throughout the root canal system.

Regarding microhardness test done in different studies

It has been indicated that microhardness determination can provide indirect evidence of mineral loss or gain in the dental hard tissues. For a given load, the Vickers indenter penetrates about twice as far into the specimen as the shallower Knoop indenter, and the diagonal is about one third the length of the longest diagonal of the Knoop indentation. Thus, the Vickers test is less sensitive to surface conditions and, because of its shorter diagonals, more sensitive to measurement errors when equal loads are applied. Investigations have shown the suitability and practicality of Vicker's microhardness test for evaluating surface changes of dental hard tissues treated with chemical agents, although the Knoop hardness test was used for evaluating surface changes of dental hard tissues in some studies (Tartari et al, Pimenta et al, Garcia et al, Cruz-filho et al, Marcelino et al)[9,10,14,15,11].

All of the tested irrigation regimens used in the reviewed articles reduced root dentin microhardness. The studies included in the current review article predominantly analyzed the microhardness change after the single use of an endodontic irrigant and also in different combination. Their findings confirmed the ability of various concentrations of NaOCL and chelating agents to reduce microhardness to a different extent due to the softening of the root canal walls and the erosion of the tubules.

Few of the review articles reported that irrigation with 1% NaOCl alternating with 17% EDTA resulted in a more accentuated decrease in microhardness and significantly different from that observed with NaOCl alone ($p<0.01$). The demineralizing effect of EDTA with consequent decrease of microhardness has been extensively demonstrated.

It was found 1-hydroxyethylidene-1, -bisphosphonate (HEBP) or etidronate to be a weak calcium-complexing agent that causes less change in dentin than Citric acid or EDTA (Tartari and others)[15]. Similary, Dineshkumar et al observed minimum reduction in microhardness by HEBP when compared to 17% EDTA or MTAD[16].

Eldeniz et al observed that citric acid was much more efficient than EDTA in reducing dentin microhardness, whereas De Deus et al had opposite results[17]. It has been shown that the higher the concentration of a solution, the stronger the chelating effect is. In the study by De Deus et al, although citric acid had the same concentration as that of the EDTA (10%), the pHs were different. In addition, those authors used citric acid with a pH close to neutral. The more acid pH of a solution might favour the removal of calcium ions from dentin. Sousa and Silva showed that 1% citric acid (pH = 1.0) removed significantly more calcium ions from dentin than 1% citric acid[18].

Apple vinegar, acetic acid, and maleic acid had a similar reducing effect on microhardness to each other and smaller than that of EDTA and citric acid. The lower concentration used for maleic and acetic acids may be an explanation for such a result. Ballal et al observed that 7% malic acid reduced dentin microhardness in a similar manner as 17% EDTA[19]. Machado- Silveiro et al observed that 10% sodium citrate has a limited capacity of demineralizing dentin, mainly when compared with 1% and 10% citric acid and 17% EDTA[20].

Patil C and Uppin V reported that hydrogen peroxide caused great decrease in dentin microhardness. H_20_2 with pH of 1.7 affected the inorganic parts of dentin through acidic demineralization and attacked the organic. And 3% H_20_2 had no effect on surface roughness of root dentin. This result was related to the materials low concentration.[21]

QMix, 17% EDTA and 5% Tamarindus indica irrigation solutions decreased dentin microhardness. Flavia et al. evaluated that QMiX and 17% EDTA reduced dentin microhardness at a greater depth when compared to 10% CA and 1% PA. Additionally, and differently from EDTA 17%, QMiX did not cause dentin erosion[22].

Taneja S et al (2014) reported an insignificant difference in Ca loss and microhardness was seen between 5% NaOCl-EDTA and 5% NaOCl-QMix groups. As QMix contains EDTA in its composition along with chlorhexidine and a detergent, the effect of QMix on root dentin could have been almost similar to EDTA. Irrigation with 5% NaOCl + 2.25% PAA caused the maximum calcium loss from root dentin and minimum microhardness.[23]

Green tea extract, tea tree oil and saline did not decrease the microhardness significantly (Rapgay T et al)[24]. Also 0.2% chlorhexidine did not affect microhardness of root canal dentin (Patil C and Uppin V)[21].

Conclusion

It can be concluded that all studies reported reduction of root dentin microhardness after treatment with various endodontic solutions except green tea extract, tea tree oil, 0.2% chlorhexidine and saline did not affect microhardness of root canal dentin.

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