

RESEARCH

Open Access



# A novel plant based intra canal medicament: ease of removal and effect on radicular dentine microhardness

Yousra Aly\*, Nada Omar, Engy M. Kataia, Maram E. Khallaf and Mohamed H. Zaazou

## Abstract

**Background:** This study aimed to evaluate the remaining amount of intra canal medicament in the root canals and their effect on microhardness of radicular dentine. In this study, ninety straight single-rooted teeth were used. Teeth were decoronated at the cemento-enamel junction to ensure a uniform root length of 14 mm ( $\pm 1$  mm). Root canals were prepared using ProTaper rotary files till size F5. The teeth were then randomly assigned to 3 treatment groups ( $n = 30$ ); Group 1:  $\text{Ca(OH)}_2$  pastes (Metapex), Group 2: *Moringa oleifera* leaf powder mixed with *Moringa oleifera* extract liquid and Group 3: *Moringa oleifera* root powder mixed with *Moringa oleifera* extract liquid. The access openings of all teeth were sealed with Cavit and all teeth were kept in the incubator at 37 °C and 100% humidity for 1 week. After 1 week, the intra canal medicament paste was removed from all teeth. For examination of the ease of removal of the intracanal medicaments, root canals were sectioned longitudinally into buccal and lingual halves and were examined under stereomicroscope at 25 $\times$  magnification. The remaining amount of intracanal medicaments was calculated using image analysis software (Image j). For microhardness evaluation, forty-five specimens were longitudinally sectioned in a bucco-lingual direction then the roots were split. The root segments were then horizontally embedded in autopolymerizing acrylic resin leaving their dentin surface exposed. The dentin surface of the mounted specimens was ground flat and smooth and polished to obtain a smooth surface. Microhardness measurement was recorded for each sample at baseline before and after application of the three intracanal medications using Vickers Microhardness Tester at magnification of 100 $\times$  using a 25 g load for 10 s.

**Results:** Regarding the evaluation of the ease of removal of the intracanal medicaments after irrigation: apically, the  $\text{Ca(OH)}_2$  recorded the highest mean value of the residual remnants with a statistically significant difference with both *Moringa oleifera* leaf and root. The microhardness evaluation results showed that all groups showed increase in the microhardness after application of the intracanal medicament for 1 week with no statistically significant difference between them.

**Conclusions:** *Moringa oleifera* could be removed easily from the root canals and showed increase in the microhardness of root canal dentin similar to the commonly used calcium hydroxide.

**Keywords:** *Moringa oleifera*, Intracanal medicament, Calcium hydroxide, Microhardness, Remnants

## Background

Root canal disinfection is one of the main objectives of endodontics. Failure of endodontic treatment may occur

due to the complexity of root canal anatomy or antibiotic resistance of some bacteria such as *Enterococcus faecalis* (Ehsani et al. 2013; Benbelaid et al. 2014; Siquiera and Roças 2008; Zan et al. 2016; Zand et al. 2016; Ramezani et al. 2016).

Mechanical preparation of root canals by hand and rotary files cannot clean all areas such as the isthmuses

\*Correspondence: yousraaly2010@gmail.com  
Restorative and Dental Materials Department, National Research Centre,  
Cairo, Egypt

and lateral canals. That's why, in such cases adjunctive aids are needed. The use of effective irrigation, as well as intra canal medicaments is essential. In addition, intra canal medicaments may indirectly contribute to the healing of the affected periapical lesions (Kawashima et al. 2009; Law and Messer 2004).

One of the most commonly used intracanal medications during endodontic treatment is calcium hydroxide  $\text{Ca}(\text{OH})_2$ . It is proved to be highly effective in treatment of teeth with chronic periapical lesions (Han et al. 2001; Siqueira et al. 2007).  $\text{Ca}(\text{OH})_2$  is known by its capacity to neutralize bacterial endotoxins and the stimulation of apical and periapical repair (Calt and Serper 1999).

It is considered a strong alkaline substance with a pH of 12.5 approximately (Siqueira and Lopes 1999). Due to this high pH, after exposure to calcium hydroxide, reduction of the organic support of the dentin matrix was observed. Moreover, this alkalinity may lead to protein structure breakdown that could alter the mechanical properties of dentin (Andreasen et al. 2002). According to Andreasen's theory, calcium hydroxide has a proteolytic action that could weaken the tooth up to 50% in 1 year. He believed that the disruption in links between the collagen fibers and hydroxyapatite crystals could be the cause of dentin microhardness reduction (Andreasen et al. 2002).

The intra canal medicament should be removed from the canals before root canal obturation. Any residual remnants of it on canal walls may interfere with the sealer penetration into dentinal tubules (Calt and Serper 1999) and may lead to unfavorable interaction between sealer and intracanal medicament (Lambrianidis et al. 1999a).

Various antibacterial agents obtained from natural sources have been previously studied (Guneser et al. 2016). It is well known now that the natural products used in medical and dental fields proved to have desirable pharmacological properties and high medicinal value. However, prior to their use, sufficient determination of these products properties is mandatory (Torres and Castro 2014). *Moringa oleifera* is a native Indian tree that proved to have antiviral, antibacterial, antioxidant, antisclerotic and anti-inflammatory properties. It is well known as a treatment of many diseases such as malaria, malnutrition, colon cancer, and myeloma (Jung 2014).

When new products are first released onto the market, laboratory tests are essential to study their effect on dental tissues (Cochrane et al. 2019). The evidence of mineral loss or gain in dental hard tissues could be indirectly estimated by microhardness measurement (Panighi and G'Sell 1992; Bosch 1992).

It was shown that the use of root canal medicaments affects root dentin physical characteristics and subsequently affects its fracture resistance (Zarei et al. 2013; Yassen et al. 2013). However, there is no sufficient

information about the effect of natural medications on fracture resistance of root dentin.

Therefore, the aim of this study was the evaluation of the ease of removal of intra canal medicaments, based on *Moringa oleifera* extracts (Egyptian Scientific Society of the moringa trees, National Research Centre, Dokki, Giza, Egypt) from the root canals and to investigate their effect on microhardness of radicular dentine when compared to a  $\text{Ca}(\text{OH})_2$  paste.

## Methods

### Preparation of tooth specimens

Ninety straight single-rooted teeth with closed apices were collected for this study from faculty of dentistry, Cairo University. They were collected from adult patients requiring extractions for orthodontic purpose. Teeth with any signs of previous root caries, cracks, curved or blocked canals were excluded.

Teeth were thoroughly cleaned from any soft tissue or calculus deposits then they were stored in saline solution at room temperature till time of use. Teeth were decoronated transversally at the cemento-enamel junction (CEJ) with a double-faced diamond disc (Microdont LDA, Brazil) at low speed with water coolant to ensure a uniform sample length of 14 mm ( $\pm 1$  mm root length).

### Canal preparation

All teeth were instrumented as follows: Working lengths were established by inserting a size 15 K-file (Mani, Inc, Japan) to the root canal terminus until it became visible through the apical foramen and then subtracting 1 mm. Root canal preparation was done using ProTaper rotary files (Dentsply, sirona) till size F5. Canals in all groups were irrigated with a standardized volume of 2 mL of sodium hypochlorite between each file. The canals were finally rinsed with sterile saline to remove any dentine debris remaining in the canal after instrumentation. Root canals were then dried with sterile paper points.

### Evaluation of the ease of removal of the intracanal medicament

For the evaluation of ease of intracanal medicament removal 45 teeth were randomly selected. The teeth were then randomly assigned to 3 treatments groups ( $n=15$ ); Group 1:  $\text{Ca}(\text{OH})_2$  pastes (Metapex, Meta Biomed, Europe). Group 2: *Moringa oleifera* leaf powder mixed with *Moringa oleifera* extract liquid and Group3: *Moringa oleifera* root powder and mixed with *Moringa oleifera* extract liquid. For the *Moringa oleifera* groups the powder was mixed with the liquid till reaching a paste consistency. The paste was applied to the canal spaces with a sterile lentulo spiral in a low-speed handpiece (Dentsply Caulk, Milford, DE, USA) and condensed in the canal

space to the level of the cemento-enamel junction using various sizes of sterile pluggers. Furthermore, the access openings of all teeth were sealed with a thickness of at least 4 mm of Cavit (3MESPE, USA). Teeth in all groups were kept in the incubator at 37 °C and 100% humidity for 1 week.

After 1 week, the temporary restoration was removed and a 25 K-file (Dentsply Maillefer, Switzerland) was used with 10 mL of saline irrigation to remove the intra canal medicament paste from all teeth. The volume of irrigant was standardized for all experimental groups.

Specimens were then longitudinally sectioned in a bucco-lingual direction by using a double-faced diamond disk at low speed, without passing through the canal space. This was followed by using a chisel and mallet to split the root. One half was examined under stereomicroscope for detection of residual intracanal medicament using magnification of 25× and remaining amount of intracanal medicaments was calculated using image analysis software as the percentage of root canal covered by intracanal medicament (ImageJ NHS, USA). Image analysis was carried out by the same observer for all groups.

#### Evaluation of the effect on root canal dentin microhardness

Forty-five specimens were longitudinally sectioned in a bucco-lingual direction after complete mechanical preparation. Sectioning was done using a double-faced diamond disk at low speed, without passing through the canal space. This was followed by using a chisel and mallet to split the root. The root segments were then horizontally embedded in autopolymerizing acrylic resin (Acrostone, Dent Product, Egypt) leaving their dentin surface and canal exposed. The dentin surface of the mounted specimens was ground flat and smooth with a series of ascending grades of carbide abrasive papers under distilled water to remove any surface scratches and finally polished with 0.1-mm alumina suspension on a rotary felt disc (Microdont LDA, Brazil) to obtain a smooth glossy mirror-like surface.

Microhardness was measured for each sample at baseline before application of the intracanal medicament and after application. Baseline microhardness value was measured at magnification of 100× using Vickers Microhardness Tester (Model LM-100, FM 1159 LECO Corporation Michigan, and USA) using a 25 g load for 10 s. The microhardness measurements were taken either on the buccal or lingual side and were determined at three different points for each sectioned root: on the coronal, middle and apical thirds. For each section three measurements were taken, and their mean was recorded for the analysis. Intracanal medicaments were then applied to roots according to their groups and left for 1 week in an

incubator at 37 °C. After 1-week intracanal medicaments were removed by flushing the surface of each specimen with 10 ml saline, then microhardness was tested again with the same parameters for each section and compared to the baseline results (Fig. 1).

#### Statistical analysis

The mean and standard deviation values were calculated for each group in each test. Data were explored for normality using Kolmogorov–Smirnov and Shapiro–Wilk tests, data showed parametric (normal) distribution.

Repeated measure ANOVA was used to compare between more than two groups in related samples. Paired wise sample *t* test was used to compare between two groups in related samples. One-way ANOVA followed by Tukey post hoc test was used to compare between more than two groups in non-related samples.

The significance level was set at  $P \leq 0.05$ . Statistical analysis was performed with IBM® SPSS® Statistics Version 20 for Windows.

#### Results

##### Evaluation of the ease of removal of the intracanal medicaments

##### $Ca(OH)_2$

The highest statistical mean value was found in Apical third then Middle third, then Coronal third. A statistically significant difference was found between apical and



**Fig. 1** A photomicrograph of Vicker's indenter on a middle section of the root after application of *Moringa oleifera* leaf intracanal medicament

each of middle and coronal thirds. Also, a statistically significant difference was found between middle and coronal thirds.

**Moringa oleifera leaf**

Middle third recorded the highest mean value followed by apical third then the coronal third. No statistically significant difference was found between the three thirds.

**Moringa oleifera root**

A statistically significant difference was found between apical and middle thirds. The apical third recorded the highest mean value followed by coronal then middle third.

**Comparing different groups**

**Apical third**

The highest mean value of remnants was found in Ca(OH)<sub>2</sub> followed by *Moringa oleifera* root then *Moringa oleifera* leaf.

A statistically significant difference was found between Ca(OH)<sub>2</sub> and both *Moringa oleifera* leaf and *Moringa oleifera* root where ( $p < 0.001$ ). No statistically significant difference was found between *Moringa oleifera* leaf and *Moringa oleifera* root where ( $p = 0.343$ ).

**Middle third**

The highest mean value was found in Ca(OH)<sub>2</sub> followed by *Moringa oleifera* leaf, then *Moringa oleifera* root.

A statistically significant difference was found between *Moringa oleifera* root and each of Ca(OH)<sub>2</sub> and *Moringa oleifera* leaf where ( $p = 0.002$ ) and ( $p = 0.004$ ) respectively.

There was no statistically significant difference between Ca(OH)<sub>2</sub> and *Moringa oleifera* leaf where ( $p = 0.964$ ).

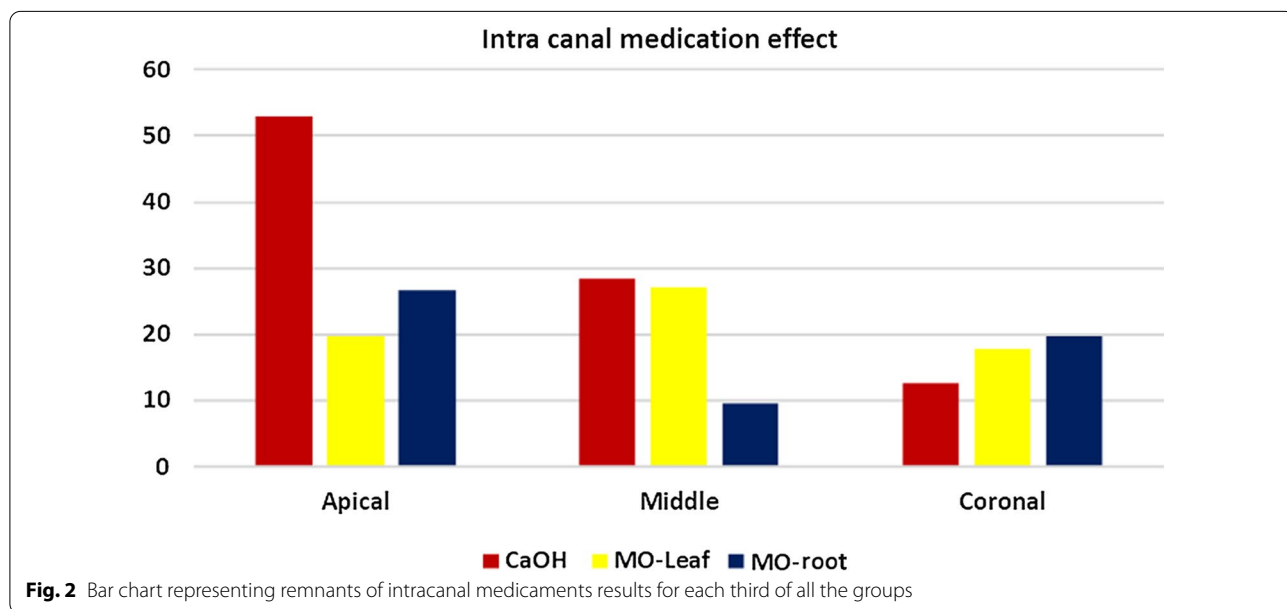
**Coronal third**

No statistically significant difference was found between the three groups. The *Moringa oleifera* root recorded the

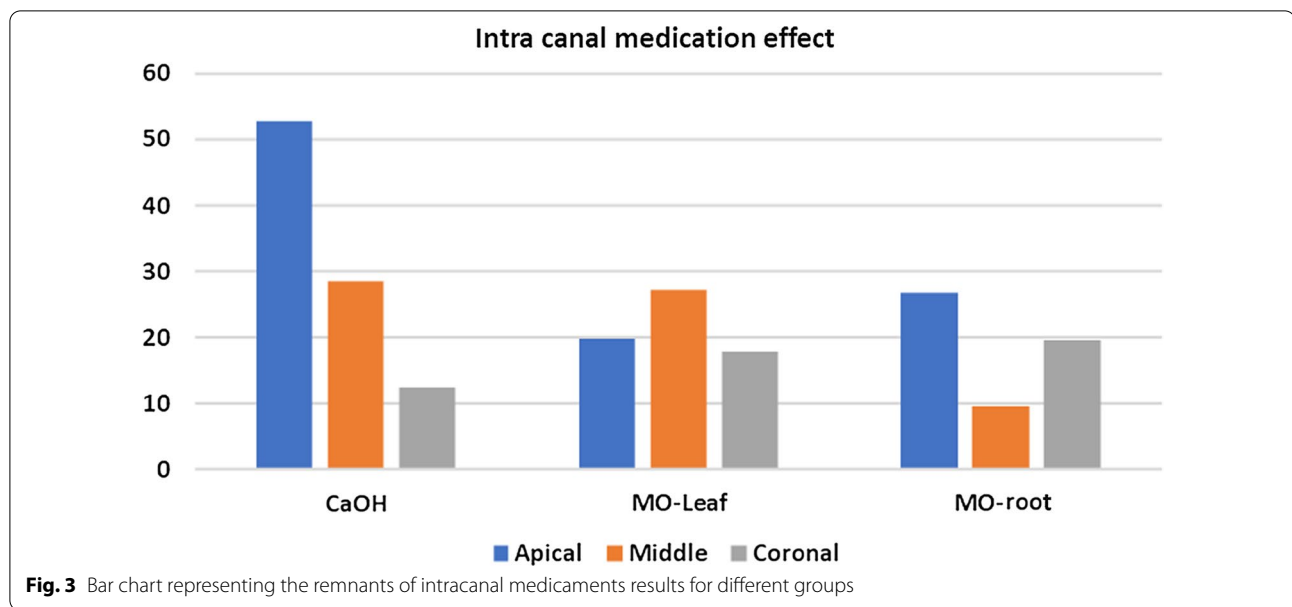
**Table 1 The mean, standard deviation (SD) of intracanal medication effect in each third in different groups**

Variables	Ease of intracanal medicament removal						p value
	Apical		Middle		Coronal		
	Mean %	SD	Mean%	SD	Mean%	SD	
Ca(OH) <sub>2</sub>	52.86	12.03	28.45	10.46	12.49	1.51	0.001*
<i>Moringa oleifera</i> leaf	19.78	4.39	27.21	10.27	17.86	6.05	0.125 ns
<i>Moringa oleifera</i> root	26.66	7.32	9.55	4.82	19.68	11.33	0.041*
p value	< 0.001*		0.001*		0.201 ns		

\*Significant ( $p < 0.05$ ) ns non-significant ( $p > 0.05$ )



**Fig. 2** Bar chart representing remnants of intracanal medicaments results for each third of all the groups



highest mean value followed by *Moringa oleifera* leaf, then Ca(OH)<sub>2</sub> (Table 1, Figs. 2, 3).

**Root canal dentin microhardness evaluation**

**Coronal third**

Ca(OH)<sub>2</sub> recorded the highest mean values of increased micro hardness and was significantly higher than both *Moringa oleifera* leaf and root groups.

**Middle third**

Ca(OH)<sub>2</sub> recorded the lowest mean values of increase of micro hardness and was statistically significant with each of *Moringa oleifera* leaf and *Moringa oleifera* root where ( $p < 0.001$ ).

**Apical third**

Ca(OH)<sub>2</sub> recorded a statistically significant high mean value, compared to each of *Moringa oleifera* leaf and *Moringa oleifera* root where ( $p = 0.008$ ) and ( $p = 0.002$ ).

In all thirds, no statistically significant difference was found between *Moringa oleifera* leaf and *Moringa oleifera* root.

**Total canal**

In total, there was no statistically significant difference between the three groups, where ( $p = 0.831$ ) (Table 2, Fig. 4).

**Discussion**

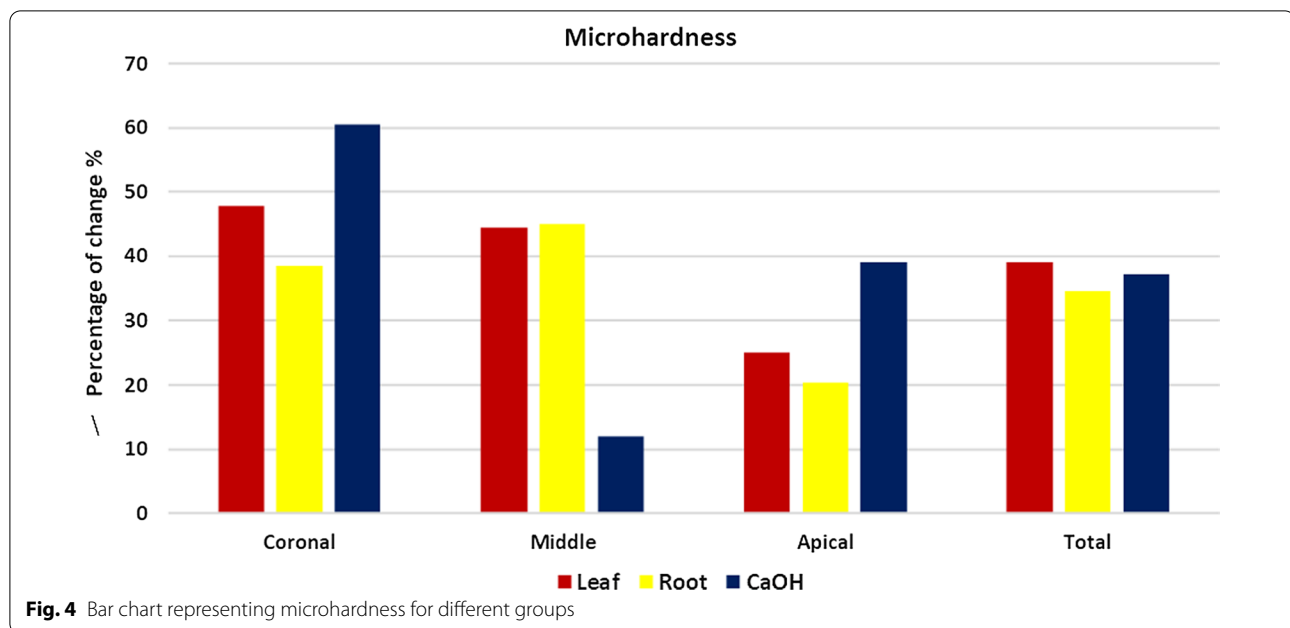
Total bacterial eradication from the root canal system is a major goal of endodontic treatment. More than one procedure should be combined to eliminate bacterial infection. These procedures include the use of efficient irrigating solutions such as sodium hypochlorite (NaOCl) or hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>) during cleaning and shaping in addition to the intracanal medicament that contains antimicrobial agents such as calcium hydroxide (Garcez et al. 2007; Bonsor et al. 2006).

**Table 2** The mean, standard deviation (SD) values of percentage of change of Microhardness of different groups

Variables	Microhardness							
	Coronal		Middle		Apical		Total	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
<i>Moringa oleifera</i> leaf	47.76	5.97	44.37	3.46	25.00	4.90	39.04	11.45
<i>Moringa oleifera</i> root	38.49	1.61	45.02	3.63	20.37	2.61	34.63	11.31
Ca(OH) <sub>2</sub>	60.58	4.64	12.07	0.65	39.01	3.00	37.22	21.23
p-value	0.003*		< 0.001*		0.002*		0.831 ns	

Means with different small letters in the same column indicate significant difference

\*Significant ( $p < 0.05$ ) ns non-significant ( $p > 0.05$ )



The use of intracanal medicaments is often mandatory to eliminate bacteria from root canals in order to stop their ingress, prevent their growth, and cut off their source of nutrients (Siqueira et al. 2001).

For root canal system disinfection, calcium hydroxide is the most widely used intracanal medicament (Mustafa et al. 2012); when applied for at least 7 days, elimination and/or reduction of the populations of living bacteria even after cleaning and shaping could be achieved (Mohammadi et al. 2012). Direct contact of calcium hydroxide (pH is about 12.5) with the mostly found bacterial species in infected root canals leads to its elimination after short period of time (BystroËm and Sundqvist 1985). The antimicrobial activity of calcium hydroxide could be attributed to hydroxyl ions release in an aqueous environment. Hydroxyl ions are highly oxidant free radicals that show extreme reactivity, reacting with several biomolecules (Freeman and Crapo 1982). This reactivity is high and indiscriminate, so this free radical rarely diffuses away from sites of generation.

According to Siqueira et al. (1999), their lethal effects on bacterial cells are probably due to the following mechanisms: (1) damage to the bacterial cytoplasmic membrane; (2) protein denaturation; and (3) damage to the DNA.

It was shown that bond strengths between root canal dentine and resin-based sealer was decreased due to presence of calcium hydroxide remnants (Barbizam et al. 2008). Ca(OH)<sub>2</sub> remnants were also shown to have interfered with the sealing ability of a silicon-based

sealer (Contardo et al. 2007). Calcium hydroxide based intracanal medications also contributed to the increased apical leakage of root canals filled with gutta percha and zinc oxide–eugenol sealer (Kim and Kim 2002) which can be explained by the accelerated setting of the sealer (Margelos et al. 1997).

Therefore, it was then mandatory to study new antimicrobial agents targeting these bacteria to achieve a higher success rate in endodontic treatments thus predicting a better prognosis for the tooth.

Nowadays, new natural products and various plants have been used as a source of medicine. That's why, many studies are being carried out to investigate these new products' properties (Mistry et al. 2014). *Moringa oleifera* is known as miracle tree because all the parts of the tree (leaves, pods, seeds, roots, flowers) can be utilized for nutritional and pharmacological benefits.

According to a study conducted by Shetty et al. (2019), *Moringa oleifera* and *Azadirachta indica* demonstrated an antibacterial effect against *Enterococcus faecalis*. They concluded that these natural products could be used effectively as antimicrobial agent in root canal therapy.

During the first 24 and 48 h, *Moringa oleifera* had an antibacterial effect against *E. faecalis*. Olson and Fahey showed that the chemical compound named 4-(4'-O-acetyl- $\alpha$ -L-rhamnopyranosyloxy)-benzylisothiocyanate is responsible for the antibacterial effect of *Moringa oleifera*. Its action mechanism depends on inhibition of essential cellular membrane enzymes (Olson and Fahey 2011; Martin et al. 2013). Jung's study showed that even with concentrations of 600 mg/ml,

extract of *Moringa oleifera* showed no cytotoxic effect against a cellular line Cos-7 (Jung 2014).

In a previous study, Khallaf et al. (2020) used *Moringa oleifera* as an irrigant solution during instrumentation and compared it to NaOCl and chlorhexidine regarding its effect on dentin microhardness and its smear layer removal ability. It was confirmed that *Moringa oleifera* when used as an irrigant alone or in combination with chlorhexidine had a similar effect in removal of remaining debris as NaOCl and chlorhexidine. Different formulations of *Moringa oleifera* used in this previous study increased the dentin microhardness all over the canal. They concluded that *Moringa oleifera* is a promising irrigant solution.

Concerning, the evaluation of remnants of the intracanal medicaments in root canals after irrigation, our results showed that in the apical part of root canals, there was significantly higher remnants of Ca(OH)<sub>2</sub> left compared to *Moringa oleifera* leaf and roots. Metapex is oil-based calcium hydroxide paste. According to manufacturers, the main ingredients of Metapex that we used in our study are calcium hydroxide 30.3%, iodoform 40.4%, silicone oil 22.4%, others 6.9%. This mixture can be filled in the root canals using disposable tips, filled with the material. Previous findings suggested that oil-based Ca(OH)<sub>2</sub> pastes were more difficult to remove than Ca(OH)<sub>2</sub> mixed with distilled water (Lambrianidis et al. 1999; Nandini et al. 2006).

No significant difference was found between Ca(OH)<sub>2</sub> and *Moringa oleifera* leaf and root in the coronal part and this may be due to the ease of flushing of intracanal medicament from the coronal part.

In our study, three points microhardness measurements were recorded for the root canal dentin (coronal, middle and apical third). A Mean Vickers hardness number.

(VHN) was calculated for each specimen third (Hasheminia et al. 2009). Dentin microhardness is directly related to tubular density that differs from an area to another on the root dentin surface. Therefore, the current study design followed Pashley et al. (2004), who declared that as the tubular density increases, dentin microhardness decreases.

Vickers microhardness tester was selected for this study as it permits to evaluate surface changes of deeper dental hard tissues. Other hardness tester such as Knoop are only restricted to evaluate the microhardness of only the superficial dentin at 0.1 mm and not advocated for deep dentin (Fuentes et al. 2003).

The decrease in dentin microhardness facilitate root canal instrumentation but it may lead to weakening of the root structure that may end up into fracture of the

endodontically treated tooth (Baghdadi and Hassanein 2004).

The results of our study showed that in total, there was no statistically significant difference in microhardness values between *Moringa oleifera* leaf, *Moringa oleifera* roots and Ca(OH)<sub>2</sub>. This could be explained by the finding that *Moringa oleifera* has a remineralizing effect, as confirmed by Nagib et al. (2016) They also stated that different formulations of *Moringa oleifera* were capable of increasing the dentin microhardness in the three thirds of the canal.

These results are very encouraging to pursue further researches on the properties of this natural product and its effect when used in root canal treatment. The aim of studies in this field is to create new treatments based on natural substances that would lead to a better prognosis.

## Conclusions

*Moringa oleifera* could be removed easily from root canals and had a comparable effect on dentinal root microhardness as the commonly used calcium hydroxide.

## Recommendations

1. Further studies on *Moringa oleifera* as intracanal medicament are required to evaluate long term effect of *Moringa oleifera* on dentin microhardness.
2. More studies are needed on *Moringa oleifera*'s other properties such as its physical stability and its effect on postoperative pain.

## Abbreviations

Ca(OH)<sub>2</sub>: Calcium hydroxide; MO: *Moringa oleifera*; NaOCl: Sodium hypochlorite.

## Acknowledgements

Not applicable.

## Authors' contributions

YA and NO performed the biomechanical preparation of the collected specimen and applied the different types of intracanal medications used in the study. MK and EK prepared the specimen for testing and analyzed the data regarding the hardness test and the evaluation of the remaining debris. YA and MZ were major contributors in writing the manuscript. All authors read and approved the final manuscript.

## Funding

National Research Centre Project 11010208.

## Availability of data and materials

The authors declare that the data supporting the findings of this study are available within the article.

## Ethics approval and consent to participate

Verbal consent. Reason: extracted teeth were collected from faculty of dentistry, Cairo University, where all patients accept that their extracted teeth for orthodontic purpose to be used in research. It was approved by the Ethics

committee (Ethics committee, National Research Centre approval number 16/344),

#### Consent for publication

Not applicable.

#### Competing interests

No competing interests.

Received: 12 November 2020 Accepted: 8 December 2020

Published online: 07 January 2021

#### References

- Andreasen JO, Farik B, Munksgaard EC (2002) Long-term calcium hydroxide as a root canal dressing may increase risk of root fracture. *Dent Traumatol* 18:134–137
- Baghdadi R, Hassanein I (2004) Effect of different irrigants on same mechanical properties of dentin—an attempt to improve fracture strength and micro-hardness of endodontically treated teeth 2004. *Egypt Dent J* 50(199):208
- Barbizam JV, Trope M, Teixeira EC, Tanumaru-Filho M, Teixeira FB (2008) Effect of calcium hydroxide intracanal dressing on the bond strength of a resin-based endodontic sealer. *Braz Dent J* 19:224–227
- Benbelaid F, Khadir A, Abdoune MA, Bendahou M, Muselli A, Costa J (2014) Antimicrobial activity of some essential oils against oral multidrug-resistant *Enterococcus faecalis* in both planktonic and biofilm state. *Asian Pac J Trop Biomed* 4(6):463–472
- Bonsor SJ, Nichol R, Reid TMS, Pearson GJ (2006) Microbiological evaluation of photo-activated disinfection in endodontics (an in vivo study). *Br Dent J* 200:337–341
- Ten Bosch JJ (1992) Demineralization and remineralization evaluation techniques. *Dent Res J* 71:924–928
- BystroEm A, Sundqvist G (1985) The antibacterial action of sodium hypochlorite and EDTA in 60 cases of endodontic therapy. *Int Endod J* 18:35–40
- Calt S, Serper A (1999) Dentinal tubule penetration of root canal sealers after root canal dressing with calcium hydroxide. *J Endod* 25:431–433
- Cochrane S, Parashos P, Burrow MF (2019) Effect on the mechanical properties of human and bovine dentine of intracanal medicaments and irrigants. *Aust Dent J* 64:35–42
- Contardo L, De Luca M, Bevilacqua L, Breschi L, Di Lenarda R (2007) Influence of calcium hydroxide debris on the quality of endodontic apical seal. *Miner Stomatol* 56:509–517
- Ehsani M, Amin Marashi M, Zabih E, Issazadeh M, Khafri S (2013) A comparison between antibacterial activity of propolis and aloe vera on *Enterococcus faecalis* (an in vitro study). *Int J Mol Cell Med* 2(3):110–116
- Freeman BA, Crapo JD (1982) Biology of disease. Free radicals and tissue injury. *Lab Invest* 47:412–424
- Fuentes V, Toledano M, Osorio R (2003) Microhardness of superficial and deep sound human dentin. *J Biomed Mater Res A* 66:8503
- Garcez S, Nunez S, Hamblin M, Ribeiro M (2007) Antimicrobial effects of photodynamic therapy on patients with necrotic pulps and periapical lesion. *Job Open Econ* 34:138–142
- Guneser M, Akbulut M, Eldeniz A (2016) Antibacterial effect of chlorhexidine-cetrimide combination, *Salvia officinalism* plant extract and octenidine in comparison with conventional endodontic irrigants. *Dent Mater J* 35(5):736–741
- Han GY, Park SH, Yoon TC (2001) Antimicrobial activity of Ca(OH)<sub>2</sub> containing pastes with *Enterococcus faecalis* in vitro. *J Endod* 27:328–332
- Hasheminia SM, Norozynasab S, Reziaanfard M (2009) The effect of three different calcium hydroxide combinations on root dentin microhardness. *Res J Biol Sci* 4:121e5
- Jung L (2014) Soluble extract from *Moringa oleifera* leaves with a new anticancer activity. *PLoS ONE* 9(4), Article ID e95492
- Kawashima N, Wadachi R, Suda H, Yeng T, Parashos P (2009) Root canal medicaments. *Int Dent J* 59:5–11
- Khallaf ME, Kataia EM, Aly Y, Omar N, Abdullah Mohamed M (2020) Cleanliness efficacy and effect on dentin microhardness of a novel plant extract/irrigant. *Bull Natl Res Cent* 44:47
- Kim SK, Kim YO (2002) Influence of calcium hydroxide intracanal medication on apical seal. *Int Endod J* 35:623–628
- Lambrianidis T, Margelos J, Beltes P (1999a) Removal efficiency of calcium hydroxide dressing from the root canal. *J Endod* 25:85–88
- Lambrianidis T, Margelos J, Beltes P (1999b) Removal efficiency of calcium hydroxide dressing from the root canal. *J Endod* 25:85–88
- Law A, Messer H (2004) An evidence-based analysis of the antibacterial effectiveness of intracanal medicaments. *J Endod* 30:689–694
- Margelos J, Eliades G, Verdelis C, Palaghias G (1997) Interaction of calcium hydroxide with zinc oxide-eugenol sealers: a potential clinical problem. *J Endod* 23:43–48
- Martin C, Martin G, Garcia A, Fernandez T, Hernandez E, Puls J (2013) Potenciales aplicaciones de *Moringa oleifera*. Una revision critica. *Pastos y Forrajes* 36(2):137–149
- Mistry KS, Sanghvi Z, Parmar G, Shah S (2014) The antimicrobial activity of *Azadirachta indica*, *Mimusops elengi*, *Tinospora cardifolia*, *Ocimum sanctum* and 2% chlorhexidine gluconate on common endodontic pathogens: an in vitro study. *Eur J Dent* 8(2):172–177
- Mohammadi Z, Shalavi S, Yazdizadeh M (2012) Antimicrobial activity of calcium hydroxide in endodontics: a review. *Chonnam Med J* 48:133–140
- Mustafa M, Saujanya KP, Jain D, Sajjanshetty S, Arun A, Uppin L, Kadri M (2012) Role of calcium hydroxide in endodontics: a review. *Glob J Med Public Health* 1:66–70
- Nagib M, Amin L, Khalaf E (2016) Biological effects of topical applications of *Moringa oleifera* extract versus fluoride on uremic patients extracted teeth. *Int J Adv Res* 4(9):1513–1520
- Nandini S, Velmurugan N, Kandaswamy D (2006) Removal efficiency of calcium hydroxide intracanal medicament with two calcium chelators: volumetric analysis using spiral CT, an in vitro study. *J Endod* 32:1097–1101
- Olson M, Fahey W (2011) *Moringa oleifera*: un 'arbol multiusos para las zonas tropicales secas. *Rev Mex Biodiv* 82(4):1071–1082
- Panighi M, G'Sell CJ (1992) Influence of calcium concentration on the dentin wet-ability by an adhesive. *Biomed Mater Res J* 26:1081–1089
- Pashley DH, Tay FR, Yiu C, Mashimoto M (2004) Collagen degradation by host derived enzymes during aging. *J Dent Res* 83:21621
- Ramezani F, Samimi S, Kharazifard M, Afkhami F (2016) The in vitro antibacterial efficacy of persian green tea extract as an intracanal irrigant on *Enterococcus faecalis* biofilm. *Iran Endod J* 11(4):304–308
- Shetty B, Vijay S, Shetty S, Bhandary S (2019) Assessment of antimicrobial activity of *Moringa oleifera* and *Azadirachta indica* leaves against *Enterococcus faecalis*, *Candida albicans*—an invitro study. *Int J Adv Res* 7(7):742–748
- Siqueira JF Jr, Guimaraes-Pinto T, Rocas IN (2007) Effects of chemomechanical preparation with 25% sodium hypochlorite and intracanal medication with calcium hydroxide on cultivable bacteria in infected root canals. *J Endod* 33:800–805
- Siqueira JF Jr, Lopes HP (1999) Mechanisms of antimicrobial activity of calcium hydroxide: a critical review. *Int Endod J* 32:361–369
- Siqueira JF, Rocas IN, Lopes HP, de Uzeda M (1999) Coronal leakage of two root canal sealers containing calcium hydroxide after exposure to human saliva. *J Endod* 25:14–16
- Siqueira JF, Rocas IN, Magalhaes FA, Uzeda M (2001) Antifungal effects of endodontic medicaments. *Aust Endod J* 27:112–114
- Siquiera J, Roças I (2008) Clinical implications and micro-biology of bacterial persistence after treatment procedures. *J Endod* 34(11):1291.e3-1301.e3
- Torres V, Castro A (2014) Fitoterapia. *Rev Actualizaci Clin Med* 42(2):2185–2129
- Yassen G, Vail M, Chu T, Platt J (2013) The effect of medicaments used in endodontic regeneration on root fracture and microhardness of radicular dentine. *Int Endod J* 46:688–695
- Zan R, Alacam T, Hubbezoglu I, Tunc T, Sumer Z, Alici O (2016) Antibacterial efficacy of super-oxidized water on *Enterococcus faecalis* biofilms in root canal. *Jundishapur. J Microbiol* 9(9):e30000
- Zand V, Lofti M, Soroush MH, Abdollahi A, Sadeghi M, Mojadadi A (2016) Antibacterial efficacy of different concentrations of sodium hypochlorite gel and solution on *Enterococcus faecalis* biofilm. *Iran Endod J* 11(4):315–319
- Zarei M, Afkhami F, Malek Z (2013) Poor fracture resistance of human root dentin exposed to calcium hydroxide intervisit medication at various time periods: an in vitro study. *Dent Traumatol* 29:156–160

#### Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.