Article published online: 2021-11-01

ORIGINAL ARTICLE

In vitro antimicrobial efficiency of different root canal sealers against *Enterecoccus faecalis*

Yakup Ustun, Burak Sagsen, Suleyman Durmaz[1], Duygu Percin[2]

Department of Restorative Dentistry and Endodontics, Faculty of Dentistry, Erciyes University, Kayseri, [1]Clinical Microbiology and Infectious Diseases, Düziçi Public Hospital, Osmaniye, [2]Medical Microbiology, Faculty of Medicine, Erciyes University, Kayseri, Turkey

Address for correspondence:
Dr. Yakup Ustun,
Erciyes Universitesi, Dis Hekimligi Fakultesi, Endodonti Anabilim Dali, 38039 Kayseri, Turkey.
E-mail: yakupustun33@hotmail.com

ABSTRACT

Objective: The antibacterial effectiveness of four different sealers AH Plus, EndoRez, mineral trioxide aggregate (MTA) Fillapex, iRoot SP against *Enterococcus faecalis* was evaluated by time kill assay method *in vitro*. **Materials and Methods:** Four sealers are used in this study: An epoxy resin-based sealer, AH Plus (Dentsply, Maillefer, Switzerland), a polymethacrylate resin-based sealer, EndoRez (Ultradent, South Jordan, UT) and two calcium silicate-based sealers, MTA Fillapex (Angelus Solucxoes Odontologicas, Londrina, Brazil), iRoot SP (Innovative BioCreamix Inc., Vancouver, Canada). Each sealer was mixed according to manufacturer's instructions. Five mg of each sealer was added to sterile tubes separately and evaluated at 20 min, 24 h, 7 days, and 30 days. Two tubes were used as positive and negative. **Results:** At the 20th min AH Plus and iRoot SP were bactericidal, MTA Fillapex, and EndoRez were ineffective at the 20th min. At the 1st day MTA Fillapex was ineffective and rest of the sealers was bacteriostatic. At the 7th day, only MTA Fillapex showed bactericidal effect, AH Plus, iRoot SP and EndoRez were bacteriostatic. At the 30th day, MTA Fillapex was still bactericidal, AH Plus, iRoot SP, and EndoRez were still bacteriostatic. **Conclusion:** All root canal sealers tested were effective against *E. faecalis*. Fresh iRoot SP and fresh AH Plus had bactericidal action against *E. faecalis*. EndoRez has bacteriostatic behavior against *E. faecalis*. MTA Fillapex was the only sealer that could be bacteriocidal at 7th and 30th day.

Key words
Antibacterial activity, *Enterococcus faecalis*, mineral trioxide aggregate Fillapex, root canal sealer, time kill assay

INTRODUCTION

The main objective of endodontic treatment is to eliminate bacteria from the root canal system and to prevent them from infecting or re-infecting the root canal or the peri-apical tissues.[1] The radicular space is a complex system with accessory, lateral, and furcation canals, with many dentinal tubules that are potential ways of entry to the radicular space.[2] The most commonly used methods for microbial control include instrumentation, antimicrobial irrigation, intracanal dressing, adequate filling, and coronal restoration.[3]

Microorganisms may be present not only throughout the pulp chamber but also in areas inaccessible to instrumentation and disinfection, such as lateral canals, apical ramifications, crevices, and dentinal tubules. Therefore, the focus of root canal treatment must be complete, three-dimensional obturation of chemomechanically prepared root canal space followed by placement of a coronal restoration that produces optimal sealing of the access opening.[2] Microorganisms may be destroyed by the antimicrobial activity of the sealer.[4-6] The root canal sealers are mandatory for three-dimensional obturation. Root canal sealers should adhere dentin and the core material and fill the irregularities between the core material and the root canal dentin.[7,8] It is stated that, the root canal sealers show antibacterial activity that may contribute to the destruction of intracanal microorganisms and all sealers exhibit highest toxicity and antibacterial activity when freshly mixed that decreases during setting.[9,10]

To evaluate the antibacterial activities of root canal sealers different methods like agar diffusion test, direct contact test, time kill assay (TKA) have been used.[10-12] The agar diffusion method has been widely used to test the antimicrobial activity of dental materials and medications.[3,13] This method allows direct comparisons of

Access this article online	
Quick Response Code:	Website: www.ejgd.org
	DOI: 10.4103/2278-9626.112311

root canal sealers against the test microorganisms.[13] It is stated that this system could be affected by the diffusibility of the tested materials and the results obtained with this system do not reflect the true antimicrobial potential of the tested materials.[14] The TKA is a method used to assess the ability of a fixed concentration of an antimicrobial agent to destroy a bacterial isolate under controlled conditions.[10,15]

Enterococcus faecalis is one of the most commonly seen microorganism recovered from the root canals of teeth with failed root treatment[16] and has also been implicated in persistent root canal infections.[17,18] Its pathogenicity ranges from life threatening diseases in compromised individuals to less severe conditions, such as infection of obturated root canals with chronic apical periodontitis. In *in vitro* studies *E. faecalis* has been shown to invade dentinal tubules.[19-22]

iRoot SP root canal sealer (Innovative BioCreamix Inc., Vancouver, Canada), has recently been introduced to the market. According to the manufacturer (http://www.veriodent.com/pb/wp_a0eb3a9d/wp_a0eb3a9d.html), iRoot SP is a convenient, premixed, ready-to-use injectable white hydraulic cement paste developed for permanent root canal filling and sealing applications. iRoot SP is an insoluble, radiopaque, and aluminum-free material based on a calcium silicate composition, which requires the presence of water to set and harden.[12]

Another recently introduced root canal sealer is a mineral trioxide aggregate (MTA) based root canal sealer, MTA fillapex (Angelus Solucxoes Odontologicas, Londrina, Brazil). According to manufacturer, it consists of resins, silica, and MTA and it has high radioopacity, low solubility, and low expansion during setting and it promotes deposition of hard-tissue (http://www.angelus.ind.br/en/endodontics/mta_fillapex/).

The aim of this study was to evaluate the time depended pharmacodynamic activities of AH Plus, EndoRez, MTA Fillapex, iRoot SP against *E. faecalis* using the TKA method. The null hypothesis was that antimicrobial activity of all the root canal sealers against *E. faecalis* decrease by time.

MATERIALS AND METHODS

Four sealers are used in this study: An epoxy resin-based sealer, AH Plus (Dentsply, Maillefer, Switzerland), a polymethacrylate resin-based sealer, EndoRez (Ultradent, South Jordan, UT) and two calcium silicate-based sealers, MTA Fillapex (Angelus Solucxoes Odontologicas, Londrina, Brazil) and iRoot SP (Innovative BioCreamix Inc., Vancouver, Canada) [Table 1].

Preparation of sealers

Sealers were mixed according to manufacturers' instructions. Four different sterile tubes were prepared for each sealer and equal amount of the sealer (5 mg ± 0.1) was added into 10 × 90 mm sterile glass tube (Isotherm, Türkiye) by using a sterile wood swab. For the standardization of the samples, each sealer was added to the bottom of the tubes at a height of approximately 10 mm. Four of the tubes were used within 20 min after mixing of the sealers and the next four tubes were used at 24 h after mixing of the sealer, four tubes at 7 days after mixing of the sealer and four tubes at 30 days after mixing of the sealers. Samples were stored in at 35°C up to the study.

Table 1: Composition of the sealers

Sealers	Compositions
AH Plus	Diepoxide, calcium tungstate, zirconium oxide, aerosol, 1-adamantane amine, diamine (3 (4),8 (9)-bis (aminomethyl) tricycle-(5.2.1.02,6)decane), dibenzyldiamine, aminoadamantane, pigments
I Root SP	Zirconium oxide, calcium silicates, calcium phosphate, calcium hydroxide filler, and thickening agents
MTA Fillapex	Salicylate resin, diluting resin, natural resin, bismuth trioxide, nanoparticulated silica, Mineral trioxide aggregate, pigments
EndoRez	30% urethane dimethacrylate, zinc oxide, barium sulfate, pigments

Time kill assay

E. faecalis, American Type of Culture Collection 29212 was used in this study. Inoculum was prepared by suspending *E. faecalis* colonies from blood agar into sterile to match a 0.5 McFarland Standard (approximately 10^8 colony forming units (CFU)/mL) using a spectrometer (Becton Dickinson, USA) at a wave length 625 nm. A 100 μL of bacterial suspension (approximately 10^8 CFU/mL) was taken with a micropipette. Then micropipette was used to inoculate this suspension into the tube containing 900 μL Triptic soy broth (Oxoid, UK), resulting in a final inoculum of approximately 10^7 CFU/mL. Then, the tube was vortexed and incubated at 35°C for 24 h.[23] A 100 μL samples were taken with micropipette from 107 CFU/mL bacteria suspension, and inoculate at 0 (20^{th} min), 1, 6, and 24 h and inoculated into another four tubes containing 900 μL Triptic soy broth and sealer. The main tube was allowed to continue the incubation up to next sample time (1, 6, and 24 h, respectively). Two more tubes containing 900 μL of Triptic soy broth were used as controls; one without bacteria for a sterility control and the other with bacteria for a growth control.

One hundred microliter samples were taken from each dilution tube and used to inoculate two 5% sheep blood agar plates (BioMerieux, France). Purity control was done with the subculture onto sheep blood agar plates. Colonies were counted following 18 h of incubation at 35°C the counts from plates showing 30-300 CFUs were averaged.[23] The average counts were converted to actual CFU per mL by multiplying the average of raw counts by

dilution factors. CFU per milliliter (*y* axis) versus time (*x* axis) was plotted on a semi-log paper.

Pharmocodynamic analysis

In vitro model time-kill curves were determined by plotting mean colony counts (log 10 CFU/mL) from each tube versus time. Bactericidal activity (99.9% kill) was defined as a 3-log 10 CFU/mL reduction in the colony count from the original inoculum. Bacteriostatic activity (99.9% growth inhibition) was defined as a 2-log 10 CFU/mL reduction and indifference was defined as 1 log 10 CFU/mL reduction in the original inoculums.

RESULTS

Antibacterial activities of the four sealers using a TKA are shown in Figure 1. Freshly mixed sealers showed differences in their activity against *E. faecalis*. At the 20th min, 1st, 7th, and 30th days and at the 20th min AH Plus and I Root SP were bactericidal, MTA Fillapex and EndoRez were ineffective at the 20th min. At the 1st day MTA Fillapex was ineffective and rest of the sealers was bacteriostatic. At the 7th day, only MTA Fillapex showed bactericidal effect, AH Plus, iRoot SP, and EndoRez were bacteriostatic. At the 30th day, MTA Fillapex was still bactericidal, AH Plus, iRoot SP, and EndoRez were still bacteriostatic [Figure 1].

DISCUSSION

Microorganisms infecting the root canal dentine might adhere superficially to the dentinal wall or penetrate deeper into the dentinal tubules.[24,25] Microorganisms that are placed deeper into the dentinal tubules could be killed by the antibacterial effects of the root canal sealers.[26] An ideal endodontic sealer should be dimensionally stable, biocompatible and should have well sealing ability, long-lasting antibacterial efficiency.[12,27-29] Antibacterial activity of sealers might help to eliminate the residual microorganisms that have survived the chemomechanical instrumentation and consequently improve the success of the endodontic treatment.[12] Although chemomechanical instrumentation is mandatory for the disinfection of the root canal system, some residual microorganisms could survive[17,21] and antibacterial activity of the root canal sealers would help to eliminate these surviving residual microorganisms.[1,11-13]

E. faecalis is one of the most commonly isolated microorganisms from refractory periapical periodontitis[30] and it is one of the most drug resistant bacteria and has ability to survive up to 12 months even under nutrient-deprived conditions in the root canal after routine root canal therapy.[4,18,31,32] Because of *E. faecalis* persistent behavior we used it as a test microorganism.

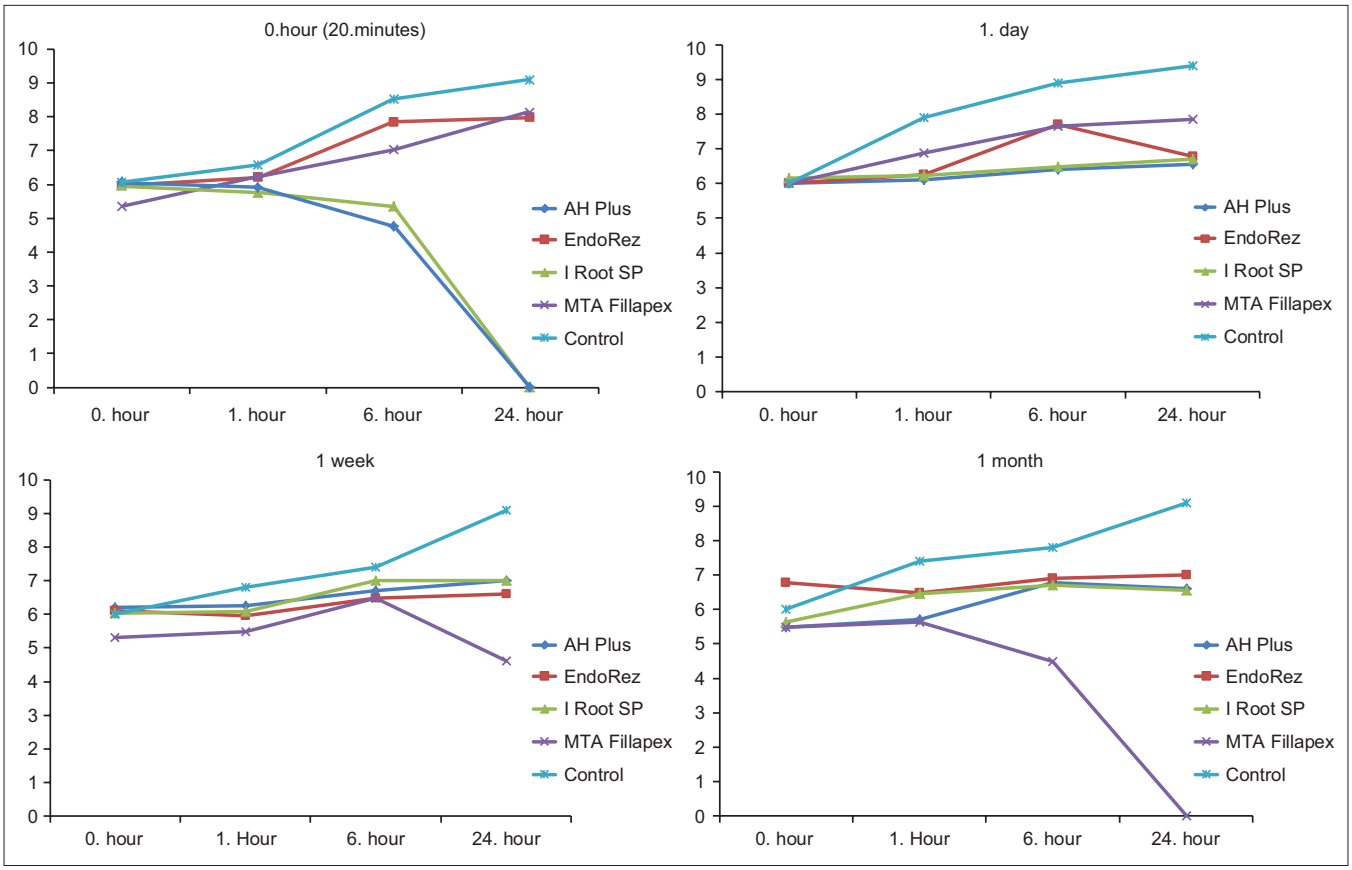

Figure 1: Antibacterial activities of the four sealers with time kill assay method at different time intervals

The antimicrobial activity of root canal sealers has been tested previously using various methods. These include agar diffusion tests,[3,33-35] direct contact tests[12,36,37] and TKA method.[10] The TKA method is a method used to assess the antimicrobial activity of a measured amount of a antimicrobial agent against a constant amount of bacterial isolate at different time intervals.[15] The kill rate is determined by measuring the number of viable bacteria at different time intervals by a graphic design called time-kill curve and it gives the opportunity to evaluate the antibacterial activity of sealers and classify them according to bacteriostatic or bacterisidal action.[4,10]

AH Plus was improved by its manufacturer from AH26 and has been reported as releasing almost no formaldehyde.[38] In the present study, AH Plus was found to be bactericidal at the 20th min but at the 1st, 7th and 30th day it was found to be bacteriostatic. Zhang *et al.*[16] and Sagsen *et al.*[14] also reported that freshly mixed AH Plus had high antimicrobial activity. The antibacterial activity of AH Plus could be related to epoxy resin and amines ingredients.[39] Our results were similar with Zhang *et al.*[12] and Kayaoğlu *et al.*[26] who reported that freshly mixed AH Plus killed *E. faecalis* effectively.

EndoRez (Ultradent, South Jordan, UT) is a hydrophilic, dual-cured sealer containing zinc oxide, barium sulphate, resins and pigments in a matrix of urethane dimethacrylate resin.[40] In the present study, EndoRez did not show antibacterial activity at 20 min. At the 1st day, EndoRez was bacteriostatic and at the 7th and 30th days it was still bacteriostatic. Our results were similar as the study of Zhang *et al.*[12] that reported EndoRez was bacteriostatic at the 1st, 7th, and 30th days. However, contrary to Zhang *et al.*,[12] according to our results at the minute EndoRez was ineffective. At the 20th min our results were similar to Eldeniz *et al.*[41] who found that EndoRez did not show any antibacterial activity.

I Root SP is a newly introduced endodontic sealer based on calcium silicate.[42] In the present study, I Root SP was found to be bactericidal at the 20th min. At the 1st, 7th, and 30th day I Root SP was still found to be bacteriostatic. Zhang *et al.*[12] reported that I Root SP showed bactericidal action at the 2nd min of contact when freshly mixed and after 1 day of setting I Root SP killed all the bacteria at the 20th min but at the 7th day I Root SP was ineffective. In the present study, freshly mixed samples showed bactericidal activity but at the 7th and 30th days we found that I Root SP was bacteriostatic contrary to Zhang *et al.*[12] The sealer contains calcium silicate cement, calcium phosphate and calcium oxide.[42] The antibacterial effect of I Root SP sealer might be a combination of high pH, hydrophilicity, and active calcium hydroxide diffusion.[12]

MTA Fillapex is another newly introduced resin salicylate and calcium silicate based root canal sealer. In the present study, MTA Fillapex was found to be ineffective at the first 20 min. At the 1st day it was bacteriostatic and at 7th and 30th day MTA Fillapex was bactericidal. On the contrary to our results Morgental *et al.*[43] stated that MTA Fillapex was effective before setting but not effective 7 days after setting. Such discrepancies are probably due to methodology. The antimicrobial activity of MTA was reported by Torabinejad *et al.*,[44] who detected its efficiency against some facultative bacteria; however, no activity was found against *E. faecalis*, *Staphylococcus aureus*, *Bacillus subtilis*, and *Escherichia coli* or against anaerobic bacteria. However, Stowe *et al.*[45] assessed the antimicrobial properties of MTA and found that it inhibited the growth of both *E. faecalis* and *Streptococcus sanguis*. MTA contains calcium oxide, which forms calcium hydroxide on contact with water, which gives antibacterial property to MTA.[39,44,46] MTA Fillapex contains calcium silicate cement and with the moisture from dentin the hydration reactions of calcium silicates begins and calcium silicate hydrogel and calcium hydroxide exists which gives the high PH and antibacterial property to MTA Fillapex.[12] Our results could be related to calcium silicate and MTA and resin ingredient of the MTA Fillapex.

In conclusion, the results of the present study showed that only fresh I Root SP and AH Plus had bactericidal action against *E. faecalis* and both sealers had continued to have bacteriostatic behavior at 1st, 7th, and 30th days. EndoRez had bacteriostatic behavior during the study except freshly mixed samples. MTA Fillapex was the only sealer that could be bacteriocidal at 7th and 30th day. Within the limitation of the present study it is essential not to forget the importance of chemomechanic preparation in endodontic practice and further investigations are needed for evaluation of the antimicrobial efficiencies of the root canal sealers.

ACKNOWLEDGMENT

We would like to thank Angelus for their support with MTA Fillapex.

REFERENCES

1. Love RM, McMillan MD, Jenkinson HF. Invasion of dentinal tubules by oral streptococci is associated with collagen recognition mediated by the antigen I/II family of polypeptides. Infect Immun 1997;65:5157-64.
2. Johnson WT, Liewehr FR. Obturation In: Color Atlas of Endodontics. In: Johnson WT, Editor. 1st ed. Philedelphia: W.B. Saunders; 2002. p. 99-100.
3. Al-Khatib ZZ, Baum RH, Morse DR, Yesilsoy C, Bhambhani S, Furst ML. The antimicrobial effect of various endodontic sealers. Oral Surg Oral Med Oral Pathol 1990;70:784-90.
4. Heling I, Chandler NP. The antimicrobial effect within dentinal tubules of four root canal sealers. J Endod 1996;22:257-9.
5. Siqueira JF Jr, Favieri A, Gahyva SM, Moraes SR, Lima KC, Lopes HP. Antimicrobial activity and flow rate of newer and established root canal sealers. J Endod 2000;26:274-7.

6. Kaplan AE, Picca M, Gonzalez MI, Macchi RL, Molgatini SL. Antimicrobial effect of six endodontic sealers: An *in vitro* evaluation. Endod Dent Traumatol 1999;15:42-5.
7. Saleh IM, Ruyter IE, Haapasalo MP, Orstavik D. Adhesion of endodontic sealers: Scanning electron microscopy and energy dispersive spectroscopy. J Endod 2003;29:595-601.
8. Pommel L, About I, Pashley D, Camps J. Apical leakage of four endodontic sealers. J Endod 2003;29:208-10.
9. Georgopoulou M, Kontakiotis E, Nakou M. *In vitro* evaluation of the effectiveness of calcium hydroxide and paramonochlorophenol on anaerobic bacteria from the root canal. Endod Dent Traumatol 1993;9:249-53.
10. Sagsen B, Er O, Esel D, Yagmur G, Altintop Y. *In vitro* pharmacodynamic activities of root canal sealers on *Enterococcus faecalis*. J Contemp Dent Pract 2009;10:35-42.
11. Asgary S, Kamrani FA. Antibacterial effects of five different root canal sealing materials. J Oral Sci 2008;50:469-74.
12. Zhang H, Shen Y, Ruse ND, Haapasalo M. Antibacterial activity of endodontic sealers by modified direct contact test against *Enterococcus faecalis*. J Endod 2009;35:1051-5.
13. Gomes BP, Pedroso JA, Jacinto RC, Vianna ME, Ferraz CC, Zaia AA, *et al. In vitro* evaluation of the antimicrobial activity of five root canal sealers. Braz Dent J 2004;15:30-5.
14. Ingle JI, Newton CW, West JD, Gutmann JL, Glickman GN, Korzon BH, Martin H. Obturation of radicular space. In: Ingle's Endodontics. In: Ingle JI, Bakland LK, Editors, 6th ed. Hamilton, ON, Canada: BC Decker Inc; 2008. p. 586-7.
15. Moody JA, Synergy testing: Broth microdilution checkerboard and broth macrodilution methods, In: Clinical Microbiology Procedures Handbook. Einsenberg HD. Washington DC, USA: American Society for Microbiology; 1992. p. 1–23.
16. Sundqvist G, Figdor D, Persson S, Sjögren U. Microbiologic analysis of teeth with failed endodontic treatment and the outcome of conservative re-treatment. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1998;85:86-93.
17. Bystrom A, Sundqvist G. The antibacterial action of sodium hypochlorite and EDTA in 60 cases of endodontic therapy. Int Endod J 1985;18:35-40.
18. Bodrumlu E, Semiz M. Antibacterial activity of a new endodontic sealer against *Enterococcus faecalis*. J Can Dent Assoc 2006;72:637.
19. Akpata ES, Blechman H. Bacterial invasion of pulpal dentin wall *in vitro*. J Dent Res 1982;61:435-8.
20. Haapasalo M, Orstavik D. *In vitro* infection and disinfection of dentinal tubules. J Dent Res 1987;66:1375-9.
21. Orstavik D, Haapasalo M. Disinfection by endodontic irrigants and dressings of experimentally infected dentinal tubules. Endod Dent Traumatol 1990;6:142-9.
22. Love RM. *Enterococcus faecalis* – A mechanism for its role in endodontic failure. Int Endod J 2001;34:399-405.
23. Wayne PA. Performance Standards for Antimicrobial Susceptibility Testing; Twenty-First Informational Supplement. In: Clinical and Laboratory Standards Institute document M100-S21, 2011. P 41-42
24. Ando N, Hoshino E. Predominant obligate anaerobes invading the deep layers of root canal dentin. Int Endod J 1990;23:20-7.
25. Peters LB, Wesselink PR, Buijs JF, van Winkelhoff AJ. Viable bacteria in root dentinal tubules of teeth with apical periodontitis. J Endod 2001;27:76-81.
26. Kayaoglu G, Erten H, Alaçam T, Ørstavik D. Short-term antibacterial activity of root canal sealers towards *Enterococcus faecalis*. Int Endod J 2005;38:483-8.
27. Geurtsen W, Leyhausen G. Biological aspects of root canal filling materials – Histocompatibility, cytotoxicity, and mutagenicity. Clin Oral Investig 1997;1:5-11.
28. Grossman L. Antimicrobial effect of root canal cements. J Endod 1980;6:594-7.
29. Orstavik D. Antibacterial properties of endodontic materials. Int Endod J 1988;21:161-9.
30. Stuart CH, Schwartz SA, Beeson TJ, Owatz CB. *Enterococcus faecalis*: Its role in root canal treatment failure and current concepts in retreatment. J Endod 2006;32:93-8.
31. Sedgley CM, Lennan SL, Appelbe OK. Survival of *Enterococcus faecalis* in root canals *ex vivo*. Int Endod J 2005;38:735-42.
32. Portenier I, Haapasalo H, Orstavik D, Yamauchi M, Haapasalo M. Inactivation of the antibacterial activity of iodine potassium iodide and chlorhexidine digluconate against *Enterococcus faecalis* by dentin, dentin matrix, type-I collagen, and heat-killed microbial whole cells. J Endod 2002;28:634-7.
33. Abdulkader A, Duguid R, Saunders EM. The antimicrobial activity of endodontic sealers to anaerobic bacteria. Int Endod J 1996;29:280-3.
34. Mickel AK, Wright ER. Growth inhibition of *Streptococcus anginosus* (milleri) by three calcium hydroxide sealers and one zinc oxide-eugenol sealer. J Endod 1999;25:34-7.
35. Mickel AK, Nguyen TH, Chogle S. Antimicrobial activity of endodontic sealers on *Enterococcus faecalis*. J Endod 2003;29:257-8.
36. Fuss Z, Weiss EI, Shalhav M. Antibacterial activity of calcium hydroxide-containing endodontic sealers on *Enterococcus faecalis in vitro*. Int Endod J 1997;30:397-402.
37. Cobankara FK, Altinöz HC, Ergani O, Kav K, Belli S. *In vitro* antibacterial activities of root-canal sealers by using two different methods. J Endod 2004;30:57-60.
38. Cohen BI, Pagnillo MK, Musikant BL, Deutsch AS. Formaldehyde evaluation from endodontic materials. Oral Health 1998;88:37-9.
39. Yasuda Y, Kamaguchi A, Saito T. *In vitro* evaluation of the antimicrobial activity of a new resin-based endodontic sealer against endodontic pathogens. J Oral Sci 2008;50:309-13.
40. Karapınar-Kazandağ M, Bayrak OF, Yalvaç ME, Ersev H, Tanalp J, Sahin F, *et al.* Cytotoxicity of 5 endodontic sealers on L929 cell line and human dental pulp cells. Int Endod J 2011;44:626-34.
41. Eldeniz AU, Erdemir A, Hadimli HH, Belli S, Erganis O. Assessment of antibacterial activity of EndoREZ. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2006;102:119-26.
42. Zhang H, Pappen FG, Haapasalo M. Dentin enhances the antibacterial effect of mineral trioxide aggregate and bioaggregate. J Endod 2009;35:221-4.
43. Morgental RD, Vier-Pelisser FV, Oliveira SD, Antunes FC, Cogo DM, Kopper PM. Antibacterial activity of two MTA-based root canal sealers. Int Endod J 2011;44:1128-33.
44. Torabinejad M, Hong CU, Pitt Ford TR, Kettering JD. Antibacterial effects of some root end filling materials. J Endod 1995;21:403-6.
45. Stowe TJ, Sedgley CM, Stowe B, Fenno JC. The effects of chlorhexidine gluconate (0.12%) on the antimicrobial properties of tooth-colored ProRoot mineral trioxide aggregate. J Endod 2004;30:429-31.
46. Al-Hezaimi K, Al-Shalan TA, Naghshbandi J, Oglesby S, Simon JH, Rotstein I. Antibacterial effect of two mineral trioxide aggregate (MTA) preparations against *Enterococcus faecalis* and *Streptococcus sanguis in vitro*. J Endod 2006;32:1053-6.

How to cite this article: Ustun Y, Sagsen B, Durmaz S, Percin D. *In vitro* antimicrobial efficiency of different root canal sealers against *Enterecoccus faecalis*. Eur J Gen Dent 2013;2:134-8.

Source of Support: Nil, **Conflict of Interest:** None declared.