ORIGINAL RESEARCH PAPER
Volume - 13 | Issue - 12 | December - 2024 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

COMPARATIVE EVALUATION OF THE EFFECT OF TWO DIFFERENT IRRIGATION PROTOCOLS USING ACTIVATED AND CONVENTIONAL NON-ACTIVATED IRRIGATION ON ELASTIC MODULUS OF ROOT DENTIN- AN INVITRO STUDY

Dentistry

Dr. Neevika Singh* 3rd MDS PG Student *Corresponding Author
Dr. Jayalakshmi K. B HOD& Professor
Dr. Sujatha I Bhat Professor
Dr. Vignesh B Kasal 3rd MDS PG Student

ABSTRACT

Aim: To evaluate the effect of 2 different clinically used irrigation protocols on elastic modulus of root dentin from coronal to apical and from canal lumen to outer root dentin and to evaluate the relation of this effect using 2 different irrigation methods. **Methods**: Forty single-rooted premolar teeth were selected, cleaned with 0.01% NaOCl, and stored in distilled water at 4°C. The crowns were sectioned to standardize root length at 15 mm, and root canals were accessed with an ISO #10 K-type file. Working length was determined, and a closed environment was created by sealing the root apex with wax. Teeth were divided into four groups (n=10) for different irrigation protocols using ProTaper rotary files up to size F4 and a 30-gauge needle.Groups:Group 1: Non-activated irrigation- 1a: 3% NaOCl + 17% EDTA + 3% NaOCl, with distilled water between NaOCl and EDTA.1b: 9% HEDP (Twin Kleen) + 3% NaOCl mixture.Group 2: Activated irrigation with EndoActivator (same as Group 1 protocols but with activation).After preparation, the roots were split, embedded in epoxy resin, and polished. Nano indentation testing measured the elastic modulus at 2.5, 5.5, and 8.5 mm from the root canal at three depths per region, totaling 45 indentations per group. **Results:** All irrigation protocols affected the elastic modulus of root dentine. 9% HEDP (Twin Kleen) + 3% NaOCl mixture showed highest elastic modulus values (P > 0.05) **Conclusion:** Within the limitations of this study it was concluded that Different clinically used irrigation protocols affect the root dentin elastic modulus.

KEYWORDS

Dentine, elastic modulus, irrigants, nano-indentation

INTRODUCTION

Root canal treatment aims to eradicate intracanal infection and prevent reinfection by filling the root canal space.[1]While mechanical preparation helps to remove microorganisms from an infected canal , instrumentation may leave up to 35% of the canal surface untouched[2], potentially leaving residual bacteria. Therefore, an active irrigation sequence is commonly used alongside mechanical preparation. Although irrigants are essential for successful root canal therapy, it is critical that they do not harm surrounding tissues, are safe for both patients and clinicians, and support the full functional recovery of the tooth.

Sodium hypochlorite (NaOCl), used in concentrations of 0.5–6%, offers tissue dissolution, antimicrobial, and anti-biofilm effects. However, it cannot remove the smear layer or fully clear hard-tissue debris, which can hinder its reach and antimicrobial efficacy[3]. To address this, NaOCl is often followed by a 15–17% EDTA solution for 1–2 minutes to remove inorganic debris. Of note, chelating agents negatively impact the free available chlorine content of NaOCl and thus reduce its tissue dissolution ability, while the antimicrobial action decreases only when the initial NaOCl concentrations are low [4]. In order to prevent these phenomena, the sequential use of NaOCl/EDTA, known as the “sequential protocol”, is routinely used in day-to-day clinical practice NaOCl during instrumentation, EDTA at the end, and a final NaOCl rinse to enhance penetration. The sequential NaOCl/EDTA protocol widens dentinal tubules but also erodes dentine, decalcifying 1–5 µm of intertubular dentine and up to 20 µm of tubular walls. This weakens dentine's flexural strength and may increase fracture risk[5]. To address these issues, "continuous chelation" was introduced in 2005, combining NaOCl with a weak chelator like HEDP, allowing simultaneous antimicrobial action, smear layer removal, and simplified procedures without diminishing NaOCl's efficacy [6]. Delivery of the irrigant using a syringe and needle or by activated methods are the most popular methods. But, there is no evidence that any adjunct irrigation method, including activated irrigation can improve the long term outcome of RCT beyond what can be achieved using instrumentation and syringe agitation.Therefore, this study aimed to evaluate effect of 2 different irrigation protocols using activated and conventional non-activated irrigation on elastic modulus of root dentin.

MATERIALS AND METHODS

Forty single-rooted extracted premolar teeth were selected with similar dimensions, and without caries, coronal or root filling, or cracks. The soft tissue remnants covering the root surfaces were removed using 0.01% NaOCl with gauze and a fine brush. The teeth were then stored until use in distilled water at 4°C for a maximum of 1 month. Dental crowns were sectioned at the cementoenamel junction with a diamond disc (Komet Brasseler, Lemgo, Germany) to standardise root length at 15 mm. Root canals were accessed and an ISO size #10 K-type file (Dentsply-Maillefer, Ballaigues, Switzerland) was inserted into the canal until the tip of the file was observed at the apical foramen. The working length was determined by subtracting 1 mm from the recorded length. A closed environment was created by sealing off the root tip with wax to mimic clinical conditions and avoid the flow of irrigants through the root apex. Subsequently, the 40 teeth were randomly assigned into 4 groups (n=10) according to the irrigation protocol.

Root Canal Instrumentation And Irrigation

Root canals were then prepared using ProTaper rotary files (Dentsply, Maillefer, Ballaigues, Switzerland) to size F4 of the ProTaper instrument. The sequence followed was SX, S1, S2, F1, F2, F3, and F4. The irrigation protocols were done with a 30-gauge slot-tipped needle, and the study groups were as follows:

Group 1: Non-activated Irrigation Group

Group 1a : 3% NaOCl+17% EDTA+3% NaOCl without activation. The canal was irrigated with 4 mL of 3% NaOCl during instrumentation, followed by 2 mL of 3% NaOCl for 1 minute, 2 mL of 17% EDTA for 1 minute and 2 mL of 3% NaOCl for 1 minute, for a total of 6 mL of final irrigation applied for 3 minutes. Distilled water was used between NaOCl and EDTA to prevent interaction.

Group 1b: 9%HEDP(Twin Kleen)+3% NaOCl without activation. The canal was irrigated throughout treatment with a mixture of one capsule of Twin Kleen and 10 mL of 3% NaOCl as described above(4 mL during the instrumentation and 6 mL for the final irrigation)

Group 2: Activated Irrigation Group

Group 2a: similar to group 1a with activation using ENDOACTIVATOR during final irrigation.

Group 2b: similar to group 1b with activation using ENDOACTIVATOR during final irrigation.

Nano-indentation Testing

The roots were split in the buccolingual direction with a low-speed

diamond saw (Accutom-50; Struers, Copenhagen, Denmark) under constant water irrigation. Samples were embedded in epoxy resin (Epon 815; Nissin, Tokyo, Japan). After setting, exposed surfaces were polished using carbide paper with a grit size of 600–2000. This was followed by polishing with 3 and 1 µm polishing diamond paste in sequence. Samples were stored in distilled water at 4°C until nano-indentation testing (CSM Instruments, SA, Switzerland). The indenter used was a pyramidal-triangular-shaped Berkovich indenter, and the maximum force applied was 20 mN. Each indent was accomplished at a 40-mN/min loading ratio and a 20-s delay of the maximum load at the intertubular dentine. The maximum penetration depth was 1400 nm. The nano-indentation test was performed in each sample from apical to the cervical region at 2.5, 5.5, and 8.5 mm for the measurement of the elastic modulus. Three measurements were done in each test region starting from the root canal lumen toward the cement [at 10, 50, and 90 µm; Figure 1]. Each group had a total of 45 indentations (3 regions × 3 deepness × 5 samples)

Figure 1

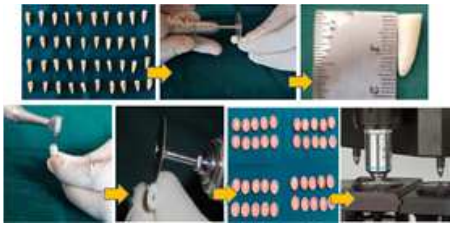

Figure 2: demonstrating major steps of methodology

Statistical Analysis

Elastic modulus values were statistically analyzed using SPSS 15.0 (SPSS, Chicago, IL, USA) for Windows, using one-way analysis of variance with a subsequent Tukey's multiple comparison test ($P < 0.05$)

RESULTS

Mean elastic modulus values of root dentine obtained at totally 90 µm (mean±SE)

Groups	Elastic Modulus (GPa)			
	Region			Mean
	Apical	Middle	Cervical	
1a	17.5±0.81[b]	17.13±0.57[a]	17.12±0.73[b]	17.25±0.4
1b	19.8±0.87[a]	20.12±0.9[a]	18.99±0.99[a]	19.64±0.52
2a	16.76±0.78[b]	17.21±0.69[a]	17.34±0.76[b]	17.11±0.42
2b	19.17±0.66[a]	17.92±0.86[a]	18.46±0.67[a]	18.52±0.42

DISCUSSION

NaOCl is the primary irrigant of choice, but it cannot dissolve hard-tissue debris created during instrumentation or the inorganic components of the smear layer, so the supplementary action of a demineralizing Agent is considered necessary. EDTA is the most common choice for this role. (Dutner et al., 2012; Willershausen et al., 2015)

This regime is very effective but is time consuming as it is not a single irrigating solution.EDTA reduces the efficacy of NaOCl when mixed.[4,5] Therefore, in this study with a desire to find out an alternative irrigating solution which can be efficient, simple, inexpensive and time saving in clinical practice , and which could be mixed with NaOCl - HEDP (1-hydroxyethylidene 1,1-disphosphonate), also known as etidronic acid or etidronate, was selected.

In this study, irrigation protocols were applied at room temperature, thus the effect of temperature was eliminated. In contrast to previous studies, which used high concentration of irrigating solution for longer periods, this study's irrigation protocols were conducted in accordance with clinical protocols to get more clinically relevant results.[7,8]

Studies have indicated that irrigation solutions affect the mechanical properties of dentine.There are several techniques and tools for analyzing the mechanical properties of materials. Nano-indentation is one of the widely used one among these. The advantage of nano-indentation test over the others is that it is capable of probing the mechanical properties and behavior of small volumes of dental structures.[9]

The penetration of different irrigation solutions into dentine has shown different results in previous studies because distinct testing protocols were used. Kuga et al.found the depth to be 107 µm when dentine bars were placed in the irrigation solution for 20 min,[10]Zou et al. recorded a depth of 77–123 µm when using different concentrations for 2 min.[11] In this study, the measurements were performed at 10, 50, and 90 µm, starting from the root canal lumen and considering that the maximum penetration depth of irrigation protocols is around 100 µm. Three measurements were carried out for each region (coronal, median, and apical) and a distance of 40 µm was preserved between the measurement points to avoid residual stresses, as mentioned by He et al.The results indicated that different irrigation protocols affected the elastic modulus of dentine.[12]

The elastic modulus was higher for (3%NaOCl+9% HEBP) than (3% NaOCl+17%EDTA). This could be due to soft chelating action of HEBP as compared to EDTA.

Improved efficacy of smear layer removal with sonic activation has been previously reported by several studies, such as those by Rödig et al.[13], Urban et al.[14] and Kharouf et al.[15], which showed that upon using sonic activation , more smear layer is removed at the apical third which is comparable to the results of our study

CONCLUSIONS

Within the limitations of this study it was concluded that Different clinically used irrigation protocols affect the elastic modulus of root dentin.

Future multidisciplinary efforts combining the knowledge from basic sciences such as Chemistry, Microbiology and Fluid Dynamics could eventually lead to more effective antimicrobials and improved activation methods to bring them closer to the residual biofilm in the root canal system.

REFERENCES:

1. Cruz-Filho AM, Sousa-Neto MD, Savioli RN, Silva RG, Vansan LP, Pecora JD. Effect of chelating solutions on the microhardness of root canal lumen dentin. J Endod 2011;37:358-62.
2. Peters OA, Schönenberger K, Laib A. Effects of four Ni-Ti preparation techniques on root canal geometry assessed by micro computed tomography. Int Endod J. 2001;34(3):221–30.
3. Zehnder M, Kosicki D, Luder H, Sener B, Waltimo T. Tissue-dissolving capacity and antibacterial effect of buffered and unbuffered hypochlorite solutions. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2002;94(6):756–62.
4. Rossi-Fedele G, Doğramaci EJ, Guastalli AR, Steier L, de Figueiredo JA. Antagonistic interactions between sodium hypochlorite, chlorhexidine, EDTA, and citric acid. J Endod. 2012;38(4):426–31.
5. Lottanti S, Gautschi H, Sener B, Zehnder M. Effects of ethylenediaminetetraacetic, etidronic and peracetic acid irrigation on human root dentine and the smear layer. Int Endod J. 2009;42(4):335–43.
6. Arias-Moliz MT, Morago A, Ordinola-Zapata R, Ferrer-Luque CM, Ruiz-Linares M, Baca P. Effects of dentin debris on the antimicrobial properties of sodium hypochlorite and etidronic acid. J Endod. 2016;42(5):771–5
7. Grigoratos D, Knowles J, Ng YL, Gulabivala K. Effect of exposing dentine to sodium hypochlorite and calcium hydroxide on its flexural strength and elastic modulus. Int Endod J 2001;34:113-9.
8. Machnick TK, Torabinejad M, Munoz CA, Shabahang S. Effect of MTAD on flexural strength and modulus of elasticity of dentin. J Endod 2003;29:747-50
9. Marshall GW, Habelitz S, Gallagher R, Balooch M, Balooch G, Marshall SJ. Nanomechanical properties of hydrated carious human dentin. J Dent Res 2001;80:1768-71.
10. Kuga MC, Gouveia-Jorge E, Tanomaru-Filho M, Guerreiro-Tanomaru JM, Bonetti-Filho I, Faria G. Penetration into dentin of sodium hypochlorite associated with acid solutions. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011;112:e155-9.
11. Zou L, Shen Y, Li W, Haapasalo M. Penetration of sodium hypochlorite into dentin. J Endod 2010;36:793-6.
12. He LH, Fujisawa N, Swain MV. Elastic modulus and stress-strain response of human enamel by nano-indentation. Biomaterials 2006;27:4388-98.
13. Rödig T, Döllmann S, Konietschke F, Drebenstedt S, Hülsmann M. Effectiveness of different irrigant agitation techniques on debris and smear layer removal in curved root canals: a scanning electron microscopy study. J Endod 2010; 36(12):1983–7.
14. Urban K, Donnermeyer D, Schäfer E, Bürklein S. Canal cleanliness using different irrigation activation systems: a SEM evaluation. Clin Oral Investig 2017; 21(9):2681–7
15. Kharouf N, Pedullà E, La Rosa GRM, Bukiet F, Sauro S, Haikel Y, et al. In vitro evaluation of different irrigation protocols on intracanal smear layer removal in teeth with or without pre-endodontic proximal wall restoration.