

Research Article

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Comparative Evaluation of The Effect of Two Chemical Root Canal Irrigants (3% Sodium Hypochlorite And 17% EDTA) And One Herbal Root Canal Irrigant (Azadirachta Indica or Neem Extract) On Dentin Microhardness: An In Vitro Study

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Abstract: Introduction: The main objective of root canal treatment is the complete debridement of the root canal system from inflamed or necrotic pulp tissues, microorganisms. Root canal treatment aims to eliminate the infection by the concept of mechanical instrumentation, sterilization and obtaining three dimensional obturation of the root canal system. During the process of root canal therapy the irrigating solutions used can alter the physicochemical properties of the dentinal wall altering its microhardness which may affect the adhesion of the dental materials and its sealing ability. This is an invitro study conducted to determine the dentin micro hardness after using different irrigating solutions during root canal irrigation. The aim of this study is comparative evaluation of the effect of two chemical root canal irrigants and one herbal irrigant on dentin microhardness. **Materials And Method:** Forty extracted human maxillary central incisor teeth with a single root were used in this study. The crown of all the teeth were decoronated transversely at cemento enamel junction. The root canals were then instrumented up to master apical file (MAF) size 45K- file (M-access Denstply) then stepback flaring done until reaching the size 60K-file and recapitulation was done with MAF. During instrumentation the root canals were irrigated with distilled water. The prepared 40 roots were sectioned longitudinally with a double face diamond disc. The 80 samples were then randomly divided into four groups and baseline values for microhardness for all the samples were recorded before treated with irrigating solutions. The samples treated with irrigating solutions with 20 samples each are Group I: 3% NaOCl, Group II: 17% EDTA, Group III: Neem extract, Group IV: Distilled water as a control group. 5ml of the corresponding irrigating solution was administered for a total of 5 minutes in each prepared sample. The Vickers micro - hardness tester was then used to assess the microhardness. The results were then analyzed statistically using Paired t test at 5% level of significance for paired comparison of baseline and post treatment of intra group and inter group comparisons was done using Independent Samples t test at 5% level of significance. **Results:** All tested irrigating solutions decreased the dentinal microhardness. Samples treated with control (distilled water) demonstrated the maximum microhardness of dentin in the present study. **Conclusion:** Within the limitations of this research it can be concluded that the herbal irrigant (Neem extract or Azadirachta indica or Neem extract) did not significantly decrease the microhardness of dentin compared to the two chemical irrigants (3% NaOCL and 17% EDTA).

Keywords: Sodium Hypochlorite, EDTA, Microhardness of dentin, Neem extract.

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INTRODUCTION

The main objective of conventional root canal treatment (RCT) is complete debridement of the root canal system from inflamed or necrotic pulp tissues, microorganisms [1], instrumentation, and obtaining three dimensional obturation of the root canal system [2, 3]. During instrumentation procedure, the root canals are irrigated

with the root canal irrigating solution for disinfection purpose as well as removal of smear layer or debris produced during mechanical instrumentation. Therefore, irrigation of root canals by irrigating solutions is an essential part of the endodontic procedure because it facilitates the debridement and disinfection of regions inadequately cleaned by

endodontic instruments [4]. During the irrigation process, these endodontic irrigants stay in close contact with the dentin surface and can influence the chemical composition of dentin and its physical characteristic features.⁵ Microhardness analysis renders an arbitrary assessment of any alteration in the mineral composition of dental hard tissues. Microhardness studies are often applied to evaluate the physical characteristics of materials and to assess the hardness of teeth [6, 7]. The irrigating solution most frequently applied during cleaning and shaping is sodium hypochlorite (NaOCl). This chemical has exquisite antimicrobial effects along with solvent capacity on vital and necrotic organic tissue [8]. Though NaOCl is an excellent irrigating solution, it cannot dissolve inorganic dentin materials [9]. EDTA supplements the action of NaOCl by chelating calcium ions in dentin and making instrumentation of root canals easier, removes smear layer and thereby exposes the bacteria living in the dentinal tubules to be acted upon by the disinfecting irrigants which allows the endodontic sealer to penetrate more intimately into the dentinal tubules, leading to an enhanced sealing of the canal. The formation of sealer tags into the dentin provides good adaptation between the sealer cement and the dentin interface [10]. A wide variety of synthetic antimicrobial agents have been used over the years as endodontic irrigants. The undesirable effects of NaOCl include tissue toxicity, allergic potential, disagreeable taste and inability to remove the smear layer. EDTA does not have antimicrobial property. Chlorhexidine is an antimicrobial agent with wide spectrum of antimicrobial activity, biocompatibility and ability to disinfect the infected root canals but does not have tissue dissolving capabilities [11]. It also stains the teeth [12], may lead to dryness and burning sensation of the mouth [13].

Hence, there is a need for alternative agents which are non-toxic and effective. It has been found that natural plant extracts could be used as effective endodontic irrigants [14]. In addition, the advantages of plant derived medications are easy access, low cost, long term sustainability, less toxicity and no induction of microbial resistance [15].

Neem has a medicinal properties like anti viral [16], anti fungal [17], anti bacterial [18] and anti carcinogenic [19] activities which makes it a potential agent for root canal irrigation.

Neem extract was also found to be effective against both gram-positive and gram-negative microbes [20], alters bacterial adhesion and prevents microbial colonization [21]. Hence can be recommended as a root canal irrigant.

Various studies have shown that different chemical root canal irrigating solutions can affect the microhardness of radicular dentin. There is limited study of herbal root

canal irrigants which are less toxic than chemical irrigants and its effect on microhardness of radicular dentin. Effect of the microhardness of radicular dentin consequently affects the clinical performance of endodontically treated teeth [22]. Microhardness determination can provide indirect evidence for losing or gaining any mineral substance in the dental hard tissues [23].

Therefore assuming the importance of the effect of irrigants on microhardness of dentin the present study is aimed to compare the effect of two chemical root canal irrigants (3% NaOCl and 17% EDTA) and one herbal root canal irrigant (*Azadirachta indica* or Neem extract) by using Vickers microhardness tester.

MATERIALS AND METHOD

Forty extracted single rooted maxillary central incisors with single straight intact root canal, fully formed apices are included in the study and teeth with root caries, anatomical deformities, cracks or fractures, narrow, constricted, calcified or obliterated and curved canals, teeth with internal resorption, previously endodontically intervened teeth were kept out of this study. The teeth were disinfected using 10% formalin, washed under tap water and stored in saline solution at room temperature till used.

Preparation of the root canal: The crown of all the teeth was decoronated transversely at cemento enamel junction with a microtome and the canals were then instrumented up to master apical file (MAF) size 45K-file (M-access Denstply) then stepback flaring done until reaching the size 60K-file. During instrumentation the root canals were irrigated with a standardized volume of 2ml distilled water with 27 gauge needle (Dispo van).

Preparation of the samples for evaluation: The prepared 40 roots were embedded mesiodistally in a freshly mix acrylic resin and were sectioned longitudinally with a double face diamond disc having a size of 0.3mm of a microtome (BUEHLER Isomet4000 linear precision saw) at low speed (4000 rpm) with water. Thus a total of 80 samples were obtained. This samples were then examined under stereomicroscope (Nikon SMZ25) to eliminate the teeth with cracks. The 80 samples were then randomly divided into four groups and baseline values for microhardness for all the samples were recorded before treated with irrigating solutions. The samples treated with the irrigating solutions are as follows:

- Group I : 20 samples immersed in 5ml of 3% NaOCl
- Group II : 20 samples immersed in 5ml of 17% EDTA
- Group III : 20 samples immersed in 5ml of Neem extract
- Group IV : 20 samples immersed in 5ml of distilled water as a control group



5ml of the corresponding irrigating solution was administered for a total of 5 minutes in each prepared sample. The samples were rinsed with distilled and the microhardness was measured using Vickers microhardness tester.

There was no significant difference in baseline microhardness values among the groups. The baseline mean at cervical level is 55.88 ± 6.24 , at middle level is 49.09 ± 7.57 and apical level is 43.15 ± 7.27 . The results are depicted in tabular and graphical forms in Tables 1-2 and Figures 1-2

RESULTS AND OBSERVATIONS

TABLE 1: P VALUES OF THE INDEPENDENT SAMPLES T TEST OF THE DIFFERENCE IN THE MEAN MICROHARDNESS OF 3% SODIUM HYPOCHLORIDE, 17 % EDTA AND NEEM EXTRACT At 0.05 LEVEL OF SIGNIFICANCE							
		17% EDTA			Neem Extract		
		Cervical	Middle	Apical	Cervical	Middle	Apical
3% Sodium Hypochloride	Cervical	0.033, S	-	-	0.002, S	-	-
	Middle	-	0.045, S	-	-	0.008, S	-
	Apical	-	-	0.034, S	-	-	0.066, S
17% EDTA	Cervical	-	-	-	P<0.001, HS	-	-
	Middle	-	-	-	-	P<0.001, HS	-
	Apical	-	-	-	-	-	0.003, S

S- Difference in means is statistically significant, HS - Difference in means is statistically highly significant, NS - Difference in means is statistically not significant

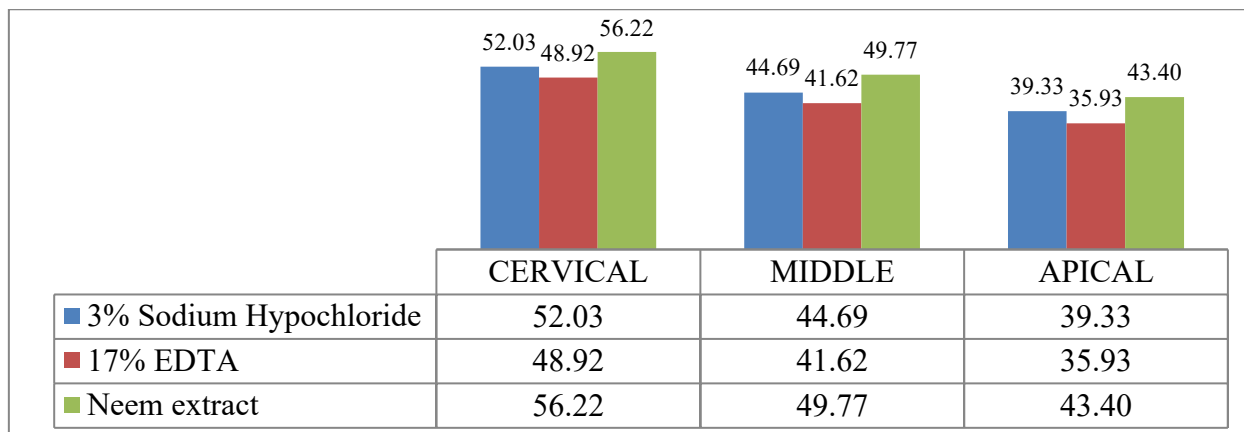


Figure. 1: Bar chart showing the comparison of mean microhardness of 3% Sodium Hypochloride, 17% EDTA and Neem Extract at cervical, middle and apical levels.

TABLE 2: P VALUES OF THE INDEPENDENT SAMPLES T TEST OF THE DIFFERENCE IN THE MEAN MICROHARDNESS OF 3%, SODIUM HYPOCHLORIDE, 17% EDTA AND NEEM EXTRACT WITH DISTILLED WATER AT 0.05 LEVEL OF SIGNIFICANCE			
	Distilled Water		
	Cervical	Middle	Apical
3% Sodium Hypochloride	0.17, S	0.04, S	0.18, S
17% EDTA	p < 0.001, HS	0.002, S	p < 0.001, HS
Neem Extract	0.829, NS	0.868, NS	0.979, NS

S- Difference in means is statistically significant , HS - Difference in means is statistically highly significant, NS - Difference in means is statistically not significant

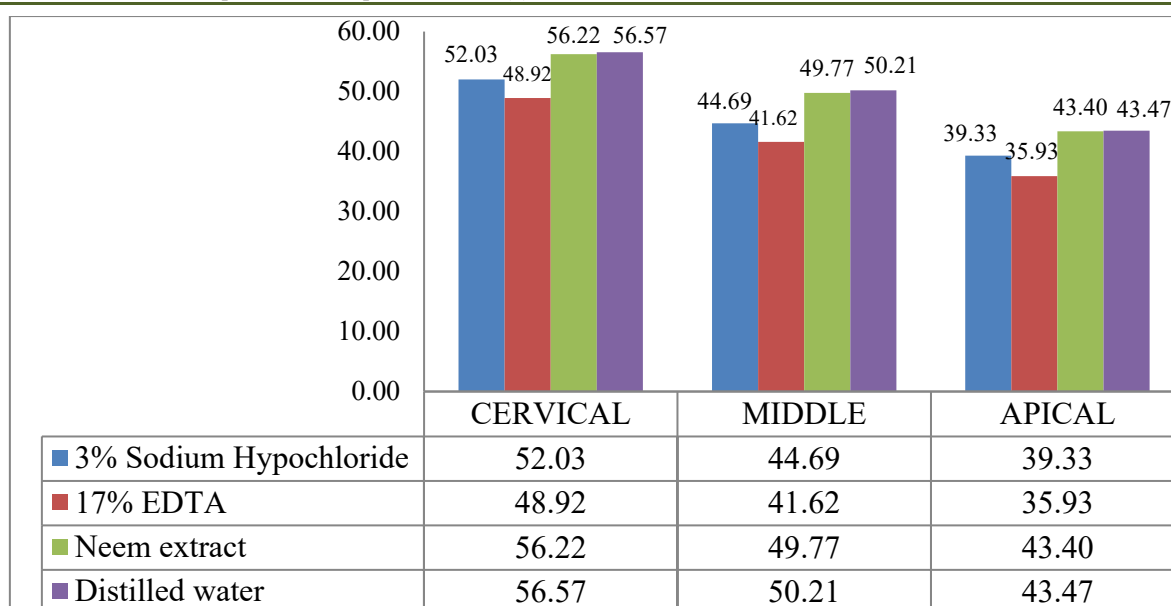


Figure. 2: Bar chart showing the comparison of mean microhardness of 3%, Sodium Hypochloride 17% EDTA 17% and Neem Extract with distilled water at cervical, middle and apical levels

DISCUSSION

The success of endodontic treatment lies on instrumentation techniques, irrigation protocol and three dimensional obturation of the root canal system. Irrigation is one of the important and critical steps during instrumentation and the use of irrigating solutions is mandated in order to improve chemo-mechanical debridement of the root canal system and its anatomic complexity lying in the form of fins and accessory canals [24].

It is reported that the interaction of irrigants individually or in combination with root dentin is capable of causing alteration of the physicochemical properties of the dentin structure such as the microhardness, permeability and solubility of root canal dentin due to change in the original proportion of the inorganic and organic components of root canal dentin [25, 26].

Research on various herbal alternatives as root canal irrigants are recently being conducted due to their nontoxic effect on the periapical tissues as compared to their chemical counterparts. Previous studies have found that various chemical irrigating solutions can affect the microhardness of root canal dentin compared to herbal root canal irrigants which have less effect or no effect on microhardness of root canal dentin.

So the present study was carried out to observe the effect of two chemical irrigants (3% NaOCl and 17% EDTA) and one herbal irrigant (*Azadiractaindica* or Neem extract) on dentin microhardness.

Forty freshly extracted single rooted human maxillary incisors extracted due to periodontal reason with mature root apices, and single straight canal were selected for

the study as they help in more ease of longitudinal separation of the tooth and also provide more standardized method for the evaluation of the study. After decoronation, the root canals were then instrumented using hand k-files up to master apical file (MAF) size 45k- file then stepback flaring was done until reaching the size 60k-file. The roots were splitted longitudinally to expose the root canal dentin for microhardness testing and it was done under water cooling to prevent dessication while sectioning. In the present study, longitudinal sectioning of the root was used rather than transverse sectioning. This was according to Cruz – filho *et al.* [27] where they observed that longitudinal sectioning can show accurate representations of clinical situation.

In the current study, the measurement of microhardness was performed at baseline and after treatment with irrigation solutions for each sample to establish a rational evaluation for the effect of the irrigating solutions on the dentin surface. Microhardness of the radicular dentin vary considerably at different locations between teeth. Microhardness was measured at three points of the root canal dentin at cervical, middle and apical third using vickers hardness tester. Mean vicker hardness number (VHN) was calculated for each specimen. The microhardness of dentin depends on the tubular density which varies from one area to another on the radicular dentin surface. Pashley *et al.* [28] reported that here is an inverse correlationship between tubular density and microhardness values, as the tubular density increases dentin microhardness decreases. In the present study microhardness decreased from coronal to apical third of root canal dentin which is contradictory to studies done by Maussoud *et al.* [29] where it was found that microhardness increases from coronal to apical third of root canal dentin due to histological

pattern of root canal dentin. This contradiction might be due to post - root canal preparation changes wherein more of inner dentin in the cervical and middle areas was removed as compared to the apical area. Findings of the present study are in accordance to the findings of Pashley *et al.* [28] which stated that the microhardness decreases from superficial region to deeper dentin region. Another possible reason could be due to the dentin in the apical third that may be very near to the CDJ. Fabiano Ribeiro Cirano, Giuseppe Alexandre Romito, José Hildebrando Todescan [30] reported that microhardness of root dentin in an intermediate region between dentin close to the CDJ and dentin next to the root canal is greater than root dentin microhardness close to root canal and CDJ.

Distilled water was used as an irrigating solution during root canal preparation for microhardness specimens because it has no effect on dentin surface thus not considered as a variable which might affect the results [31].

The result of the present study showed that both the chemical irrigants; 17% EDTA and 3% NaOCl significantly decreased the microhardness of the dentin but the decrease in dentin hardness was more with 17% EDTA than with 3% NaOCl (cervical $p=0.033$, middle $p=0.045$, apical $p=0.034$), herbal irrigant: neem extract (cervical $p<0.001$, middle $p<0.001$, apical $p=0.003$) and also with the control group: distilled water (cervical $p<0.001$, middle $p=0.002$, apical $p<0.001$). EDTA showed more reduction in microhardness of dentin. This may be because of the chelating action of EDTA solution as it binds to calcified component of dentin through its chelation action which in turn causes demineralization and softening of dentin. The demineralizing effect of EDTA consequently decrease the microhardness of dentin [32]. A study done Abdul Karim Al-azzawi, Nasser Hussein (2011) [33] showed that irrigation with EDTA and NaOCl decrease the microhardness of dentin. EDTA gave more reduction of dentin microhardness compared to NaOCl which is in accordance to our study. More studies on decrease of microhardness of dentin with EDTA when compared with sodium hypochlorite was also reported by Diyar Khalid Bakr, Sazan Sherdil Saleem, Basam Kareem Amin (2016) [34] and Soha F. Massoud, Sybel M. Maussa, Seham A. Hanafy *et al.* (2017) [29].

Suparna Ganguli Saha *et al.* (2017) [35] compared the microhardness of dentin with 17% EDTA, 3% NaOCl, 0.2% chitosan and 6% morinda citrifolia juice (herbal irrigants) and reported that 17% EDTA and 0.2% chitosan decrease more dentin microhardness compared to 3% NaOCl and 6% morinda citrifolia juice which is comparable to the present study.

Tenzin Rapgay *et al.* (2018) [36] did a comparative study on the effect of chemical irrigants; QMix and 17% EDTA with herbal irrigants; tea tree oil,

tamarindus indica, green tea extract on root dentin microhardness and they concluded that EDTA showed maximum reduction in microhardness of dentin whereas tea tree oil and green tea extract did not show significant reduction in microhardness. Findings of this study are comparable to the present study in respect to the herbal irrigant (neem extract).

Somiya Gupta *et al.* (2025) [37] did a comparative evaluation of herbal irrigants, green tea, triphala, neem, tulsi on the microhardness of dentin where 2% chlorhexidine was used as the positive control and distilled water as negative control and concluded that herbal irrigants showed less effect on microhardness of dentin rather than chemical irrigants.

The present study revealed that neem extract did not decrease the microhardness of dentin significantly and was similar to the control group (cervical $p=0.829$, middle $p=0.0868$, cervical $p=0.979$).

Study conducted by Rajesh Poddar *et al.* (2015) [38] found that 6% MCJ, A. Indica, and 3% NaOCl showed a significant reduction in the mean CFU counts for aerobic and anaerobic bacteria between baseline and 3 days and they concluded that there is no difference in the antimicrobial efficacy of 6% MCJ, neem extract and 3% NaOCl as root canal irrigants. Prashant Babaji *et al.* (2016) [39] compared herbal irrigants (M. citrifolia, A. indica extract, aloe vera) with NaOCl for their antimicrobial effect against E. faecalis using agar diffusion method and reported that the highest inhibition zone was seen with NaOCl followed by M. citrifolia, A. indica extract, aloe vera and hence concluded that the tested herbal medicines can be used as a root canal irrigating solution. Based on the results obtained and taking into consideration, the limitations of this study, it can be concluded that among the tested root canal irrigants, herbal irrigant (neem extract) does not affect the microhardness of dentin so it can be considered superior to the two chemical irrigants (3% NaOCl and 17% EDTA) with regards to its harmless effect on the microhardness of dentin.

Further studies with larger sample size as well as in-vivo studies are recommended to evaluate the other properties of the irrigants like their effects on other dental material, their antibacterial properties etc, to rate the success of treatment outcome clinically.

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REFERENCES

- Peters OA. Current challenges and concepts in the preparation of root canal systems: a review. *J Endod.* 2004 Aug 1;30(8):559-67.
- H. Schilder. Filling root canals in three dimensions. *Dent Clin North Am.* 1967;11:723-744.
- Schilder H. Cleaning and shaping the root canal. *Dent Clin North Am.* 1974;18:269-96.
- Lee OYS, Khan K, Li KY, Shetty H, Abiad RS, Cheung GSP, *et al.* Influence of apical preparation size and irrigation technique on root canal debridement: a histological analysis of round and oval root canals. *Int Endod J.* 2019; 52: 1366–1376.
- Nogueira BML, da Costa Pereira TI, Pedrinha VF, de Almeida Rodrigues P. Effects of different irrigation solutions and protocols on mineral content and ultrastructure of root canal dentine. *Iran Endod J.* 2018; 13: 209–215
- .Faraoni-Romano JJ, Turssi CP, Serra MC. Concentration-dependent effect of bleaching agents on microhardness and roughness of enamel and dentin. *Am J Dent.* 2007; 20: 31–34.
- Chuenarrom C, Benjakul P, Daosodsai P. Effect of indentation load and time on knoop and vickers microhardness tests for enamel and dentin. *Mat Res.* 2009; 12: 473–476.
- Hsieh SC, Teng NC, Chu CC, Chu YT, Chen CH, Chang LY, *et al.* The antibacterial efficacy and in vivo toxicity of sodium hypochlorite and electrolyzed oxidizing (EO) water-based endodontic irrigating solutions. *Materials (Basel)* 2020; 13: 260.
- McComb D, Smith DC, Beagrie GS. The results of in vivo endodontic chemomechanical instrumentation—a scanning electron microscopic study. *Int Endod J.* 1976 Jan;9(1):11-8.
- De-Deus G, Reis C, Di Giorgi K, Brandão MC, Audi C, Fidel RA. Interfacial adaptation of the Epiphany self-adhesive sealer to root dentin. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2011 Mar 1;111(3):381-627.
- Kanisavaran ZM. Chlorhexidine gluconate in endodontics: an update review. *Int Dent J.* 2008 Oct;58(5):247-57.
- Yamashita JC, Tanomaru Filho M, Leonardo MR, Rossi MA. Scanning electron microscopic study of the cleaning ability of chlorhexidine as a root-canal irrigant. *Int Endod J.* 2003 Jun 1;36(6):391-4.
- Yusof WZ, Khoo SP. Mucosal sensitivity to chlorhexidine mouthwash. *Singapore dent J.* 1988 Dec;13(1):39-40
- Kamat S, Rajeev K, Saraf P. Role of herbs in endodontics: An update. *J Endodontology.* 2011;23(1):98-101.
- Vani T, Rajani M, Sarkar S, Shishoo CJ. Antioxidant properties of the ayurvedic formulation triphala and its constituents. *International Journal of Pharmacognosy.* 1997 Jan 1;35(5):313-7.
- Rao AR, Sukumar S, Paramasivam TV, Kamalakshi S, Parashuraman AR, Shantha M. Study of antiviral activity of tender leaves of Margosa tree (*Melia azadiricta*) on vaccinia and variola virus: a preliminary report. *Indian J Med Res.* 1969;57(3):495-502.
- Khan M, Wassilew SW. Natural Pesticides from the Neem Tree and Other Tropical Plants (eds Schmutterer, H. and Asher, K. R. S.), GTZ, Eschborn, Germany 1987. p. 645– 650.
- Chopra IC, Gupta KC, Nair BN. Biological activities and medicinal properties of neem (*Azadirachta indica*). *Indian J Med Res.* 1952;40:511– 515.
- Balasenthil S, Arivazhagan S, Ramachandran CR, Ramachandran V, Nagini S. Chemopreventive potential of neem (*Azadirachta indica*) on 7, 12-dimethylbenz [a] anthracene (DMBA) induced hamster buccal pouch carcinogenesis. *J Ethnopharmacol.* 1999 Nov 1;67(2):189-95.
- Bhargava K, Kumar T, Aggarwal S, Zinzarde S, Sanap A, Patil P. Comparative evaluation of the antimicrobial efficacy of neem, green tea, triphala and sodium hypochlorite: An in vitro study. *J Dent Res Rev.* 2015 Jan 1;2(1):13-6.
- Jahromi MZ, Toubayani H, Rezaei M. Propolis: a new alternative for root canal disinfection. *Iran Endod J.* 2012;7(3):127-33.
- Lewinstein I, Hirschfeld Z, Stabholz A, Rotstein I. Effect of hydrogen peroxide and sodium perborate on the microhardness of human enamel and dentin. *J Endod.* 1994 Feb 1;20(2):61-3.
- Behrend GD, Cutler CW, Gutmann JL. An in-vitro study of smear layer removal and microbial leakage along root-canal fillings. *Int Endod J.* 1996 Mar;29(2):99-107.
- Haapasalo M, Endal U, Zandi H, Coil J. Eradication of endodontic infection instrumentation and irrigation solutions. *Endod Top J.* 2005 Mar;10(1):77-102.
- Panighi M, G' Sell C. Influence of calcium concentration on the dentin wettability by an adhesive. *Journal of biomedical materials research.* 1992 Aug;26(8):1081-9.
- Craig RG, Gehring PE, Peyton FA. Relation of structure to the microhardness of humandentin. *Dent Res J.* 1959 May;38(3):624-30.
- Cruz-FilhoAM, Sousa-Neto MD, Savioli RN, Silva RG, Vansan LP, Pécora JD. Effect of chelating solutions on the microhardness of root canal lumen dentin. *J Endod.* 2011 Mar 1;37(3):358-62.
- Pashley DH, *et al.* "Dentine Permeability: Effects of smear layer removal". *Journal of Prosthetic Dentistry.* 1981;46(5): 531-538.
- Soha F, Massoud, Sybel M, Moussa, Seham A. Hanafy, Rania M. El Back. Evaluation of the microhardness of root canal dentin after different irrigation protocols (in Vitro Study). *Alexandria Dent J* 2017;42:73-79.



30. Fabiano RibeiroCirano, Giuseppe AlexandreRomito, José HildebrandoTodescan. Determination of root dentin and cementum micro hardness. *Braz J Oral Sci.* 2004;3(8):420-424.
31. Barbizam JV, Trope M, Teixeira EC, Tanomaru-Filho M, Teixeira FB. Effect of calcium hydroxideintra canal dressing on the bond strength of a resin-based endodontic sealer. *Braz Dent J.* 2008;19(3):224-7.
32. Zandbiglari T, Davids H, Schäfer E. Influence of instrument taper on the resistance to fracture of endodontically treated roots. *Oral Surg Oral Med Oral Pathol Oral RadiolEndod.* 2006 Jan 1;101(1):126-31.
33. Hussein IN, AL-azzawi AK. An in-vitro evaluation the effect of endodontic irrigation solutions on the microhardness of root canal dentin. *Mustansiria Dent J.* 2011;8(1):19-2.
34. Diyar Khalid Bakr, SazanSherdilSaleem, Basam Kareem Amin. Effect of sodium hypochlorite, chlorhexidin and EDTA on dentin microhardness. *Zanco J. Med. Sci.* 2016;20(1).
35. SuparnaGangulySaha, Vini Sharma, AnujBharadwaj, PoorviShrivastava, MainakKantiSaha, SandeepDubey, Shubham Kala, ShubhraGupta. Effectiveness of Various Endodontic Irrigants on the Micro-Hardness of the Root Canal Dentin: An in vitro Study. *Journal of Clinical and Diagnostic Research.* 2017 Apr;11(4):ZC01-ZC04.
36. TenzinRapgay, Preeti Gupta, Hitesh Gupta, Arvinder Singh and Anjula Jain. Effect of Different Irrigant Solutions on Root Dentine Microhardness: An In Vitro Study. *Acta Scientific Dental Sciences.* 2018 Aug;2(8):03-08.
37. Somiya Gupta, Ajay kumarnagpal, Sunil Kumar, ShivangiDokaniya and Jugal Kishore Das. *Int. J. Adv. Res.* 2025 june;13(06):1335-1341.
38. Podar R, Kulkarni GP, Dadu SS, Singh S, Singh SH. In vivo antimicrobial efficacy of 6% Morindacitrifolia, Azadirachta indica, and 3% sodium hypochlorite as root canal irrigants. *Eur J Dent.* 2015 Oct;9(4):529-534.
39. Babaji P, Jagtap K, Lau H, Bansal N, Thajuraj S, Sondhi P. Comparative evaluation of antimicrobial effect of herbal root canal irrigants (Morindacitrifolia, Azadirachta indica, Aloe vera) with sodium hypochlorite: An in vitro study. *J Int Soc Prev Community Dent.* 2016 May;6(3):196-199 2016 May-Jun;6(3):196–199.