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Original Article

Pulp tissue dissolution capacity of QMix 2in1 irrigation solution

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ABSTRACT

Objective: The aim of this study was to evaluate the tissue dissolution efficacy of four root canal irrigation solutions (sodium hypochlorite [NaOCl], chlorhexidine gluconate [CHX], Octenidine [OCT], and QMix 2in1) on bovine pulp tissue. **Materials and Methods:** Fifty bovine pulp tissue samples, each weighing 6.55 mg, were prepared and randomly divided into four experimental groups and one control group ($n = 10$) according to the dissolution irrigants used: (1) 5.25% NaOCl group; (2) 2% CHX group; (3) OCT group; (4) QMix 2in1 group; and (5) control group (saline solution). These samples were then placed into special bovine dentin reservoir models and immersed for 1 h with each test solution (0.1 mL of each) at room temperature. The pulp samples were then blotted dry and weighed again. The percentage of weight loss was calculated. Statistically analyzed with one-way analysis of variance and *post-hoc* Tukey tests ($P = 0.05$). **Results:** Saline solution did not dissolve the bovine pulp tissue. All groups, except OCT, dissolved pulp samples more effectively than the control group ($P < 0.05$). The highest tissue dissolution was observed in 5.25% NaOCl group ($P < 0.05$). No statistically significant difference was found between the tissue-dissolving effect between QMix 2in1 and those of 2% CHX. **Conclusions:** Within the limitations of this *in vitro* study, NaOCl exhibited the best tissue-dissolving effect out of all solutions tested. CHX and QMix 2in1 were able to dissolve pulp tissue but less than NaOCl. OCT and saline solutions could not exhibit significantly tissue-dissolving effectiveness. This study shown that QMix 2in1 has little capacity to dissolve pulp tissue therefore used alone is not sufficient for this purpose.

Key words: Chlorhexidine, octenidine, pulp tissue, QMix 2in1, tissue-dissolving

INTRODUCTION

Successful endodontic treatment relies on excellent chemomechanical debridement of pulp tissue, debris, and pathogenic microorganisms.[1,2] Due to morphological complexities of root canals such as curvatures, lateral branches, and apical ramifications, up to 50% of canal walls may remain uninstrumented during preparation, which results in insufficient debridement.[3] Thus, pulp tissue remnants and smear, in which microorganisms can survive and proliferate, might cause postoperative pain and endodontic treatment failure.[4,5]

The use of endodontic irrigants which should have antimicrobial activity, tissue-dissolving capabilities and low cytotoxicity on the periapical tissue is, therefore, crucial in extending debridement into physically inaccessible areas.[6] In this context, sodium hypochlorite (NaOCl) is the most widely used irrigant due to its extensive antimicrobial activity, the capability to dissolve the organic part of smear layer and pulp tissue remnants from root canals.[7] Many authors[8-11] have reported that the dissolving capability of NaOCl depends on the concentration, volume, temperature, pH and contact time of solution. The concentrations

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ranging from 0.5% to 5.25% of NaOCl present great tissue-dissolving capability.[12,13] However, despite the excellent tissue-dissolution activity, higher concentrations of NaOCl are cytotoxic to periradicular tissue.[14] Therefore, a nontoxic irrigant with a higher antimicrobial activity and tissue-dissolution capability is still being researched.

Chlorhexidine gluconate (CHX) has been suggested as an irrigant with due to its broad-spectrum antimicrobial effect, substantivity, and relatively low cytotoxicity.[15] However, Naenni *et al*.[12] and Okino *et al*.[16] have demonstrated that CHX does not dissolve pulp tissue.

Octenidine hydrochloride (OCT), a bispyridine derivative, is a mucous membrane antiseptic used to heal severe burns. It has also been suggested as a possible endodontic irrigant due to its antimicrobial effectiveness and lower cytotoxicity.[7,17] Previous studies showed it outperformed CHX in bacterial anti-adhesive activity[18] and wide antimicrobial properties.[19-21] However, there is no data on its ability to dissolve pulp tissue.

QMix 2in1 is a novel irrigant containing ethylenediaminetetraacetic acid (EDTA), CHX, and a nonspecified detergent which has been shown to be as effective as 17% EDTA in removing the smear layer.[22] In addition, it has been found comparable with NaOCl and CHX in antimicrobial activity.[23] To the best of our knowledge, no study in literature evaluates the tissue-dissolving capacity of QMix 2in1 solution. Therefore, the aim of this *in vitro* study was to evaluate the dissolution ability of OCT and QMix 2in1 in comparison with 5.25% NaOCl and 2% CHX on bovine pulp tissue, using a dentin model.

MATERIALS AND METHODS

Pulp tissue and dentin model preparation

Fifty freshly extracted bovine mandibular incisors [Figure 1a] were used in this study. The teeth were extracted from bovine jaws dissected after death and frozen at −20 C until required. The animals were slaughtered for commercial purposes (at Cekmece meat and meat products, Istanbul, Turkiye).

In preparation for the experiment, all teeth were left at room temperature to defrost. A diamond bur then cut a horizontal groove was with at the cementoenamel junction level to separate the crowns from the roots. Pulp tissues were removed carefully with the aid of hemostatic forceps, washed with distilled water to remove excess blood and debris [Figure 1b], and blotted dry. In total, fifty pulp tissue samples, each weighing 6.5 ± 0.5 mg, were prepared with a #12 surgical blade. The initial weight of each sample was calculated with a precision balance (Mettler Toledo ME204, OH, USA) in an airtight container. Besides, standardized dentin reservoir models (n = 50) [Figure 1c and d] were prepared from the crowns of bovine incisors. Space in the inner face of crowns with an average volume of about 120 mm^3 was prepared using marked diamond burs, as in Slutzky-Goldberg *et al*.[24]

Dissolution test

Pulp tissue samples were randomly divided into five groups (n = 10) according to the dissolution irrigant to be used.

- NaOCl group: 0.1 mL of 5.25% NaOCl (Wizard, Rehber Chemistry, Istanbul, Turkiye) solution was used for 1 h. The pH of the solution was measured using a pH meter (HI 2211 pH-ORP Meter, HANNA Instruments, USA) at room temperature and adapted to pH 12 with 1N HCl. The amount of final active chlorine content was also verified just before each test by an iodine/thiosulfate titration method, as previously described[25]
- CHX group: 0.1 mL of 2% CHX (Klorhex, Drogsan, Ankara, Turkey) solution was used for 1 h
- OCT group: 0.1 mL of OCT (Octenisept, Schülke and Mayr, Norderstedt, Germany) solution was used for 1 h
- QMix 2in1 group: 0.1 mL of QMix 2in1 (Dentsply Tulsa Dental Specialties, Tulsa, OK, USA) solution was used for 1 h
- Control group: 0.1 mL of isotonic saline (I. E. Ulagay Drug Industry, Istanbul, Turkiye) solution was used for 1 h.

The previously weighed bovine pulp fragments were inserted into prepared dentin reservoir models with 0.1 mL of each test solution [Figure 1e]. Dentin models were then coated with paraffin and incubated for 1 h and at 37 C. After incubation, the remaining pulp tissue was removed, rinsed with distilled water to remove tissue remnants, blotted dry, and re-weighed. The mean percentage of weight loss was calculated. Data were then statistically analyzed with one-way analysis of variance and *post-hoc* Tukey tests using IBM SPSS Statistics 20 software (IBM SPSS Inc, Chicago, IL, USA). Testing was performed at the 95% confidence level (P = 0.05).

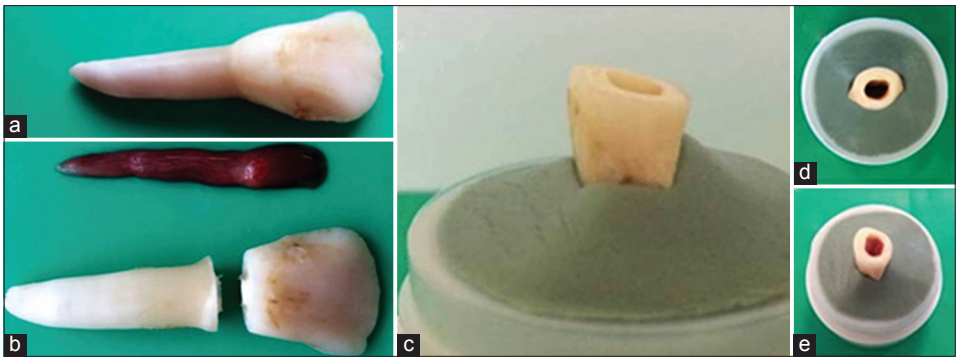

Figure 1: (a) Bovine mandibular incisor tooth, (b) the pulp tissue, (c and d) dentin reservoir model, (e) placement of the pulp tissue sample into the dentin model

RESULTS

The percentage of weight loss (mean values, standard deviation, minimum and maximum) of bovine pulp samples after exposure to experimental and control solutions is shown in Table 1. The highest rate of dissolution came from the NaOCl group ($P < 0.05$), whereas control group did not dissolve the pulp tissue. CHX and QMix 2in1 groups dissolved more bovine pulp tissue than the control ($P < 0.05$); but less than the NaOCl group ($P < 0.05$). No statistically significant difference was found between the OCT and control groups ($P > 0.05$).

Table 1: Mean, minimum and maximum percentage weight loss of bovine pulp tissue after exposure to test solutions

Groups	Weight loss (%) ±SD	Minimum (%)	Maximum (%)
NaOCl[a]	59.88±11.44	47.62	80.00
CHX[b]	14.55±9.92	2.5	31.58
OCT[bc]	10.60±8.09	0	21.05
QMix 2in1[b]	21.34±4.85	15.09	27.66
Control[c]	0.06±6.35	−13.00	12.50

[abc]No statistically significant difference between group is indicated by the same superscript letter. SD: Standard deviation, NaOCL: Sodium hypochlorite, CHX: Chlorhexidine gluconate, OCT: Octenidine

DISCUSSION

Bovine pulp tissue is regarded as comparable to human pulp tissue despite some minor differences[26] and was used in previous tissue dissolution studies.[27-29] Due to its similarity to a human pulp and easier standardization of the surface area of its samples, fresh bovine pulp tissue was selected in the present study.

Moorer and Wesselink[8] showed that tissue dissolution depended on factors including the amount of organic matter compared to irrigant in root canal system and surface area of tissue available for contact with the irrigant. Therefore, the bovine pulp tissue and test solutions were prepared with standardized weight (6.5 ± 0.5 mg of each tissue sample and 0.1 mL for each solution).

Haapasalo *et al*.[30] showed that dentin powder delayed the killing of *Enterococcus faecalis*. In addition, dentin has considerable buffering against both NaOCl and calcium hydroxide that reduces their tissue dissolution capacities.[24] Therefore, to simulate the clinical conditions, we used a dentin model previously performed by Slutzky-Goldberg *et al*.[24] that allows a contact with all tissue surface between the irrigants. Because finding the endpoint of complete tissue dissolution was difficult due to the number of bubbles and the eye perception of the examiner;[16] we used a fixed time (1 h) instead and samples were weighed before and after exposure.

Based on our results, NaOCl exhibited the best tissue-dissolving effect of all solutions tested, in agreement with the previous studies.[12,29,31] The rate of tissue dissolution after 1 h of exposure to 5.25% NaOCl was 59.88% ± 11.44% at room temperature. However, Almeida *et al*.[32] reported that a pulp tissue weight loss of 84.88% after 30 min incubation with 5.25% NaOCl by using a test tube model. The differences between the tissue dissolution rates of NaOCl solutions may be related to the dentin model we used, which was more effective in simulating the clinical conditions. In addition, different experimental conditions such as concentration, pH, volume, mechanical shaking, physical irrigation, surface area of tissue contacted to test solution, time and temperature can affect tissue dissolution capacity of NaOCl.[8,10] Variations of these factors may make comparisons between studies difficult.

CHX is recommended as an endodontic irrigant because of its wide antimicrobial spectrum, lower toxicity, and intracanal substantivity.[15] On the

other hand, previous studies suggested that it is not comparable with NaOCl regarding the organic tissue dissolution capacity.[12,15,16] This is in accordance with the findings of the present study, which confirmed its lower tissue dissolution than NaOCl.

The antibacterial effect of OCT against *E. faecalis* has been demonstrated in previous studies[21,33] using a root dentin infection model. Similarly, Eldeniz *et al*.[20] reported antifungal activity of OCT comparable to NaOCl and CHX. However, there has been no study evaluating the pulp tissue dissolution of OCT. According to our results, OCT did not dissolve pulp tissue significantly in contact with dentin. As there is limited literature, further investigations are needed to determine the possible explanations for the incapability of tissue-dissolving effect of OCT solution.

QMix 2in1, which was formulated of EDTA, CHX and a surfactant, is recommended as a final irrigant to remove the smear layer and improve root canal disinfection.[22,23] In addition, a final irrigant should also have a tissue dissolution effect due to pulp tissue remnants in anatomically complex teeth such as dens invaginatus, C-shaped molars, and internal resorption cases, especially in 1-visit endodontic treatment.[24] However, in the present study QMix 2in1 could not significantly dissolve pulp tissue in comparison with NaOCl. Moreover, as expected, QMix 2in1 showed similar tissue-dissolving effect with CHX.

Saline solution was the control in this study. Interestingly, saline solution increased some of sample tissue's weight (data not shown). According to Cobankara *et al*.[31] chloride and sodium ions might be found on the surface of those tissues. However, considering all samples, the weight increase was not statistically significant to our results.

CONCLUSIONS

Within the limitations of this *in vitro* study, NaOCl exhibited the best tissue-dissolving effect out of all solutions tested. QMix 2in1 was as efficient as CHX in dissolving pulp tissue, but both less than NaOCl. On the other hand, OCT could not dissolve pulp tissue significantly at all, nor could saline solution. Future studies may be necessary to confirm these findings.

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Conflicts of interest
There are no conflicts of interest.

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