

Development and Preclinical Evaluation of Preparation Effectiveness for the Treatment of Hard Tooth Tissues after Temporary Filling Removal

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Abstract

Objective: The purpose of this study was development and preclinical study of the effectiveness of antiseptic liquid for the purification of dentinal tubules. Liquid application is planned after extraction from the prepared carious cavity of a temporary filling. According to the recommendations of clinicians, liquid should be sufficiently flowable to penetrate the lumen of the dentinal tubules and wash out fragments of temporary filling materials. At the same time, having an antiseptic effect, it should not change the strength characteristics of tooth hard tissues. **Materials and Methods:** Teeth, removed by orthodontic indications, were sealed with Clip Tripack materials (VOCO, Germany) and Restavrin Tempo (Tehnodent, Russia). Sealed teeth were kept in distilled water. Temporary fillings made of Clip Tripack materials and Restavrin Tempo were removed with an excavator from the teeth. Teeth were divided into two groups. The cavities of the first group of teeth were washed with one of the 12 variants of the test fluid, they were longitudinally sawn, and the surface of the cavity was examined with a scanning electron microscope. The cavities of the second group of teeth were washed with one of the 12 variants of the ultrasound-controlled test fluid, sawed, and microscopized. Visualization assessed the purity of the dentinal canal lumens. In addition, the antiseptic potential of 12 variants of the test liquid was evaluated. **Results:** Five variants of the ratio of components of antiseptic liquid for cleaning dentinal tubules from the remnants of the temporary filling material correspond to the task in hand. **Conclusion:** Antiseptic liquid for cleaning the dentinal tubules, made according to the compositions, in the described variants No. 1, 4, 5, 7, and 10, allows to effectively remove the remnants of the temporary filling material from the lumens of the dentinal tubules. Ultrasound activation reduces the evaporation time of the antiseptic liquid, which reduces the time of the cleaning procedure, and as a consequence, the patient's stay in the chair, while not reducing its effectiveness.

Key words: Dentinal tubules, endodontic treatment, temporary filling materials, ultrasound activation

INTRODUCTION

Improving the algorithms for treating patients suffering from complications of carious disease is a priority area of scientific thought in the field of therapeutic dentistry.^[1,2] The main goal of endodontic therapy is the elimination of pathogens from the carious cavity, the root canal system, and the dentinal tubules. To achieve this goal, walls of carious cavity and root canals are subjected to mechanical treatment.^[3] However, during the mechanical treatment of cavity, thinning of the walls of the carious cavity and root of the tooth is possible,

and decentralization of the channels, formation of cracks, and perforations in the walls are possible.^[4,5] Possibility of iatrogenic errors related to the displacement of the lumen of the root canals and violation of integrity of hard tissues of the

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teeth is a risk factor, should cause the dentist's alertness and, as a consequence, lead to the minimization of the volume of remachining.^[6] When using drugs, it is recommended to follow this procedure during treatment of inflammation of periapical tissues.^[7]

However, it is not advisable to significantly reduce the volume of machining, since the widening of the lumen of the root canal system ensures the possibility of a deep penetration of the preparation, which **ishes** out sawdust and microorganisms. At present, a comparative assessment of irrigation and irrigation algorithms of the root canal system is carried out.^[8,9] In the process of comparative evaluation, different approaches are implemented: Standard irrigation protocols are optimized, irrigation solutions used are combined, and the expediency of using ultrasound is investigated.^[10,11]

Irrigation of the root canal system with chemical preparations changes its geometry and the strength characteristics of the root canal walls, which, on the background of mechanical treatment, increases the likelihood of unfavorable outcomes of endodontic therapy.^[12]

Consequently, the liquid that is irrigated into the hard tissues of the tooth after removing the temporary fill should be sufficiently fluid to remove the fragments of the temporary filling from the lumens of the dentinal tubules, should be bactericidal for fighting infection, and should not destroy hard teeth.

The purpose of the study

The purpose of the study was the selection of the optimal composition of antiseptic liquid for cleaning the dentinal tubules from the remnants of temporary filling materials, including those based on the oligomeric matrix, with an evaporation period of at least 9 min for use with ultrasound activation.

MATERIALS AND METHODS

In the composition of antiseptic liquid, monohydric alcohols and their esters were introduced, allowing the use of the composition with ultrasound activation, perfume, which is an evaporating liquid without residue, an antiseptic additive providing a prolonged bactericidal effect in the restoration area, with the following content:

- Monohydric alcohol 20.0–40.0%
- Antimicrobial additive 0.01–2.0%
- Odorant 1.0–10.0%
- Esters of monohydric alcohol up to 100.0%.

As monohydric alcohol, ethyl, n-propyl, isopropyl alcohols were used, in quality of odorants-their acetates; as an antimicrobial additive used chlorhexidine and its derivatives

(chlorhexidine hydrochloride, chlorhexidine bigluconate, chlorhexidine gluconate, chlorhexidine acetate), as a odorant - amyl acetate and isoamyl acetate, giving the composition a fruity aroma.

The evaporation time of the tested liquid variants was determined by the procedure of GOST 31693–2012. In a Petri dish, kept in a thermostat for 1 h at a temperature of $37 \pm 1^\circ\text{C}$, 1.0 ml of liquid was added and a stopwatch included. On visual disappearance of the liquid, the cup was placed on a scale (weighing accuracy 0.01 g) and the weight change was monitored. The stopwatch was turned off when the cup weight became constant. The time elapsed from the moment the liquid was introduced until constant weight was reached which was taken during the evaporation time. Liquids evaporating for 9–10 min were re-examined by activating them with ultrasound. For further research, liquids evaporated within 3–5 min were selected.

The ability of the fluids to clean the dentinal tubules was evaluated based on the scanning electron microscope imaging at a magnification of 1500 times and the field of view of $183 \mu\text{m}^2$. For this purpose, the ratio of the number of gaping lumens of the dentinal tubules to the amount of dentinal tubules, "closed" by the filling material (having particles of a filling material in the lumen), was calculated. Cleansing ability was assessed in points: 0 points - 90–100% of dentinal tubules were closed by particles of temporary filling material after treatment with liquid; 1 point - 50–90%, 2 points - 10–50%, and 3 points - 0–10%.

To perform the laboratory tests, 144 teeth were immersed for 24 h in distilled water, and cavities were formed in the crowns of teeth, which were sealed with Clip Tripack materials ($n = 72$) and Restavrin Tempo ($n = 72$). Sealed teeth were kept in distilled water at a temperature of $37 \pm 1^\circ\text{C}$ for 10 days. For 36 temporary fillings of Clip Tripack and Restavrin Tempo materials, the excavator was removed and the cavity was washed for 4–5 min with one of the 12 variants of the test fluid, the teeth were longitudinally sawn, and the surface of the cavity was examined with a scanning electron microscope. Of the remaining 72 teeth, the fillings were removed by the excavator for 4–5 min, and the cavity was rinsed with one of the 12 variants of the ultrasound-controlled test fluid. Teeth were sawed, microscopic.

To identify the antibacterial activity of the test liquid variants, microorganisms most frequently found in dental practice, such as *Enterobacter* spp., *Staphylococcus aureus*, and *Streptococcus* spp., were sown in nutrient media by conventional methods.^[13] In the bacteriological laboratory, several series of experiments were conducted, in which the control culture was used without addition of the test liquid to the nutrient media and experimental crops with the addition of one of the variants of the test liquid. Antibacterial properties were investigated after exposure during the evaporation time of liquids. To determine the microbicidal activity of

the proposed composition, the sensitivity of bacteria to the variants of the test fluid was determined. For this purpose, a bacterial suspension was prepared from a culture of microorganisms grown on a dense nutrient medium. The turbidity was determined according to the standard for the optical standardization of bacteria (LA Tarasevich GISK, ISO 42-28-86-07). The densitometer was measured according to the international standard, which corresponds to a theoretical optical density of 0.18 ± 0.02 (BaSO_4 concentration 5.5×10^{-5} mol/l) when measured by FEC on an interference filter at a wavelength (540 ± 1) nm, and the working length of the cuvette is 5 mm with a confidence probability of 0.95. In tubes with variants of the tested liquid, 0.1 ml of a microbial suspension was introduced and mixed with shaking for a few seconds, then held for a time defined as the evaporation time of the liquid, neutralized, and seeded on a dense nutrient medium. The plates were incubated at $37 \pm 1^\circ\text{C}$. After the time necessary for the cultivation of microorganisms of this species, the growth of the colonies was evaluated. In Table 1, the growth and absence of growth of strains of microorganisms are indicated by the signs “+” and “-,” respectively.

Variants of the proposed liquid were prepared in a mixer at room temperature. Pre-weighed liquids in the closed containers were mixed: A monohydric alcohol, a monohydric alcohol ester, a perfume, and then the antiseptic additive were added and mixed until it dissolved and a clear liquid with a characteristic odor was obtained. The evaporation time of the obtained compositions was checked with activation and without activation by ultrasound, as well as the antimicrobial activity and the degree of purity of the hard tissues of the cavity of the removed tooth after treatment with the variants of the activated and not activated liquid. We considered the

following combinations of ingredients:

- Variant No. 1: The components were mixed according to the claimed content: 30.0 g of isopropyl alcohol, 64.0 g of ethyl acetate, and 5.0 g of isoamyl acetate. Then, 1.0 g of chlorohexidine acetate was added and mixed until a clear liquid was obtained.
- Variant No. 2: The components were mixed in the following ratio: 50.0 g of isopropyl alcohol, 44.0 g of ethyl acetate, and 5.0 g of isoamyl acetate. Then, 1.0 g of chlorohexidine acetate was added and mixed until a clear liquid was obtained.
- Variant No. 3: The components were mixed in the following ratio: 10.0 g of isopropyl alcohol, 84.0 g of ethyl acetate, and 5.0 g of isoamyl acetate. Then, 1.0 g of chlorohexidine acetate was added and mixed until a clear liquid was obtained.
- Variant No. 4: The components were mixed according to the claimed content: 30.0 g of n-propyl alcohol, 64.0 g of ethyl acetate, and 5.0 g of isoamyl acetate. Then, 1.0 g of chlorhexidine hydrochloride was added and mixed until a clear liquid was obtained.
- Variant No. 5: The components were mixed according to the claimed content: 35.0 g of ethyl alcohol, 59.0 g of ethyl acetate, and 10.0 g of isoamyl acetate. Then, 0.1 g of chlorhexidine bigluconate was added and mixed until a clear liquid was obtained.
- Variant No. 6: The components were mixed in the following ratio: 30.0 g of isopropyl alcohol, 64.991 g of ethyl acetate, and 5.0 g of isoamyl acetate. Then, 0.009 g of chlorohexidine acetate was added and mixed until a clear liquid was obtained.
- Variant No. 7: The components were mixed in the following ratio: 30.0 g of n-propyl alcohol, 59.0 g of

Table 1: Clinical and laboratory parameters of antiseptic liquid for purification of dentinal tubules at different ratio of ingredients

Examples	Indicator names				
	Evaporation time (min)*	Evaporation time with activation (min)*	Growth of strains	Degree of cleanliness of dentinal tubules after washing with liquid (point)	
				Not activated by ultrasound	Activated by ultrasound
Variant No. 1	9.67±1.15	4.91±1.37	-	2	3
Variant No. 2	3.47±0.86	0.53±0.19	-	0	0
Variant No. 3	15.2±1.71	8.25±1.91	-	0	1
Variant No. 4	9.57±1.87	3.57±0.82	-	2	3
Variant No. 5	9.28±1.94	4.16±0.73	-	1	3
Variant No. 6	9.01±1.61	4.54±0.58	+	0	2
Variant No. 7	9.63±1.35	4.88±0.73	-	2	3
Variant No. 8	18.31±1.54	9.25±1.04	-	1	2
Variant No. 9	9.93±3.01	3.82±1.46	-	0	0
Variant No. 10	9.82±1.58	4.31±1.17	-	2	3
Variant No. 11	15.44±3.79	6.57±2.21	+	0	1
Variant No. 12	13.28±2.04	5.76±1.37	+	2	2

*The differences in evaporation time are reliable ($P < 0.05$)

propyl acetate, and 10.0 g of isoamyl acetate. Then, 1.0 g of chlorhexidine was added and mixed until a clear liquid was obtained.

- Variant No. 8: The components were mixed in the following ratio: 30.0 g isopropyl alcohol, 54.0 g ethyl acetate, and 15.0 g amyl acetate. Then, 1.0 g of chlorhexidine acetate was added and mixed until a clear liquid was obtained.
- Variant No. 9: The components were mixed in the following ratio: 30.0 g isopropyl alcohol, 64.0 g ethyl acetate, and 3.0 g isoamyl acetate. Then, 3.0 g of chlorhexidine was added and mixed. After a long stirring, an opaque liquid was obtained due to the non-dissolved antiseptic additive.
- Variant No. 10: The components were mixed in the following ratio: 30.0 g isopropyl alcohol, 62.0 g isopropyl acetate, and 7.0 g amyl acetate. Then, 1.0 g of chlorhexidine gluconate was added and mixed until a clear liquid was obtained.
- Variant No. 11: The components were mixed in the following ratio: 3.0 g of isopropyl alcohol, 30.0 g of ethyl acetate, and 66.0 g of isoamyl acetate. Then, 1.0 g of chlorhexidine was added and mixed. After a long stirring, an opaque liquid was obtained due to the non-dissolved antiseptic additive.
- Variant No. 12: The components were mixed in the following ratio: 10.0 g of n-propyl alcohol, 36.9999 g propyl acetate, and 53.0 g isoamyl acetate. Then, 0.0001 g of chlorhexidine was added and mixed. After mixing, a clear liquid with a characteristic odor was obtained.

RESULTS

Within the limits of the estimated ratios, liquids significantly differing in clinical and laboratory parameters were obtained [Table 1].

For example, after mechanical removal of the temporary restorative material from the formed cavity restavrin tempo and its washing with liquid (variant No. 12), the second degree of purity of the dentinal tubules is revealed [Figure 1]. The ultrasound activation of this composition did not lead to a significant increase in the purity of the dentinal tubules.

Treatment of the cavity with liquid (variant No. 7) without ultrasound activation led to a second degree of purity of the dentinal tubules. Against the background of the application of ultrasound, three points of purity of the dentinal tubules are achieved [Figure 2].

CONCLUSION

The possibility of achieving a given frequency of the dentinal tubules, as a rule, increases with the use of ultrasound

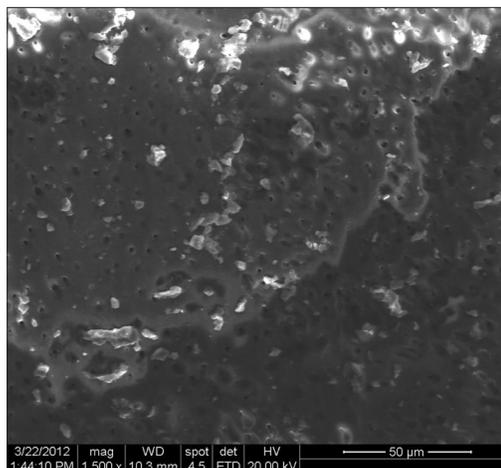


Figure 1: The second degree of purity of the dentinal tubules after treatment of the cavity with liquid (variant No. 12), ×1500

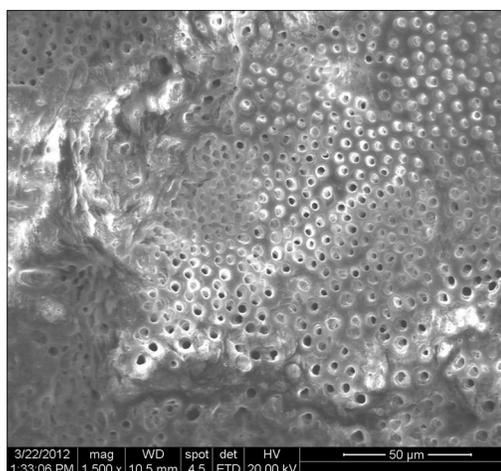


Figure 2: Yawning lumens of the dentinal tubules after irrigation and treatment of the cavity with liquid (variant No. 7), ×1500

activation, while the optimal ratio of components that make up the liquid should be considered as the fundamental factor.

Antiseptic liquid for cleaning the dentinal tubules, made according to the compositions, in the described variants No. 1, 4, 5, 7, 10, allows to effectively remove the remnants of the temporary filling material from the lumens of the dentinal tubules.

Ultrasound activation reduces the evaporation time of the antiseptic liquid, which reduces the time of the cleaning procedure, and as a consequence - the patient's stay in the chair, while not reducing its effectiveness.

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