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Original Article

THE EFFECT OF ADDITION 5% PROPOLIS NANOPARTICLES IN EPOXY RESIN AND BIOCERAMIC SEALERS ON THE GROWTH OF *ENTEROCOCCUS FAECALIS* ATCC 29212 AND THE DENTINAL TUBULAR PENETRATION: *IN VITRO*

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ABSTRACT

Objective: The goal of endodontic treatment is to eliminate bacteria and their products from the root canal. Bacteria are the main etiological factors of pulpal and periapical diseases. Chemomechanical preparation and administration of root canal medicaments cannot completely eliminate bacteria in the root canal system, especially *Enterococcus faecalis,* which have high resistancy, therefore, an ideal obturation material is required. Adequate root canal filling quality affects the success of endodontic treatment. The aim of this study was to observe the effect of addition 5% propolis nanoparticles to the commercial epoxy resin and the bioceramic sealer on the growth of *E. faecalis* ATCC 29212 and the dentinal tubular penetration.

Methods: Thirty-five tooth samples were randomly divided into 5 groups. Root canal preparation was carried out with the same working length of 14 mm by cutting the tooth at the Cementoenamel Junction (CEJ); sample was inoculated with *E. faecalis* ATCC 29212 for 48 h. Obturation used four types of sealer, Group I (epoxy resin with 5% propolis nanoparticles), Group II (bioceramic with 5% propolis nanoparticles), Group III (bioceramic) and Group IV (epoxy resin). Data were analyzed using the Kruskal wallis test with a significant level of $p<0.05$.

Results: In the bacterial growth test, there was a significant difference in the number of bacterial colonies between the epoxy resin groups with 5% propolis nanoparticles, bioceramic with 5% of propolis nanoparticles, bioceramic and epoxy resin ($p = 0.000<0.05$). In the dentinal tubular penetration there was a significant difference between epoxy resin with 5% of propolis nanoparticles, bioceramic sealer with 5% propolis nanoparticles, bioceramic, and epoxy resin ($p = 0.001<0.05$).

Conclusion: The addition of 5% propolis nanoparticles to commercial bioceramic and epoxy resin sealers can eliminate *E. faecalis* bacteria in the root canals and increase dentinal tubular penetration. Bioceramic sealer has a higher antibacterial effect and dentinal tubular penetration compared to epoxy resin.

Keywords: Propolis nanoparticles, Sealer, Bioceramic, Epoxy resin, *E. faecalis*, Dentinal tubular penetration

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INTRODUCTION

Endodontic treatment aims to eliminate bacteria and their products from the root canal, bacteria are the main etiological factors of pulpal and periapical diseases [1]. Root canal filling aims to prevent bacterial infection and reinfection into the root canal system and periradicular tissue. Adhesion and penetration of the sealer into the dentinal tubules is an important factor in the success for endodontic treatment [2, 3]. Chemomechanical preparations and root canal medicaments cannot completely eliminate all microbes in the root canal system, especially *E. faecalis* which have high resistancy, therefore it is important to use sealer that has an antibacterial effect [4, 5].

Enterococcus faecalis represents the most resistant bacterial species and causes failure of the endodontic treatment which is around 24%-77% as a cause of endodontic infection and failure of endodontic treatment [6]. *E. faecalis* can entery the dentinal tubules and bind to collagen in survive extreme conditions [7, 8]. The resistancy of *E. faecalis* in the root canals is influenced by its ability to survive in an extreme environment such as temperature of 10 °C-45 °C, pH 9.6 and is supported by its virulence factor, which survive without supply of nutrients, lytic enzymes, cytolysin, pheromone aggregation substances, lipoteichoic acid and resistancy to the root canal medicaments [7].

Endodontic sealers must be able to have antibacterial properties, good adhesion and dentinal tubular penetration. Various natural ingredients with therapeutic properties have been tried as endodontic sealers such as propolis. Natural substance that has been known to have good antibacterial, anti-inflammatory and antioxidant properties. Propolis consist of resinous substances which can increase the sealing ability and viscosity of endodontic sealers which can be applied clinically. Propolis has biologically active components of flavonoids, polyphenols and cinnamic acid derivatives [9–11].

Raheem *et al.*, (2019) reported that propolis nanoparticle-based sealers had a higher antimicrobial effect compared to other types of sealers due to the content of flavonoids [12]. In addition, it was reported that propolis nanoparticles could increase the dentinal tubular penetration [10, 13]. Combining propolis nanoparticles with an endodontic sealer can increase the contact surface area between dentine in the root canal and obturation material. The effect of addition nanoparticle material to endodontic sealers causes the increase of surface contact area with higher antimicrobial effect compared to macro-sized materials [13].

There are several types of commercial endodontic sealers use in clinical. Based on its components, endodontic sealers can be categorized into zinc oxide-eugenol, calcium hydroxide, glass ionomer, silica, epoxy resin and bioceramic. The use of bioceramic and epoxy resin in this study based on their good physical properties. The addition of natural ingredients such as propolis nanoparticles to the endodontic sealer material is expected to increase the antibacterial effect against *E. faecalis* and increase the ability of the dentinal tubular penetration.

The aim of this study was to observe the effect of addition 5% propolis nanoparticles to the commercial epoxy resin and the bioceramic sealer on the growth of *E. faecalis* ATCC 29212 and the dentinal tubular penetration.

MATERIALS AND METHODS

Methods

The main ingredient in this research is propolis nanoparticles marketed by PT. Natural Nusantara (POM RI) number POM TR. 173 600121. The preparation of Epoxy Resin with 5% propolis

nanoparticles made by adding 5% liquid propolis nanoparticles with an epoxy resin (Adseal, Metabiomed) at ratio of 1:0.05, mixed the mixing slab until homogene. The preparation of bioceramic with 5% liquid propolis nanoparticles made by adding 5% liquid propolis nanoparticles with bioceramic (Ceraseal, Metabiomed) at a ratio of 1:0.05, mixed the mixing slab until homogene.

Test the characterization of modified sealer materials

Density test

The tool used is a pycnometer; the pycnometer is cleaned and dried. The empty pycnometer then weighed and the weight recorded. Enter the sample slowly until the volume is half of the pycnometer cervix. Close the pycnometer and make sure that no bubbles form. The pycnometer that has been filled with the sample then weighed, the resulting mass is the weight of the sample plus the pycnometer.

Viscosity of the sealer material test

The tool used is a viscometer. Spindle number 2 used, which is dipped into the sealer preparation until the spindle is submerged. Results can be observed on the viscometer screen. The constant value that appears on the screen is read on the dPas scale.

Fourier transform infrared (FTIR) test

Structural characterization was carried out using an FTIR 780 spectrophotometer (PG Instruments, Leicestershire, UK) and the KBr technique, operating in the 400–4000 cm^{-1} range, with a scan speed of 32 cm^{-1} and a spectral width of 2.0 cm^{-1}. For this purpose, after setting time/hardening, the specimens were ground/grinded using a dental milling machine (Benco Dental, Pittston, PA, USA) to obtain a fine powder suitable for making KBr pellets and then the FTIR spectrum of the sealer material was recorded.

***In vitro* research**

Enterococcus faecalis culture

In this study, the Kranz method was used [14], the Gram-positive bacterial species *E. faecalis* (ATCC 29212) was used. The strain was grown under standard anaerobic conditions (80% N2, 10% CO2 and 10% H2) in 10 ml nutrient broth medium (Oxoid Ltd., Hampshire, UK) for 24 h. Then vortex one minute. For inoculation, a bacterial suspension was prepared in nutrient broth media (OD 546 nm 0.5 Mac Farland, which corresponds to 108 CFU/ml) [14].

Root canal preparation

In this study, 35 mandibular premolars were used which had been approved by the Health Research Ethics Commission (KEPK) University of North Sumatra, Indonesia No: 1165/KEP/USU/2021. Tooth samples were obtained from the dentist's practice which were extracted for orthodontic treatment purposes with the following inclusion criteria: (1) the roots of the teeth were intact, (2) the teeth had one root and one root canal, (3) the roots were relatively straight, (4) there is no caries on the root, (5) the apex of the tooth is completely closed. The tooth samples were then cleaned with an ultrasonic scaller and divided into five groups randomly and then stored in saline, 0.9% NaCl solution (OneMed, Indonesia) at room temperature.

Each sample was cut with a carborundum disc at the cementoenamel junction (CEJ) to obtain the same working length of 14 mm. Access preparation was carried out with an endo access bur; then glide path was carried out with K file #10, determining the working length by subtracting 1 mm from the root canal length. Irrigation with 5% sodium hypochlorite solution (OneMed, Indonesia) with a 30G one-side-vented irrigation needle. Root canal preparation using crown down technique with resiproct blue file 25.06 (Fanta) according to the working length. Final irrigation of the root canal with 2 ml of 5% sodium hypochlorite (OneMed, Indonesia) and activation with sonic Eddy (VDW), then saline and 17% ethylene diamine tetra acetic acid (EDTA) solution, leave for one minute, then irrigate with 2 ml of saline (OneMed, Indonesia).

Root canal inoculation with *E. faecalis*

Prior to inoculation, all root canals were irrigated with 2 ml of Calcinase (Lege artis pharma GmbH and Co KG, Dettenhausen, Germany) for 180 seconds, then irrigated with 3 ml of distilled water. Tooth samples were then autoclaved in a moist state for 20 min at 121 °C. After sterilization, all root canals were inoculated with 100 µl of *E. faecalis* ATCC 29212 suspension (OD 546 nm 0.5) for 48 h under standard anaerobic conditions (80% N2, 10% CO2, and 10% H2). To avoid sample drying, all specimens were moistened with nutrient broth after 24 h of incubation. Bacterial growth was confirmed by characteristic culture using blood agar; bacterial colonies were identified using an automatic identification machine (Vitec 2 Compact), the growing bacteria was confirmed as *E. faecalis*.

Obturation

All tools and materials must be sterilized, glassware wrapped in aluminum foil and put in an autoclave at 121 °C for 15 min, consumables sterilized with UV light. Root canal preparation was carried out with a reciproct file (Fanta) #40.06 according to the working length, then irrigated with a sterile distillate water solution (OneMed, Indonesia) by agitation technique using sonic Eddy (VDW) for 10 seconds and dried with paper points. Obturation was carried out with a single cone technique and different sealer materials according to the sample group. Group I was obturated with epoxy resin with the addition of 5% propolis nanoparticles, group II was obturated with bioceramic with the addition of 5% propolis nanoparticles, group III was obturated with bioceramic and group IV was with epoxy resin and group V was the control group, teeth were not performed root canal filling. After obturation the apex and coronal were closed with RMGIC (Nova) and light curing, then the samples were stored in incubator at 37 °C with 100% humidity for eight days to thoroughly set the sealer.

After eight days of sealer hardening, the apex of the tooth was cut with a sterile carborundum disk into two sections, 5 mm apical and 9 mm in the middle in sterile conditions in a sterile glass cabinet room to avoid bacterial contamination.

Bacterial growth test of *E. faecalis*

The median 9 mm long section of the tooth sample was used to test for bacterial growth. Gutta-percha in the root canal was removed with a sterile peeso reamer size 2 (ISO size 90) and 3 (ISO size 110), then the dentinal shaving from the root canal was carried out with peeso reamer size 4 (ISO size 130) until 5 (ISO size 150) then the dentinal shavings were collected with the help of a sterile microbrush and put into a 50 ml sterile pot containing 1 ml of normal saline solution (OneMed, Indonesia). Dentin debris remaining in the root canal was rinsed with 3 ml of saline. Then vortexed, serial dilutions up to 10^6 were adjusted and aliquots (100 µl) plated into blood agar (Konakion MM 10 mg). After that, all plates were cultured anaerobically for 24 h and the number of bacterial colonies in CFU/ml was counted.

Dentinal tubular penetration test

The apex of the tooth measuring 5 mm, which had been cut horizontally from all samples, was embedded in a self-curing acrylic to facilitate SEM procedure. SEM acquisition was carried out with 1800x of magnification. Furthermore, the depth of penetration sealer into the dentinal tubules was measured using Image-J software (National Institute of Health). The measurement is start from the boundary of the root canal wall to the direction where the sealer has penetrated; the sealer is marked in the white area.

Data analysis

Data were analyzed using the Kruskal-Wallis test with a significant level of $p<0.05$.

RESULTS

Density test results

The density value of bioceramic with the addition of 5% propolis nanoparticles was higher (0.9664 g/ml) compared to commercial bioceramic (0.9513 g/ml) and epoxy resin with the addition of 5% propolis nanoparticles was higher (0.9528 g/ml) compared to commercial epoxy resin (0.9492 g/ml).

Table 1: Sealer density test results

No.	Sample	Empty pycnometer weight average	Weight of pycnometer+sample (PI)	Pycnometer weight+Average sample	Pycnometer volume	ρ (density)
		(g)	(g)	(g)	(ml)	(g/ml)
1	*bioceramics*+5 % propolis nanoparticles	11.9987	16.8306	16.8306	5	0.9664
2	*Bioceramics*	11.9987	16.7551	16.7551	5	0.9513
3	*epoxy resins*+5% ropolis nanoparticles	11.9987	16.7627	16.7627	5	0.9528
4	*epoxy resins*	11.9987	16.7448	16.7448	5	0.9492

Table 2: Sealer viscosity test results

No.	Sample	Distilled water(s)	Sample (s)	ρ distilled water	P (density) of the sample	μ (viscosity) of distilled water	μ (viscosity) of the sample	μ sample mean
				(g/ml)	(g/ml)	cp	cp	cp
1	*bioceramics*+5% propolis nanoparticle	10.94	10.3	0.9661	0.9664	0.8183	0.7684	0.7657
	bioceramics+5% propolis nanoparticle	10.94	10.3	0.9661	0.9664	0.8183	0.7722	
	bioceramics+5% propolis nanoparticle	10.94	10.1	0.9661	0.9664	0.8183	0.7565	
2	*bioceramics*	10.94	10.1	0.9661	0.9513	0.8183	0.7439	0.7412
	bioceramics	10.94	10.0	0.9661	0.9513	0.8183	0.7387	
	bioceramics	10.94	10.1	0.9661	0.9513	0.8183	0.7409	
3	*epoxy resins*	10.94	10.1	0.9661	0.9528	0.8183	0.7436	0.7434
	epoxy resins	10.94	10.0	0.9661	0.9528	0.8183	0.7399	
	epoxy resins	10.94	10.1	0.9661	0.9528	0.8183	0.7466	
4	*epoxy resins*+5% propolis nanoparticle	10.94	10.2	0.9661	0.9492	0.8183	0.7504	0.7477
	epoxy resins+5% propolis nanoparticle	10.94	10.2	0.9661	0.9492	0.8183	0.7474	
	epoxy resins+5% propolis nanoparticle	10.94	10.1	0.9661	0.9492	0.8183	0.7452	

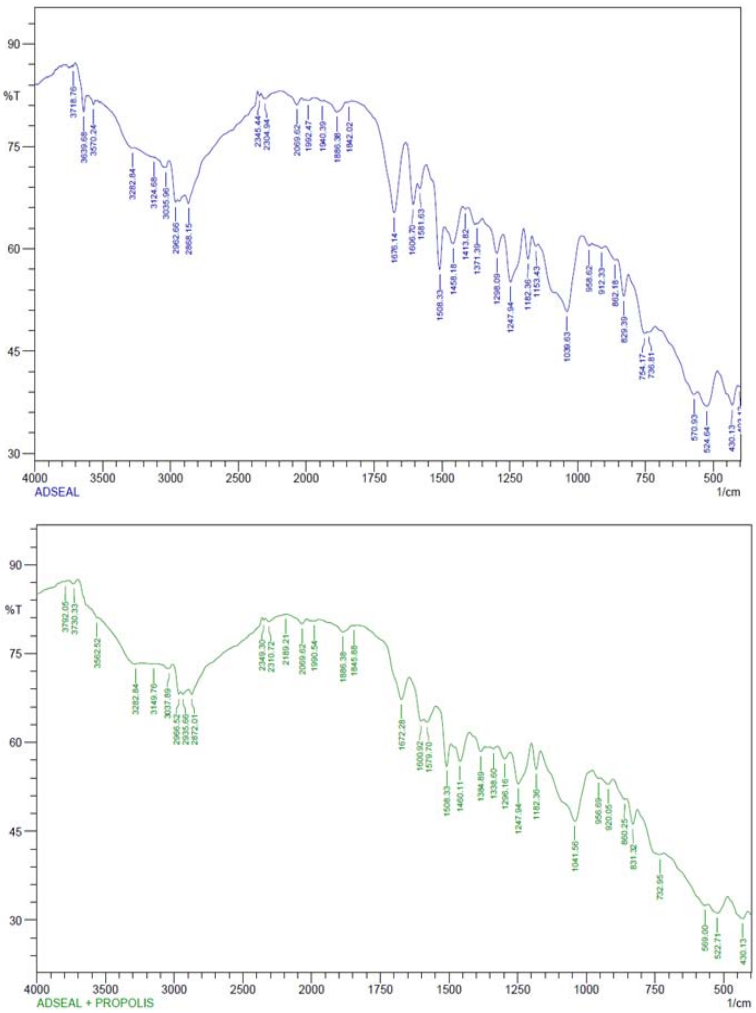

Fig. 1: The FTIR spectrum of the basic ingredients of epoxy resin and epoxy resin with the addition of 5% propolis nanoparticles

Viscosity test results

Viscosity value of bioceramic sealer with the addition of 5% propolis nanoparticles was higher (0.7657 cp) compared to commercial bioceramic sealer (0.7412 cp). The viscosity value of epoxy resin with the addition of 5% propolis nanoparticles was higher (0.7477 cp) compared to commercial epoxy resin sealers (0.7434 cp) (table 2). The addition of 5% propolis nanoparticles to a commercial sealer increases its viscosity.

FTIR test results for sealer materials

The FTIR spectrum of the basic ingredients of epoxy resin and epoxy resin with the addition of 5% propolis nanoparticles, there was no significant difference in IR absorption. The addition of new peaks at 3,792 cm^{-1} and 3,718 peaks shifted slightly to 3,730 cm^{-1}; several peaks that appeared after the addition of propolis were 2,966, 2,189 and 1,338 $cm^{-1,}$ while one peak disappeared after adding propolis at 754 cm^{-1}. The addition of 5% propolis nanoparticles did not show any changes in chemical structure.

Furthermore, IR absorption for bioceramic sealer and bioceramic sealer combination with the addition of 5% propolis nanoparticles generally showed no significant change in absorption, especially the main functional groups such as OH and CH. After the addition of propolis, there were only 3 spectral peaks that increased, namely at a frequency of 2,382 cm^{-1} and two frequencies in the 503 and 430 cm^{-1} areas. The addition of 5% propolis nanoparticles did not show any changes in chemical structure.

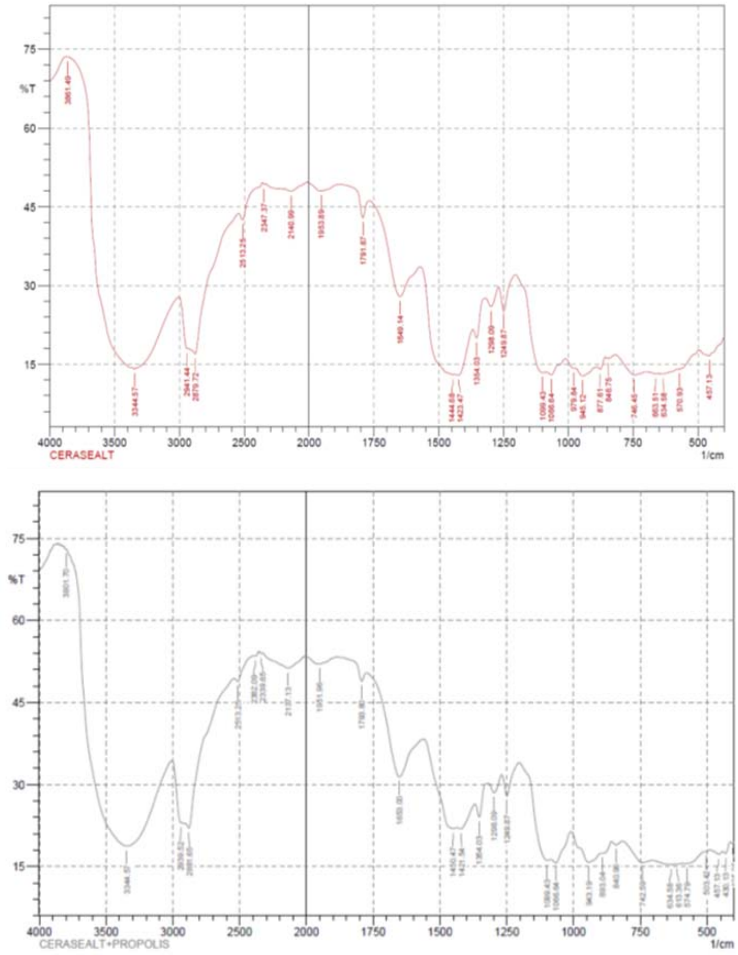

Fig. 2: IR absorption spectrum for bioceramic and bioceramic combination with the addition of 5% propolis nanoparticles

Results of *E. faecalis* growth test

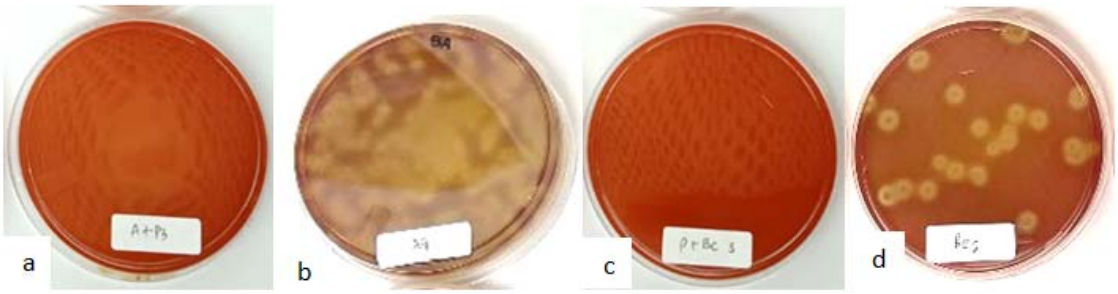

Fig. 3: Representative picture of the results of the bacterial growth test, (a) epoxy resin with 5% propolis nanoparticles, (b) epoxy resin, (c) bioceramic with 5% propolis nanoparticles, (d) bioceramic

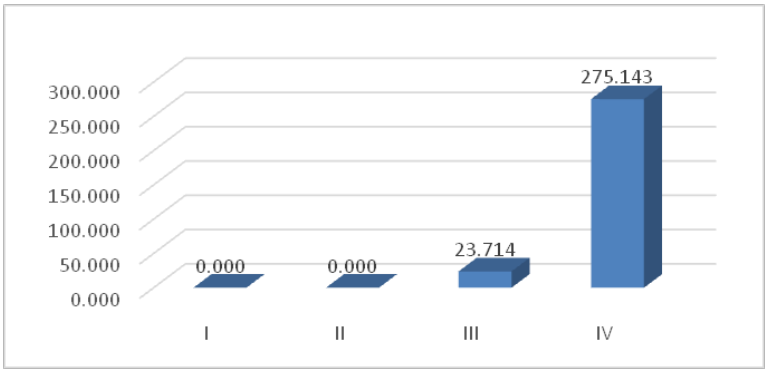

Fig. 4: Graph of the average number of bacterial colonies I. Epoxy resin with the 5% propolis nanoparticles, II. bioceramic with 5% propolis nanoparticle, III. bioceramic, IV. epoxy resins

The average number of colonies can be seen in fig. 4. *T*he highest average growth of the number of bacterial colonies occurred in the epoxy resin group with an average of 275.143 CFU/ml, while the lowest average number of bacterial colonies occurred in the epoxy resin with the addition of 5% propolis nanoparticles and bioceramic with the addition of 5% propolis nanoparticles. %, ie with an average of 0 CFU/ml.

Test results dentinal tubular penetration with Scanning Electron Microscope (SEM)

The results obtained in the SEM examination at the apical length of 5 mm can be seen in representative images of sealer penetration into the dentinal tubules in each group at 1800x magnification, indicating an overall difference. Penetration of the sealer into the dentinal tubules is seen in the white dotted areas on the SEM (fig. 5).

***Analysis* results of *E. faecalis* bacterial growth test**

Table 3: Kruskal wallis test growth of *E. faecalis* bacteria

Group	Kruskal wallis test
(I) *epoxy resin* with 5% propolis nanoparticles (II) bioceramic with 5% propolis nanoparticles (III) bioceramic (IV) epoxy resin	p = 0.000

Based on the results of the Kruskal Wallis test in table 3, there was a significant difference in the number of bacterial colonies between the epoxy resin groups with the addition of 5% propolis nanoparticles, bioceramic with the addition of 5% propolis nanoparticles, bioceramic and epoxy resin (p = 0.000<0.05).

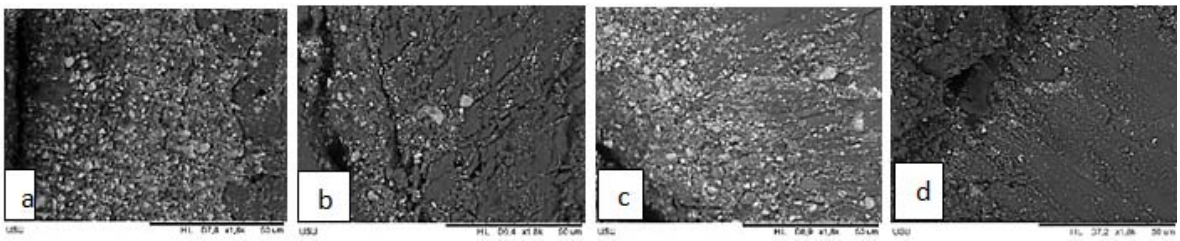

Fig. 5: Representative SEM test for penetration of sealer into dentinal tubules (a) epoxy resin with 5 % propolis nanoparticles (b) epoxy resin (c) bioceramic with 5 % propolis nanoparticles and (d) bioceramic (magnification 1800x)

The images generated from the SEM were then measured for sealer penetration into the dentinal tubules with Image-J (National Institute of Health) software. Measurements were taken from the boundary of the root canal wall and then a line was drawn towards the farthest penetration of the sealer marked with a white area. From the results of this analysis, the average penetration depth of the sealer into the dentinal tubules will be obtained, which can be seen in fig. 6.

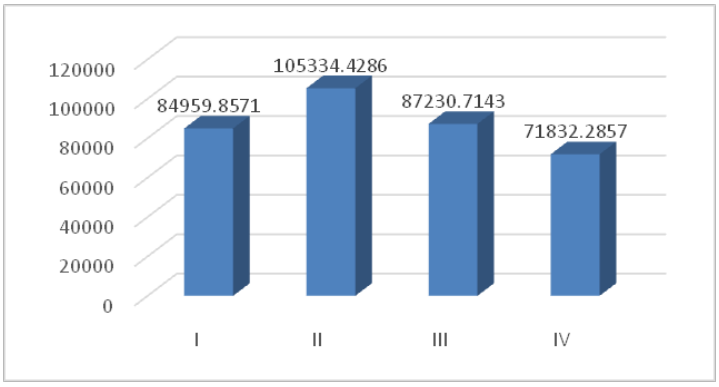

Fig. 6: Average penetration of sealer (*μm*), I. epoxy resin with 5% propolis nanoparticles, II. bioceramic with 5% propolis nanoparticles, III. bioceramic, IV epoxy

Based on fig. 6. the highest average sealer penetration occurred in the bioceramic group with the addition of 5% propolis nanoparticles, namely with an average of 105.334, while the lowest average penetration of sealer was in epoxy resin, namely with an average of 71.832 µm.

Analysis test results of dentinal tubular penetration

Table 4: Table testing continued with Kruskal wallis

Group	Kruskal-wallis test
(I) *Epoxy resin* with 5% propolis nanoparticles (II) Bioceramic with 5% propolis nanoparticles (III) Bioceramic (IV) Epoxy resin	p = 0.001

Based on the results of the Kruskal Wallis test in table 4, there was a significant difference in sealer penetration between epoxy resin with the addition of 5% propolis nanoparticles, bioceramic with the addition of 5% propolis nanoparticles, bioceramic, and epoxy resin (p = 0.001<0.05).

DISCUSSION

Based on the results of the density test (table 1), the density value of bioceramic with the addition of 5% propolis nanoparticles was higher (0.9664 g/ml) compared to commercial bioceramic (0.9513 g/ml) and epoxy resin with the addition of 5% propolis nanoparticles was higher (0.9528 g/ml) compared to commercial epoxy resin (0.9492 g/ml). The density of commercial sealers with the addition of 5% propolis nanoparticles increased compared to the density of commercial sealers. Based on the results of the viscosity test (table 2), the viscosity value of the bioceramic sealer with the addition of 5% propolis nanoparticles was higher (0.7657 cp) compared to the commercial bioceramic sealer (0.7412 cp). The addition of 5% propolis nanoparticles has the effect of increasing the viscosity value of commercial sealers.

In the *E. faecalis* growth test in root canals, the highest average number of bacterial colonies occurred in the control group with an average of 314.571 CFU/ml, while the lowest average number of bacterial colonies occurred in epoxy resin with the addition of propolis 5% nanoparticles and bioceramic with the addition of 5% propolis nanoparticles, namely with an average of 0 CFU/ml (fig. 4). Based on the Kruskal Wallis test (table 3), statistically, there was a significant difference in the number of bacterial colonies between the epoxy resin groups added with 5% propolis nanoparticles, bioceramic added with 5% propolis nanoparticles, bioceramic, epoxy resin (p = 0.000<0.05). Raheem *et al.*, (2019) reported that propolis nanoparticle-based sealers have antibacterial properties compared to other commercial sealers because they contain flavonoids [12]. The antibacterial ability of propolis comes from its high flavonoid content consisting of pinocembrin, kaempferol and quercetin, which can cause structural and functional damage to bacterial cell walls [15].

Castadlo *et al.*, (2002) reported that the antimicrobial effect of propolis comes from the content of flavonoids, pinocembrin, galangin and pinobanksin. Other substances such as prenylatid p coumaric and diterpenic acid, are antibacterial [16]. Takaisi *et al.*, (1994) reported that propolis has an antimicrobial effect by preventing cell division resulting in a material called Pseudo multicellular Strepthococus, which can damage the cytoplasm, cytoplasmic membranes and cell walls causing partial bacteriolysis which inhibits protein synthesis [17].

Propolis nanoparticles in terms of nanoparticle size, have high solubility and easily diffuse into the dentinal tubules. Proper closure of the dentinal tubules can eliminate bacteria in infected root canals and prevent bacterial reinfection [10]. The adaptability of the propolis extract to bind the dentin surface is related to the flavonoids contained in it, which are believed to have the ability to produce crystals after reacting with dentine then bind and close the open dentinal tubules [11]. The flavonoids contained in propolis extract have a chemical formula with the elements C, H and O, which can react with hydroxyapatite ($Ca10(PO4)6(OH)_2$) found in dentin [11, 18].

In the sealer penetration test into the dentinal tubules, the highest average penetration of the sealer occurred in the bioceramic group with the addition of 5% propolis nanoparticles with an average of 105,334 µm., while the lowest average penetration of the sealer occurred in epoxy resin, namely with an average of 71,832 µm (fig. 6). Based on the results of the Kruskal-Wallis test (table 4), there was a significant difference in sealer penetration between epoxy resin with the addition of 5% propolis nanoparticles, bioceramic sealer with the addition of 5% propolis nanoparticles, bioceramic, and epoxy resin (p = 0.001<0.05)

The results of this study are also in line with the research conducted Raheem *et al.*, 2020, that propolis nanoparticle-based sealers had better penetration into the dentinal tubules compared to other types of sealers [10]. The addition of propolis with bioceramic sealer showed the highest rating in terms of penetration of the sealer into the dentinal tubules. This is in line with previous research conducted by Wang Y, *et al.* (2018), which looked at the penetration and filling quality of bioceramic sealers, it was reported that bioceramic sealers were able to penetrate and cover more dentinal tubules than epoxy resin sealers [19]. In addition, bioceramic sealers can release Ca^{2+}ions. Bioceramic sealer contains calcium phosphate silicate with very small particles (<1 µm), which are hydrophilic and easily enter the lateral canal well, have a chemical composition and structure similar to the hydroxyapatite structure in teeth, thus increasing the bond between the sealer and the root canal wall [20, 21].

The depth of penetration of the sealer into the dentinal tubules is affected by the properties of the sealer used. Based on the results of the viscosity test of this modified sealer material, it is known that the addition of 5% liquid propolis nanoparticles has a higher viscosity value compared to commercial sealers without the addition of 5% liquid propolis nanoparticles. Sealers with high viscosity can penetrate accessory canals, lateral canals and isthmus [20, 21].

Penetration of the sealer into the dentinal tubules provides several advantages, namely: (1) Increases the contact area between the sealer and the root canal dentin so that the sealing capacity of the root canals increases; (2) Prevent reinfection of bacteria through dentinal tubules and eliminate remaining bacteria; (3) increase fracture resistance. The ability to penetrate the sealer into the dentinal tubules is an ideally important property of a sealer material [2, 3].

CONCLUSION

Propolis nanoparticles can increase the viscosity of commercial sealer materials. Based on the FTIR value, bioceramic and epoxy resin sealers can be used as root canal sealers. The addition of 5% propolis nanoparticles to a commercial sealer of the bioceramic and epoxy resin types increased the antibacterial properties against *E. faecalis* and the penetration of the sealer into the dentinal tubules. Bioceramic sealer has a higher antibacterial effect and sealer penetration compared to epoxy resin.

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Nil

AUTHORS CONTRIBUTIONS

All the authors have contributed equally.

CONFLICT OF INTERESTS

Declared none

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