Evaluation of Antibacterial Effects of Ginger Extract When Used as One Component of the Root Canal Sealers; (An in vitro Study)

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Abstract:
The present study aimed to evaluate the antimicrobial properties of aqueous ginger extract as endodontic sealer, against Staphylococcus aureus, Enterococcus faecalis, Streptococcus sanguis, Candida albicans, anaerobic bacteria and normal flora of oral cavity, and to evaluate the most effective dilution of ginger extract against Enterococcus faecalis in dentinal tubules in order to use it as one component of root canal sealer. Disc diffusion test and direct contact method were used to evaluate the antimicrobial properties of the aqueous ginger extract. The antimicrobial activity was tested 1, 3 and 30 days after dentinal tubules manipulation using different dentin sealer. The Results showed that the highest antimicrobial activity was exhibited by the 20% (w/v) aqueous ginger extract. Moreover, this ginger extract (20%) showed a remarkable antibacterial activity against Enterococcus faecalis in infected dentinal tubules when examined in vitro; the study indicates that ginger extract might have promising effect to be use as one component of root canal sealer.
Introduction

Root canal therapy was mainly used to prevent and treat periradicular inflammation by the elimination of microorganisms from the root canal system, which includes instrumentation, antimicrobial irrigation, intracanal dressing, and adequate filling with coronal restoration. (1, 2, 3) The success of endodontic treatments depend on elimination of bacteria and their substrate from the root canal system so the antimicrobial activity plays an important role in the efficacy of an endodontic sealer used during root canal filling, and for this reason many studies have dealt with the antibacterial activity of endodontic sealers (3-7). Facultative microorganisms such as Enterococcus faecalis and Staphylococcus aureus and even Candida albicans have been considered to be the most resistant species in the oral cavity and possible cause of root canal treatment failure (8,9), especially Enterococcus faecalis which had been a common isolated from infected root canals, its well recognized as a pathogen associated with persistent apical – periodontitis in endodontically treated teeth and highly prevalent in failed root filled teeth (9). The safety and lower side effects of many herbal extracts have suggested them as sources of new pharmaceutical preparations. (10-13) History of ginger and its applications were well documented, ginger (Zingiber officinale, F. Zingiberaceae) has been listed as “Generally Recognized as Safe“(GRAS) document in FDA. A dose of 0.5 – 1.0 gram of ginger powder ingested 2 – 3 time for periods, ranging from 3 months to 2,5 years did not cause any adverse effect(7). Many studies found that rhizom of ginger has strong antibacterial effects and to some extent antifungal properties. (14, 15, 16) The ginger extract has antimicrobial action at levels equivalent to 2000 mg/ ml of the spices. (17) The active constituents of ginger inhibit multiplication of bacterial colonies like Escherichia coli, Proteus spp., Staphylococci, Streptococci and Salmonella. (19 - 20) Ginger extract inhibits Aspergillus, a fungus known for production of Aflatoxin (carcinogen). (6,21) Also fresh ginger juice showed inhibitory action against A. Niger, S. Cerevisia, Mycoderma spp. and L. Acidophilus at 4, 10, 12 and 14 % respectively at ambient temperature(7). Enterococcus faecalis is an opportunistic, facultative anaerobic. It is well recognized as pathogen associated with persistent apical periodontitis in endodontically treatment teeth and is highly prevalent in failed root filled teeth. (1, 5,9) Many studies have been directed towards finding an effective way to eradicate and/or prevent E. faecalis from gaining access to the root canal space. E. faecalis can gain entry into the root canal system during treatment, between appointments, or even after the treatment has been completed (7). Therefore, it is important to consider treatment regimens aimed at eliminating or preventing the infection of E. faecalis during each of these phases. The need for root canal sealer with antibacterial action is required to maximize the disinfection, especially in those cases where an infection is resistant to regular treatment and therapy can’t be successfully completed due to the presence of pain or continuing exudates (2,5). Thus, the aim of this study was to analyze in vitro antimicrobial activity of aqueous ginger extract on different microorganisms at different time intervals after manipulation in infected dentinal tubules.

Materials & Methods

This study was conducted in College of Dentistry, University of Mosul in two parts. The first part was in vitro evaluation of the antimicrobial properties of different concentrations of aqueous ginger extracts. The most effective concentration was choosing to be implemented in the second
part, which includes the evaluation the antimicrobial activity of this concentrations against E. faecalis in dentinal tubules in an ex vivo samples.

Preparation of aqueous ginger extracts
Two types of ginger powder were used; First one was purchased from the local market and the second was a commercially available powder (Ginger/ UAE). The aqueous extract was prepared using cold extraction techniques. Forty grams of ginger powder were placed in 160 ml of sterile distilled water and left at room temperature for 24 hrs with continuous mixing using magnetic stirrer. Then mixture was filtered and after filtration it was dried using incubator at 40°C. The liquid has evaporated, and the precipitated extract was left at the base of the baker. Five ml of distill water (D.W.) was added to 1 gram of this extract powder to produce 20% (w/v) as standard stock solution. Serial dilutions were prepared from this stock solution (10%, 5%, 2.5%, 1.25%, 0.625%, and 0.313% (w/v)).

Antimicrobial susceptibility test
Disc diffusion method were used filter to study the antimicrobial activity of different concentrations of aqueous ginger extract on Staphylococcus aureus, Streptococcus sanguis, Escherichia coli, anaerobic bacteria, normal flora of mouth and Candida albicans. After the incubation period, the diameters of the zones of inhibition were measured and all the data were expressed in mm.

Preparation of pastes
Depending on the results of the antimicrobial inhibition zone, the 20% ginger solution gives the widest inhibition zone and this concentration was selected to be used in this part of the study. The pastes were prepared daily by mixing 10 ml of aqueous ginger extracts (20%) with 0.2 gm of orabase. Orabase gel and Zinc Oxide Eugenol ( ZOE) to be used as a control group.

Assessment of antibacterial efficacy of ginger paste in dental tubules:
One hundred twenty freshly extracted teeth with single canal extracted (for different reasons) obtained from Department of Surgery, College of Dentistry, University of Mosul and private clinics to be used in this part of the study. The crowns were removed at the cement-enamel junction. The root canal of the teeth were instrumented. Same procedures were done to the apical one third of the canal section. In the coronal and apical section of the root specimens, small cavities were prepared (2.5 mm diameter and 1.5 mm in the depth) in order to leave some space for composite filling and temporary filling. Apical cavities closed by means of composite resin to prevent bacterial leakage, the root specimens then were sterilized by autoclave for 30 min at 121°C. Each tooth was transferred to brain heart infusion broth (BHI) and incubated for 24 hrs at 37°C as a test for sterility. These teeth were transferred to 2 ml sterile physiological saline (SPS) (Physio – Denta/ Syria) in individual tubes for wash out BHI and to avoid dehydration and contamination. They were then incubated for another 24 hrs at 37°C, following incubation in SPS. Each tooth was removed from SPS and root canals were carefully dried with sterile paper points under a septic condition. The root specimens glued upright in Petri dishes using a quick setting steel epoxy resin (Eaglestar/ USA), then inoculated with a standard volume of 10 µl (10 cfu) of Enterococcus faecalis suspension and incubated at 37°C for 24 hrs. All specimens were divided randomly into 3 groups (n =40), for evaluation of antibacterial efficacy of each material in a time dependent method.
(1, 3 and 30 days)\(^{2,3,25,26}\). Then each group where subdivided in to four subgroups with ten teeth in each subgroup. The first subgroup teeth were filled completely with ginger paste (20%), while the second and the third subgroups were treated with ZOE and orabase respectively and the last subgroup were left untreated. In the first group, the materials were left in the canal for one day by sealing the orifice with temporary filling material, the treated and untreated teeth were stored in SPS for 24 hrs at 37°C after treatment, the cotton pledgets and paste of ginger and orabase were removed from the canals. Subsequently, root canals were dried with sterile absorbents paper points. The dentin chips were obtained using a special penetration drill (Co 213/208 Dentsply Suiss/France) they were collected on to separated sterile Petri dishes. The dentin chips of the teeth were diluted in 5 ml of BHI, 10 ml of this pipette out and poured onto blood agar plates. They were incubated for 24 hrs at 37°C and colony forming unit were enumerated. \(^{2, 3, 25, 26}\) For the second and third groups (II, III): the teeth were treated in the same manner as previously described. All teeth were stored in SPS for three and thirty days respectively and the second bacteriologic samples were taken in the same manner as mention before \(^{22, 23}\).

The mean and standard deviation for bacterial counts of each group at different time intervals were calculated. The analysis of variance at level of significance (0.05 – 0.01) was performed through utilizing one way analysis of variance.

**Results**

The results in (Table 1) showed that the ginger extracts were effective against all types of microorganisms used in this study, and the (20%) concentration had the best antimicrobial effect among the different dilutions of aqueous ginger extract of with the zone of inhibition range from 25- 35 mm and 20- 30 mm for UAE and Iraqi powder respectively (figure 1and 2).

### Table 1:- Antimicrobial activity of aqueous ginger extract using disc diffusion test.

<table>
<thead>
<tr>
<th>Types of Solution</th>
<th>Concentration %</th>
<th>Staph.</th>
<th>Strep.</th>
<th>E. coli</th>
<th>N. flora</th>
<th>Anaerobic bact.</th>
<th>Candida</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iraqi Ginger extract</td>
<td>20</td>
<td>20</td>
<td>26</td>
<td>30</td>
<td>30</td>
<td>20</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>10</td>
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<td>5</td>
<td>15</td>
<td>22</td>
<td>20</td>
<td>--------</td>
<td>16</td>
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</tr>
<tr>
<td></td>
<td>2.5</td>
<td>14</td>
<td>22</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>1.25</td>
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<tr>
<td></td>
<td>0.625</td>
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<td>--------</td>
</tr>
<tr>
<td></td>
<td>0.3125</td>
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<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
</tr>
<tr>
<td>UAE Ginger extract</td>
<td>20</td>
<td>35</td>
<td>26</td>
<td>25</td>
<td>25</td>
<td>35</td>
<td>35</td>
</tr>
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<td></td>
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<td>18</td>
<td>20</td>
<td>20</td>
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<td>20</td>
</tr>
<tr>
<td></td>
<td>2.5</td>
<td>25</td>
<td>--------</td>
<td>20</td>
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<td>18</td>
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</tr>
<tr>
<td></td>
<td>1.25</td>
<td>--------</td>
<td>--------</td>
<td>14</td>
<td>--------</td>
<td>17</td>
<td>--------</td>
</tr>
<tr>
<td></td>
<td>0.625</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>0.3125 %</td>
<td>--------</td>
<td>--------</td>
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</tr>
</tbody>
</table>

*Data are mean of two replication.
*---No inhibition was observed.
The antibacterial effect of the ZOE and ginger sealer against *E. faecalis* was significantly higher than orabase or untreated groups at different time intervals, ginger extract and ZOE sealer showed the highest inhibition at 30 days which was statistically significant (P< 0.05) but there were no significant differences in between them at these time intervals as shown in Tables (2 and 3) and Figure (3). Ginger paste give negative growth in 8 specimens and positive growth in 2 specimens only while ZOE (sealer) show negative growth in 7 specimens and positive growth in 3
specimens. Also the result reveal that the bacterial counts at each time interval for untreated specimens were significantly not different from the specimens that treated with orabase, which indicates that orabase use in this study have no antibacterial effect at these time intervals.

**Table (2):- Comparison for the antibacterial effect of 20% ginger and ZOE sealer against Enterococcus faecalis at different time intervals:**

<table>
<thead>
<tr>
<th>Groups</th>
<th>Time interval</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 day</td>
</tr>
<tr>
<td>Untreated</td>
<td>109.2 ± 14.6  (A)</td>
</tr>
<tr>
<td>Orabase</td>
<td>110.0 ± 13.3  (A)</td>
</tr>
<tr>
<td>ZOE sealer</td>
<td>64.6 ± 34.5   (B)</td>
</tr>
<tr>
<td>20% Ginger</td>
<td>66.6 ± 37.8   (B)</td>
</tr>
</tbody>
</table>

*Data represents mean ± SD of bacterial count
*The different letters horizontally mean significant difference exist P<0.05.

**Table (3):- Comparison between the antibacterial effect of different sealer against Enterococcus faecalis during study periods.**

<table>
<thead>
<tr>
<th>Time interval</th>
<th>untreated</th>
<th>Orabase</th>
<th>ZOE sealer</th>
<th>20% Ginger</th>
</tr>
</thead>
<tbody>
<tr>
<td>1day</td>
<td>109.2 ± 14.6  (C)</td>
<td>110.0 ± 13.3 (C)</td>
<td>64.6 ± 34.5  (A)</td>
<td>66.6 ± 37.8  (A)</td>
</tr>
<tr>
<td>3days</td>
<td>158.0 ± 25.7  (B)</td>
<td>146.8± 28.5  (B)</td>
<td>6.70 ± 2.75  (A)</td>
<td>5.90 ± 2.7   (A)</td>
</tr>
<tr>
<td>30days</td>
<td>198.0 ± 8.1   (C)</td>
<td>190.5 ± 13.9 (C)</td>
<td>3.0 ± 5.1    (A)</td>
<td>2.0 ± 0.4    (A)</td>
</tr>
</tbody>
</table>

*Data represents mean ± SD of bacterial count.
*The different letters horizontally mean significant difference exist P<0.05.

**Figure (3):- Effect of Orabase, ZOE sealer and 20% Ginger on the bacterial counts after 1 day, 3 days and 30 days.**

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**Discussion**

The main goal of successful root canal therapy is to eliminate bacteria and microorganisms from root canal system and to prevent subsequent reinfection.\(^1,2,9\) Three-dimensional sealing of the root canal system is another goal of endodontic treatment and is essential for preventing canal re-infection and the maintenance of healthy periapical tissue\(^7,8\). The agar diffusion method has been widely used to test the antimicrobial activity of dental materials and medications.\(^3,5\) The advantage of this method is that it allows direct comparisons of root canal sealers against the test microorganisms, indicating which compound has the potential to eliminate bacteria in the local microenvironment of the root canal system. According to our results, 20% ginger extract produced the largest inhibitory zones of the microbial growth against all microorganisms studied in all times after manipulation. All sealers tested demonstrated a higher antimicrobial value in the first 24 h after manipulation, while the antimicrobials effect were prolonged up to 30 days, especially knowing that microorganisms can remain in the ramifications of the root canal system after chemo mechanical preparation and intracanal dressing.\(^1,7,9\) This is in agreement with many studies which found that ZOE based sealer, has been shown to exhibit the greatest antimicrobial activity against *E. faecalis* when compared to other sealers.\(^1,2,5\) *E. faecalis* possesses certain virulence factors including lytic enzymes, cytolsin, aggregation substance, pheromones, and lipoteichoic acid.\(^7\) It has been shown to adhere to host cells, express proteins that allow it to compete with other bacterial cells, and alter host responses.\(^7,9\)

Based on the statically differences among the root canal filling materials evaluated in this study, 20% ginger extract produced the largest inhibitory zones of the microbial growth against all microorganisms studied in all times after manipulation which was equal to the ZOE antimicrobial activity, and this is in agreement with many studies which found that ginger has strong antibacterial and to some extent antifungal properties.\(^14,15,22,23\) Roder (2004) results indicate that ginger had antibacterial effect on *E. faecalis* but not on *E. coli*. In vitro studies have shown that active constituents of ginger inhibit multiplication of bacteria.\(^11,12\) Ginger rhizome contain, the pungent substances namely gingerol, shogoal, zingerone, paradol and volatile oil. The volatile oil consists of mainly mono and sesquiterpenes; camphene, beta-phellandrene, curcumene, cineole, geranyl acetate, terpineol, terpenes, borneol, geraniol, limonene, linalool, alpha-zingiberene (30-70%), beta-sesquiphellandrene (15-20%), beta-bisabolene (10-15%) and alpha-farnesene, in addition to the oleoresin zingiberol, the principal aroma contributing component as well as zingiberene, gingediol, diarylheptanoids and phytosterols.\(^17,18\) The most effective antimicrobial constituent was found to be citral. In another advance, it was shown that ethanol extracts of ginger were able to inhibit growth of both gram-negative and gram-positive bacteria, although the inhibitory effect was more pronounced for gram-positive bacteria.\(^28\) Bactericidal activity against the highly resistant gram-negative bacteria *Pseudomonas aeruginosa* was notable also.\(^29\) Though research is still needed, our preliminary study showed that ginger preparation has good antimicrobial against *E. faecalis*. A well-
sealed coronal restoration and root canal filling are important steps in preventing bacteria from entering the canal space and provides steps that can be used to eliminate *E. faecalis* during endodontic retreatment. From the results of the present study we can conclude that 20% aqueous ginger extract can be used as one component of endodontic sealer to inhibit bacterial growth as effective antibacterial agent.

**References**


