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Letter to the editor

Eradicating *Enterococcus faecalis* in root canal system: An update

The successful treatment of persistent and recurrent endodontic infections depends on eradicating the remaining microorganisms in the root canal system. However, the complexity of the root canal system often poses a major challenge to root canal disinfection and the removal of biofilms. In this regard, among the microorganisms, *Enterococcus faecalis* (*E. faecalis*) is considered the most common cause of endodontic failures and can significantly affect the success rate of root canal therapy. As an anaerobic, gram-positive bacterium, *E. faecalis* is able to form a biofilm in the root canal without synergistic support from other bacteria and is highly resistant to antimicrobial agents in endodontic therapy. Therefore, using promising tools and novel intracanal medicaments is a priority to eradicate microorganisms.[1–3] This brief letter focused on novel methods to eliminate *E. faecalis* in the root canal system.

In order to eradicate *E. faecalis* in the root canal system, Sasikala et al. evaluated the antimicrobial efficacy of triple antibiotic paste (metronidazole, ciprofloxacin, and minocycline) and amoxicillin-clavulanate paste (ACP) as intracanal medications against *E. faecalis* in 60 extracted single root teeth. To this end, the samples were contaminated with *E. faecalis*. Afterward, they were divided into 4 groups (n = 15) and disinfected as follows: Group 1) triple antibiotic paste (TAP), Group 2) ACP, Group 3) $Ca(OH)_2$ (positive control group), and Group 4) NaCl (negative control). Based on the number of colonies formed, the results showed that ACP had the highest inhibitory effect against *E. faecalis*, followed by Group 1. Consequently, using ACP as an alternative to TAP is recommended to eradicate *E. faecalis*.[3]

Consistent with the previous study, Eskandari et al. investigated the efficacy of graphene oxide, double antibiotic paste (metronidazole and ciprofloxacin), and their combination effect against *E. faecalis*. 108 extracted premolars were included in this in vitro study. The samples were contaminated with *E. faecalis*. Intracanal medicaments were dressed into the canals as follows: Group 1) graphene oxide (n = 30), Group 2) double antibiotic past (n = 30), Group 3) graphene oxide and double antibiotic past (n = 30), Group 4) NaCl as a positive control group (n = 9), and Group 5) negative control group, i.e., no bacterial contamination (n = 9). Each group was also divided into three subgroups, with exposure times of 1 day, 7 days, and 14 days. The results showed that Group 3 was superior in eradicating *E. faecalis* within 1 day. Therefore, combining graphene oxide and double antibiotic paste as a novel material can be considered a promising intracanal medicament versus *E. faecalis*.[4]

Photodynamic therapy (PDT) shows satisfactory results in eradicating *E. faecalis* from infected root canals.[2] In this perspective, a newly published article investigated the efficacy of PDT activated with an Er: YAG laser at a wavelength of 2940 nm against *E. faecalis*. To achieve this goal, 50 extracted single roots were scheduled and divided into 5 groups of 10 samples each for this study. The samples were infected with *E. faecalis* and disinfected with the following techniques: Group 1) negative control group, i.e., no intervention, Group 2) disinfecting with NaOCl, Group 3) NaOCl + Er: YAG, Group 4) PDT (i.e., 50 μmol/L methylene blue + irradiated with a 660 nm laser device), and Group 5) PDT + Er: YAG (i.e., 50 μmol/L methylene blue + irradiated with an Er: YAG laser at a wavelength of 2940 nm for 1 min). The results revealed that Groups 3 and 5 were superior in eradicating microorganism from infected root canals. Accordingly, PDT is recommended as a supplementary safe technique for eradicating *E. faecalis*.[5]

Another study evaluated the antimicrobial efficacy of PDT with two photosensitizers, namely toluidine blue and phycocyanin, irradiated with a diode laser at a wavelength of 635 nm to eradicate *E. faecalis*. For this purpose, 55 extracted teeth were selected, infected with *E. faecalis*, and randomly divided into 11 groups (n = 5). The *E. faecalis* biofilms were disinfected with toluidine blue and phycocyanin, which were activated with a diode laser set to a variety of power densities (i.e., 636, 954, 1273, and 1592 W/cm^2). According to the results, both photosensitizers activated by a diode laser with a high power density (1592 W/cm^2) were more effective in eradicating *E. faecalis* from the root canals. Inhibiting biofilm is associated with increasing the light power of laser devices and should be considered in clinical situations to eradicate *E. faecalis*.[6]

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Another challenge in eradicating biofilm from the root canal system is the canal isthmus. These isthmuses can restrict endodontic procedures and irrigation solutions, leading to treatment failure. In this context, Ibrahim and Jawad evaluated the efficacy of Er, Cr: YSGG laser as an activator of 2% chlorhexidine gluconate (CHX) in the isthmus region of the root canals. To achieve this goal, 75 extracted mesial roots of the first and second molars were included in this study. The samples were infected with *E. faecalis* and then divided into 5 groups (n = 15), including 2 control groups and 3 experimental groups. The experimental groups were disinfected as follows: Group 1) 2% CHX + conventional syringe irrigation, Group 2) 2% CHX + passive ultrasonic irrigation, and Group 3) 2% CHX + Er, Cr: YSGG laser at (0.25, 0.5, 0.75, 1, and 1.25) W in 60 μs/pulse. The isthmus areas were evaluated using an atomic force microscope and a scanning electronic microscope. Based on the study's results, Group 3 (i.e., 2% CHX + Er, Cr: YSGG at 0.75 W, 60 μs) provided superior removal of biofilm in the isthmus areas. Therefore, activation of 2% CHX with an Er, Cr: YSGG laser at a wavelength of 2780 nm with an output power of 0.75 W is recommended to eradicate the biofilm of *E. faecalis* from the infected root canals.[7]

Innovative approaches play a crucial role in eradicating *E. faecalis* in endodontic procedures. Two relevant studies concerning this issue are as follows: 1) In the first study, the antimicrobial properties of nanosilica-based and three antibiotics (i.e., doxycycline, metronidazole, and ciprofloxacin) against *E. faecalis* biofilms were investigated. The results showed that silica nanoparticles, in combination with three antibiotics, exhibited a superior inhibitory effect on *E. faecalis*. 2) The second study evaluated lipopeptide biosurfactant (LB) as a potential root canal irrigation agent to eradicate *E. faecalis* biofilms. The results of the in vitro study revealed that LB has a high potential to eradicate *E. faecalis*, particularly in combination with NaOCl. LB was capable of increasing NaOCl's antimicrobial effect. Therefore, LB has the potential to be used both as a stand-alone root canal irrigation solution and as a supplement to NaOCl in root canal therapy. As can be inferred from the results of these two studies, applying innovative approaches to eliminate biofilms contributes to the long-term success of root canal treatment.[8,9]

According to the content of this brief letter, the following procedures should be considered for the eradication of *E. faecalis*: 1) using amoxicillin-clavulanate paste as an intracanal medication, 2) using graphene oxide + double antibiotic paste (metronidazole and ciprofloxacin), 3) applying photodynamic therapy, 4) using 2% CHX + Er, Cr: YSGG, 5) using nanosilica-based + three antibiotics (doxycycline, metronidazole, and ciprofloxacin), and 6) lipopeptide biosurfactant + NaOCl. Consequently, clinicians' ability to apply novel methods requires a multidisciplinary therapeutic approach indispensable to eradicating biofilms in the root canal system.

Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

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