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Comparative Evaluation of The Effect of Calcium Hydroxide and Herbal Intracanal Medicaments on The Microhardness of Radicular Dentin: An In Vitro Study

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ABSTRACT

Aims: The aim of the study was to evaluate the effect of calcium hydroxide and herbal intracanal medicaments on the microhardness of radicular dentin.

Methods and material: Forty freshly extracted human mandibular single rooted premolars were collected for this study. The teeth were cleaned of any debris and calculus were stored in normal saline. The teeth were decoronated at cemento-enamel junction using low speed diamond disc with mounted on straight handpiece under water cooling. Each root was sectioned longitudinally separating each root into buccal and lingual segments. Thus 80 specimens were obtained. After this exposed dentinal surface of the specimens were polished using abrasive paper. Then the segments were sectioned horizontally to obtain 3mm mid root section. The root segment was then horizontally embedded in autopolymerizing acrylic resin, leaving their dentin exposed.

80 specimens were divided into four groups. Group I (n=20): Calcium Hydroxide paste, Group II (n=20): Turmeric paste, Group III (n=20): Aloe vera gel, Group IV (n=20): Control Group. Medicament were applied on the exposed dentin. The specimens were stored in airtight containers with their respective medicaments for 2 weeks. Microhardness was measured using a Vicker's microhardness tester with a 50-g load for 10 seconds on the polished surface.

Statistical analysis used: Data obtained was entered and sorted in Microsoft Excel (v.2010). Statistical analysis was performed using Statistical package for social sciences (SPSS) software (v.21.0). Descriptive quantitative data was expressed in mean and standard deviation respectively. Data normality was checked by using Shapiro – Wilk test.

Results: Mean microhardness value Group IV> Group III> Group II> Group I

Conclusion: This study found that calcium hydroxide significantly reduced radicular dentin microhardness more than turmeric paste, aloe vera gel, and the control group. While turmeric paste and aloe vera gel similarly decreased microhardness, only turmeric showed a significant reduction compared to the control group. Aloe vera gel also reduced

microhardness, but the difference was not statistically significant.

Keywords: *Calcium hydroxide, Turmeric paste, Aloe vera gel, Microhardenss*

1. INTRODUCTION

The root canal system supports microbial growth, leading to persistent infections that complicate treatment. Despite mechanical debridement and antimicrobial irrigation, complete microbial eradication is difficult. Post-treatment infections highlight the need for effective microbial control, as both aerobic and anaerobic bacteria contribute to inflammation and flare-ups.[1,2]

One particularly challenging microorganism in root canal infections is Enterococcus faecalis (E. faecalis), especially in retreatment scenarios. While E. faecalis can be eliminated in its planktonic state in laboratory settings, it exhibits significant resistance within the root canal. This resilience stems from various factors, including biofilm formation, which shields it from the immune system and antimicrobial agents. Furthermore, E. faecalis can invade dentinal tubules, establishing a biofilm that is highly resistant to removal, even with advanced treatment protocols.[3]

The primary aim of root canal therapy is to remove microorganisms and their toxic by-products.[4,5] Standard procedures involve mechanical preparation with files and irrigants, yet the complex root canal anatomy such as isthmuses and lateral canals often hinders complete cleaning, making effective irrigation and intracanal medicaments critical.[6,7] In multi-visit treatments, intracanal medicaments are essential for preventing bacterial regrowth between appointments, with calcium hydroxide being widely used due to its high pH and strong antibacterial properties.[8]

Despite calcium hydroxide's effectiveness, there are limitations that have driven interest in natural alternatives like turmeric (Curcuma longa) and aloe vera. These herbal agents are appreciated for their antimicrobial properties, low toxicity, and minimal side effects. Plant-based substitutes are gaining traction for their perceived safety and lower potential for microbial resistance.[6,9]

Turmeric and aloe vera, specifically, have shown promise in endodontics due to their antimicrobial, anti-inflammatory, and wound-healing qualities. However, some chemicals used in traditional treatments can weaken dentin by reducing its microhardness, which could compromise the tooth's structural integrity.[9,10,11]

This study aims to assess the effects of calcium hydroxide, turmeric, and aloe vera on the microhardness of radicular dentin. The goal is to evaluate whether these herbal alternatives, beyond their antimicrobial benefits, also help preserve dentin structure better than traditional medicaments. This research is driven by the need for intracanal medicaments that are not only effective against pathogens but are also safe, economical, and protective of tooth structure.

2. MATERIAL AND METHODS:

Forty freshly extracted human mandibular single rooted premolars were collected for this study. Teeth with dental caries, any fracture lines, resorption and immature apex were excluded from the study. The teeth were cleaned of any debris and calculus using ultrasonic scalers and were stored in normal saline. The teeth were decoronated at cemento-enamel junction using low speed diamond disc with mounted on straight handpiece under water cooling. Each root was sectioned longitudinally with low-speed diamond disc separating each root into buccal and lingual segments. Thus 80 specimens were obtained. After this exposed dentinal surface of the specimens were polished using abrasive paper. Then the segments were sectioned horizontally to obtain 3mm mid root section. The root segment was then horizontally embedded in autopolymerizing acrylic resin, leaving their dentin exposed.

80 specimens were divided into four groups:

1) Group I (n=20): Calcium Hydroxide paste

In this group the exposed dentin of each specimen was saturated with calcium hydroxide paste (Fig.34).

2) Group II (n=20): Turmeric paste

5 gms of Turmeric powder was mixed with 50 ml of sterile saline (Fig.5) to obtain paste[12] (Fig.6). This freshly prepared paste was applied on exposed dentin of each specimen (Fig.35).

3) Group III (n=20): Aloe vera gel

Aloe vera gel was prepared by mixing 50 ml of aloe vera extract (Fig.7 and 9) with 5 gms of carboxymethylcellulose (Fig.9) and this gel[97] (Fig.10) was then applied on exposed dentin of each specimen (Fig.36).

4) Group IV (n=20):

Control Group (without application of intracanal medicaments) (Fig. 11).

In this group the specimens were saturated with distilled water (Fig.41).

The specimens were kept in air tight container saturated with respective medicaments for 2 weeks. After 2 weeks specimens were cleaned with distilled water to remove the medicament after that Vicker's microhardness tester was used to measure the microhardness of each specimen. The indentations were created on the polished surface of each specimen with the help of a 50-g load held straight to the polished side for 10 s and the microhardness of each specimen was obtained.

3. RESULTS

The results of this study were as follows: The null hypothesis was rejected.

Microhardness values for each sample of Group I, II, III and IV are shown in table 1. Graph 1 shows mean microhardness values of all experimental groups.

Mean microhardness value of Group I ie. Calcium hydroxide was 31.62 HV, Group II ie. Turmeric paste was 40.92 HV, Group III ie. Aloe vera gel was 43.89 HV and that of Group IV ie. Control group was 46.35 HV.

Group IV> Group III> Group II> Group I

46.35> 43.89> 40.92> 31.62

Mean microhardness values were used for statistical analysis, with descriptive data expressed as mean and standard deviation. Normality was checked using the Shapiro-Wilk test, and a 95% confidence interval and 5% significance level were applied. The study power was set at 80%. Unpaired t-test was used for intergroup comparisons of quantitative parameters, while the Chi-square test was used for categorical comparisons.

According to the statistical analysis done pairwise comparisons were done and they revealed the following –

1) The mean microhardness was more in Group IV Control group (46.35) followed by Group III Aloe vera gel (43.89), Group II Turmeric paste (40.92) and Group I Calcium hydroxide (31.62). This is shown in table 1 and Graph 1.
2) Among Group IV (Control group), Group III (Aloe vera gel), Group II (Turmeric paste), and Group I (Calcium hydroxide), it was observed that the mean microhardness of radicular dentin was highest in Group IV, followed by Group III, Group II, and Group I.
3) Pairwise comparisons revealed the following:

a) Group I (Calcium Hydroxide) had the lowest mean microhardness of radicular dentin compared to Groups II (Turmeric paste), III (Aloe Vera Gel), and IV (Control Group), with a statistically significant difference, indicating calcium hydroxide reduced microhardness more than the other groups.

b) Group II (Turmeric paste) had lower microhardness than Groups III (Aloe Vera Gel) and IV (Control Group), with a significant difference compared to the control group, but no significant difference between Group II and Group III, suggesting similar effects of turmeric paste and aloe vera gel.

c) The comparison between Group III (Aloe Vera Gel) and Group IV (Control Group) showed no significant difference in microhardness, indicating aloe vera gel did not significantly reduce it compared to the control group. These findings are supported by Table 2 and Graph 2.

Table 1: Descriptive statistics of microhardness of radicular dentin after application of Calcium Hydroxide paste, Turmeric paste and Aloe vera gel as an intracanal medicament.

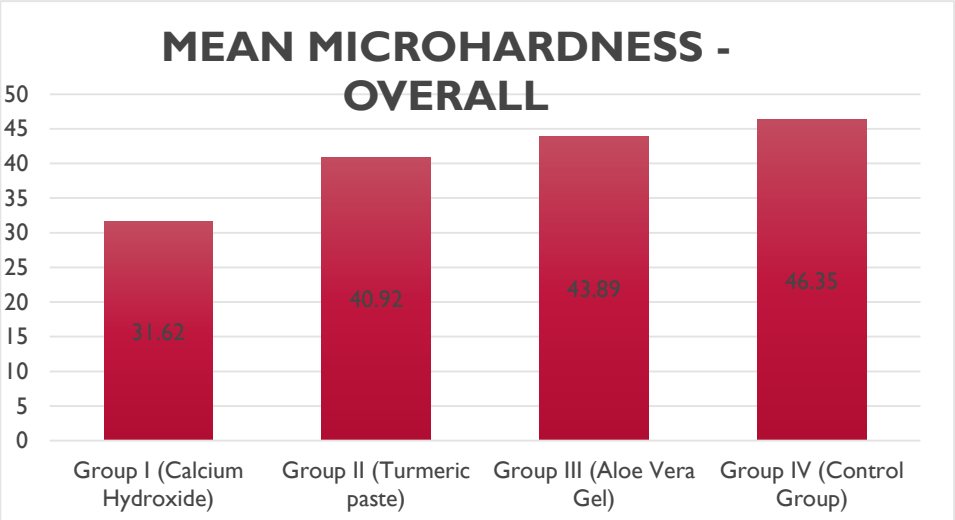
	Mean	SD	SE	Minimum	Maximum
Group I (Calcium Hydroxide)	31.62	2.22	0.49	28.0	35.6
Group II (Turmeric paste)	40.92	2.49	0.55	37.0	45.5

Group III (Aloe Vera Gel)	43.89	4.18	0.93	36.2	54.7
Group IV (Control Group)	46.35	6.89	1.54	30.8	56.4

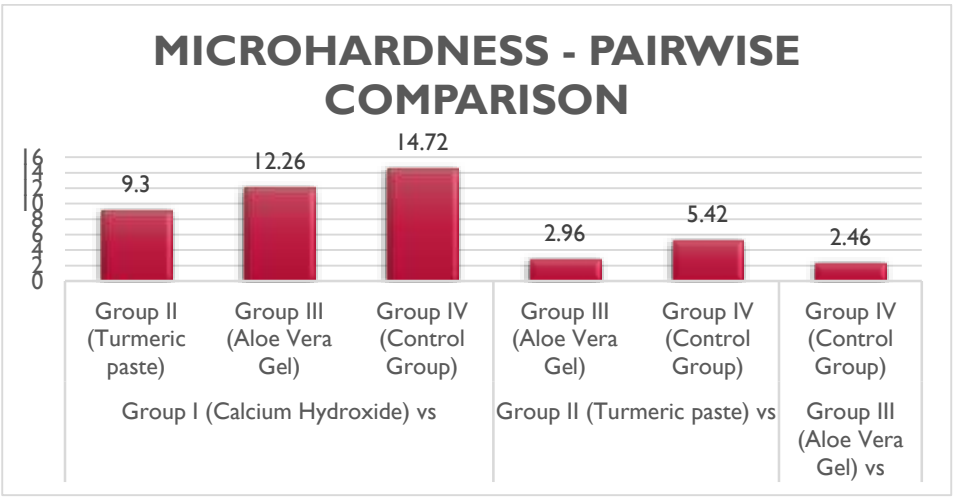
Table 2: Pairwise comparative statistics of microhardness of radicular dentin after application of Calcium Hydroxide paste, Turmeric paste and Aloe vera gel as an intracanal medicament using Tukey's post hoc test.

Group	Comparison Group	Mean Difference	P value, Significance
Group I (Calcium Hydroxide) vs	Group II (Turmeric paste)	9.3	p < 0.001*
	Group III (Aloe Vera Gel)	12.26	p< 0.001*
	Group IV (Control Group)	14.72	p< 0.001*
Group II (Turmeric paste) **vs**	Group III (Aloe Vera Gel)	2.96	p =0.147 (NS)
	Group IV (Control Group)	5.42	p =0.001*
Group III (Aloe Vera Gel) vs	Group IV (Control Group)	2.46	p =0.290 (NS)

Graph 1: Comparison of mean microhardness values amongst different groups.



Graph 2: Pairwise comparison of microhardness of radicular dentin after application of Calcium Hydroxide paste, Turmeric paste and Aloe vera gel as an intracanal medicament.



4. DISCUSSION:

Microbes and their by-products are key causes of endodontic diseases, with Enterococcus faecalis commonly found in root-filled teeth with persistent infections. Successful treatment relies on eliminating bacteria and their harmful substances from the root canal.[3] Biomechanical preparation alone is insufficient, so intracanal medicaments are recommended for further decontamination.[12] Calcium hydroxide, widely used for over a century, dissociates into calcium and hydroxyl ions and is used for various endodontic treatments. However, it may not fully eliminate microorganisms and may have limited antimicrobial effectiveness in certain conditions.[13]

Phytomedicine has gained interest in dentistry for its anti-inflammatory, antibiotic, and analgesic properties.[14] Aloe vera, known for its antimicrobial, antioxidant, and anti-inflammatory effects, is used in dentistry for conditions like gingivitis and periodontitis. It shows activity against both Gram-positive and Gram-negative bacteria.[15] Similarly, turmeric, containing curcumin, has antioxidant, antimicrobial, and anti-inflammatory properties and is used in managing periodontal disease and oral cancers.[16]

This research aimed to compare the effects of calcium hydroxide, turmeric, and aloe vera on the microhardness of radicular dentin as intracanal medicaments, focusing on their antibacterial properties, availability, affordability, and minimal side effects.The current investigation aimed to assess the microhardness of radicular dentin following the administration of Calcium hydroxide, Turmeric paste, and Aloe vera gel. Additionally, a control group was incorporated in the study, where

the dentinal surface was subjected to distilled water.

This study found that calcium hydroxide significantly reduced the microhardness of radicular dentin compared to turmeric paste, aloe vera gel, and the control group. This reduction is due to calcium hydroxide's demineralizing effect and collagen degradation, which aligns with Yassen's study, noting that the elevated pH of calcium hydroxide disrupts the dentin matrix and damages collagen fibers.[17,18] Similar findings were reported by Elfaramawy et al., who noted a decrease in root dentin microhardness over time, though activated charcoal can alleviate this effect.[19] Amonkar and colleagues also found that prolonged calcium hydroxide use significantly decreases dentin microhardness.[20] Parashar et al. also observed a significant decrease in microhardness following calcium hydroxide treatment, consistent with the findings of this study.[2] Scientific evidence indicates that the high alkalinity and small size of calcium hydroxide allow it to penetrate the collagen fibrils, altering the three-dimensional structure of tropocollagen.[21] This leads to a reduction in both microhardness and elastic modulus. The alkaline nature of calcium hydroxide also denatures the organic matrix of dentin.[22] Yoldas et al. suggest that the decrease in microhardness caused by calcium hydroxide may result from its proteolytic activity. The increase in pH following calcium hydroxide exposure can weaken the dentin matrix's organic support, leading to protein degradation and disruption of collagen-hydroxyapatite connections, ultimately affecting dentin's mechanical properties.[17]

Turmeric paste has shown least microhardness reduction as compared to calcium hydroxide. These findings are in accordance with **Prabhakar et al**, **Mohamed AI et al** which showed that calcium hydroxide significantly reduced dentine microhardness when compared with turmeric.[8,23]

Basir et al. investigated the effects of various turmeric concentrations on enamel microhardness and anti-caries properties. They found that turmeric improved enamel microhardness and demonstrated anti-caries effects. The researchers suggested that curcumin, the polyphenolic compound in turmeric, may inhibit MMP-9, an enzyme that breaks down collagen in demineralized dentin, by chelating Zinc ions necessary for MMP activity.[24] The USDA's Agricultural Research Services reported that turmeric contains calcium (Ca) and phosphorus (P), which may precipitate on demineralized dentin surfaces, blocking porosities and dentinal tubules, thereby reducing surface roughness.[25] While turmeric remains stable at a pH of 6.5, it becomes unstable in neutral to basic conditions. This pH change can weaken the dentin matrix, breaking down protein structures and disrupting the bond between collagen fibers and hydroxyapatite crystals, negatively affecting dentin's mechanical properties.[8]

Aloe vera gel showed the least reduction in microhardness compared to calcium hydroxide and turmeric paste, aligning with findings from Parashar et al. However, there is limited data on aloe vera's effects on root dentin microhardness.[2] Sinha et al. (2016) found that aloe vera did not negatively affect dentin shear bond strength when used as a cavity disinfectant.[26] Additionally, research by Bertolini showed that aloe vera has antimicrobial properties against caries-causing microorganisms, particularly Streptococcus mutans.[27] Recent studies also suggest aloe vera inhibits matrix metalloproteinases (MMP) 2 and 9, enhancing its potential benefits.[28] Aloe vera gel is composed mainly of 98-99% water, with 1-2% active components including anthraquinones, flavonoids, naphthoquinones, polysaccharides, vitamins, amino acids like arginine, and various sugars such as glucose, mannose, and fructose. It also contains enzymes like catalase, oxidase, and amylase, along with minerals including calcium, magnesium, sodium, and potassium. Silva et al. indicated that the remineralizing properties of a 90% Aloe vera solution may contribute to calcium deposition on dentin surfaces, which can affect dentin hardness.[29] Karad et al. found that Aloe vera enhances microhardness due to its MMP-inhibiting activity and neutral pH.[30] Aloe vera contains alloin, which reduces collagen degradation and helps retain Ca/PO4 ions in dentin. Aloe vera gel has more calcium and phosphorus than turmeric, which may explain why it affects microhardness less.[25] Distilled water, used as a control, doesn't alter dentin.[31]

This study finds that calcium hydroxide reduces radicular dentin microhardness more than turmeric paste, aloe vera gel, and the control. Turmeric and aloe vera both lower microhardness, with turmeric showing a significant reduction compared to the control, while aloe vera's effect was not statistically significant

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