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Экспериментально обоснованный выбор раствора оптимального антисептика для гигиенического ухода за полостью рта и зубными протезами

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АННОТАЦИЯ

Введение. Ассортимент антисептических средств, применяемых в клинической практике врача-стоматолога, весьма велик. Однако лишь единичные исследования посвящены сравнительной характеристике их эффективности в условиях полости рта.

Цель. Выбрать оптимальное очищающее антисептическое средство путем экспериментального исследования.

Материалы и методы. В качестве жидкостей-омывателей для очищения от зубного налёта использованы водный раствор Фурацилина® (0,02%), хлоргексидина биглюконат (0,05%), Мирамистин® (0,01%), цетилпиридиния хлорид (0,05%), перекись водорода (3%), Йодинол®, Ротокан®, дистиллированная вода. Модель зубного ряда была создана из кварцевых пластин с имитацей свежего зубного налета. Биоматериал, имитирующий зубной налет, включал в себя два раствора: 1) крепкий свежий настой листьев чёрного чая, остывший до температуры +25°С; 2) овсяный кисель при температуре от +60°С до +65°С. Использован авторский способ скрининга стоматологических очистителей, основанный на сравнении прозрачности лабораторной модели зубного ряда до и после воздействия на неё исследуемого раствора посредством определения с помощью амперметра силы электрического тока в фотосенсорном устройстве от датчика оксигемографа при падении на него белого света, испускаемого мини-излучателем и прошедшего сквозь биологический материал и пластины.

Результаты. Очищающая способность дистиллированной воды самая низкая ($p < 0,05–0,001$). Ротокан®, Фурацилин® и Йодинол® обладают невысокой очищающей способностью, а Йодинол® может вызывать ожог десневой манжетки при повышенной реакции к нему и аллергические реакции. Средней степенью эффективности обладает перекись водорода, но она пересушивает слизистую оболочку рта. Самым высоким очищающим эффектом обладал хлоргексидина биглюконат, несколько уступали ему Мирамистин® и цетилпиридиния хлорид ($p > 0,05$). Раствор хлоргексидина биглюконата значительно превосходил по очищающей способности перекись водорода ($p < 0,05$), Йодинол® ($p < 0,02$), Фурацилин® ($p < 0,02$), Ротокан® ($p < 0,01$).

Заключение. Описанный способ получил патент Российской Федерации на изобретение № 2019121293. Проведенные экспериментальные исследования показали, что наилучшим очищающим эффектом обладает раствор хлоргексидина биглюконата 0,05%.

Ключевые слова: *зубной налет; хлоргексидина биглюконат; рот; антисептическое средство для полости рта; модель зубного налета; зубные протезы*

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Experimentally Justified Choice of Optimal Antiseptic Solution for Hygienic Care of Oral Cavity and Dentures

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ABSTRACT

INTRODUCTION: The range of antiseptic agents used in clinical practice, is rather wide. However, only single studies are devoted to comparative characteristics of their effectiveness in the conditions of the oral cavity.

AIM: To choose the optimal antiseptic dental cleaner by experimental study.

MATERIALS AND METHODS: An aqueous solution of Furacilin® (0.02%), chlorhexidine bigluconate (0.05%), Miramistin® (0.01%), cetylpyridinium chloride (0.05%), hydrogen peroxide (3%), Iodinol®, Rotokan®, distilled water were used as washing liquids for elimination of dental plaque. The model of the dentition was created from quartz plates with an imitation of fresh plaque. Biomaterial imitating dental plaque included two solutions: 1) a strong fresh infusion of black tea leaves, cooled to +25°C; 2) oatmeal jelly with temperature from +60°C to +65°C. The authors' method of screening dental cleaners was used, based on comparing the transparency of the laboratory model of the dentition before and after exposure to the test solution by determination with an amperemeter of strength of the electric current in the photosensor device from the oxyhemograph sensor after white light emitted by a mini-emitter passed through biological material and plates and fell on it.

RESULTS: The cleaning capacity of distilled water is the lowest ($p < 0.05$–0.001). Rotokan®, Furacilin® and Iodinol® have a low cleaning capacity, and Iodinol® can cause a burn of the gingival cuff in case of high reaction to it, and allergic reactions. Hydrogen peroxide has an average degree of efficiency, but it dries the oral mucosa. Chlorhexidine bigluconate has the highest cleaning effect, Miramistin® and cetylpyridinium chloride are slightly inferior to it ($p > 0.05$). By the cleaning capacity, chlorhexidine bigluconate solution is significantly superior to hydrogen peroxide ($p < 0.05$), Iodinol® ($p < 0.02$), Furacilin® ($p < 0.02$), Rotokan® ($p < 0.01$).

CONCLUSION: The described method received the patent for invention of the Russian Federation No. 2019121293. Experimental studies have shown the best cleaning effect of 0.05% solution of chlorhexidine bigluconate.

Keywords: *dental plaque; chlorhexidine bigluconate; mouth; antiseptic agent for the oral cavity; plaque model; dentures*

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ECO•VECTOR

INTRODUCTION

A range of antiseptic drugs used in the clinical practice of a dentist, is rather wide. In connection with a new coronavirus infection caused by SARS-CoV-2, the question of the choice of an antiseptic for the oral cavity is raised by many researchers [1, 2]. For the highest effectiveness, the method of use of antiseptic liquids, concentration of active substances in dental rinses should be determined depending on the dental and general somatic status of the patient [3–6].

Chlorhexidine bigluconate solution in various concentrations (from 0.05% to 2%) is widely used for individual oral hygiene and for therapeutic purposes in patients with removable and non-removable dentures (including implanted ones), non-removable orthodontic devices [7–11]. The effectiveness of chlorhexidine bigluconate solution against *Candida* fungi has been shown [12]. Its use before and after surgical interventions in the oral cavity, as well as during dental implantation and endodontic treatment reduces the risk of complications [13–16]. A number of publications present the results of comparative clinical and experimental studies of antiseptic properties and virucidal effect of solutions of hydrogen peroxide, chlorhexidine bigluconate and a complex of iodine with polyvinylpyrrolidone [17, 18]. An alcohol solution of chlorhexidine bigluconate is successfully used for disinfection of the skin [19].

However, only single studies are devoted to comparative characteristics of the effectiveness of solutions in conditions of the oral cavity.

The **aim** of this study was to select the optimal antiseptic cleaning solution by means of experimental study.

MATERIALS AND METHODS

To remove the dental plaque, the following mouthwashes were used:

- aqueous solution of Furacilin® (0.02%);
- chlorhexidine bigluconate (0.05%);
- Miramistin® (0.01%);
- cetylpyridinium chloride (0.05%);
- hydrogen peroxide (3%);
- Iodinol®;
- Rotokan®;
- distilled water.

Dental plaque was imitated by biomaterial that included two solutions:

1) strong fresh infusion of black tea leaves (four teaspoons per 180 g of boiling water) cooled to + 25°C;

2) oatmeal jelly at temperature +60°C ... +65°C.

The tea infusion was the ground for the studied object promoting retention of oatmeal jelly on it. Both solutions created a grayish-green film on the object. The proposed imitator of dental plaque was analogous in composition to a fresh dental plaque that forms on the brushed teeth of most people after breakfast, since many people on the planet eat warm porridge in the morning and drink a cup of tea.

Use of the tooth plaque imitator increased the speed, safety and accuracy of the experiment, since it excluded infection of the experimenter with infectious diseases and standardized the technology of screening.

The model of the dentition consisted of 4 plates, firmly fixed with the narrow edges on a common base in one row, across the base and perpendicular to its surface with 2 mm intervals, parallel and in mirror-like manner to each other. Each plate had 2 mm thickness, 4 mm width and 10 mm height. The plates were made of colorless transparent silica glass in the form of flat rectangular sheets (Figure 1).

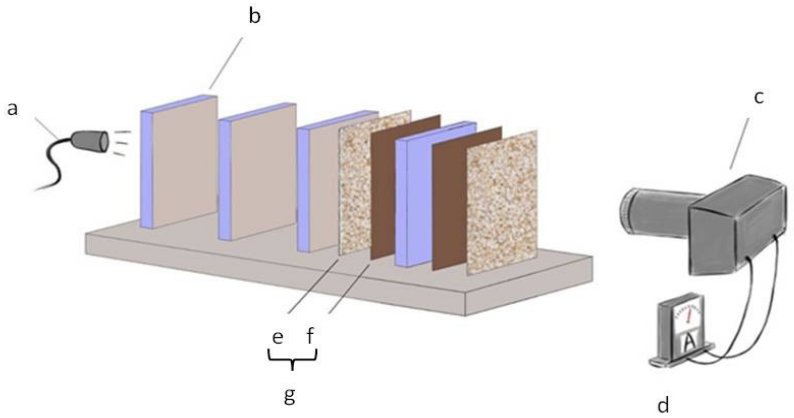

Fig. 1. Experimental set-up: light source (a); one of four glass plates imitating front teeth (b); photocell (c) connected with ammeter (d); oatmeal decoction (e); a film (f) of black tea imitating tooth plaque (g).

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The quartz plates-imitators of the front teeth were fully and alternately immersed (for 1–2 sec) first in the tea infusion, then in the jelly. The model was held with the plates down to drain the excessive biomaterial, and the plates were dried with a hairdryer.

The proposed method of screening of dental cleaners is based on comparison of transparency of the laboratory model of the dentition before and after exposure to the studied solution. For this, the force of electric current from oxyhemograph sensor was determined with ammeter of photocell in complete darkness when white the light from a mini-emitter fell on it after passing through the biomaterial and plates.

In the analysis of the results obtained, it was assumed that decrease in the strength of the photocurrent evidences increase in the content of light-absorbing biomaterial. The intensity of light passing through the transparent plates was recorded before, immediately after application of a plaque simulator to their surface and after irrigating the surface of the plates for two minutes with the test agent heated first to temperature of +43°C, and then to +65°C, using an oral irrigator. The technical result was a rapid assessment of the cleaning activity of the antiseptic agent under standard laboratory conditions.

We will comment and speak in detail about some technical aspects of the described method. Thus, the photocurrent, as said above, was determined by measuring the electric current in the photocell with the ammeter when light with the constant wavelength and intensity given off by the emitter fell on it. With their contours, dimensions and volume, the glass plates imitated the permanent upper incisors.

In our method, a commercial external pulse oximeter sensor was used, designed to be applied to the finger of the hand based on the maximum diameter of the male index finger 15 mm. An excessive increase or decrease in the gap between the light source and the photocell in the pulse oximeter sensor reduces the accuracy of the results obtained. As shown above, the proposed model of the dentition consisted of four plates 2 mm thick and three 2 mm spaces between them. The total distance between the extreme surfaces of the artificial dentition plates was 14 mm, which is optimal for evaluation of the total transparency of the transilluminated object with a food product on its eight surfaces. All this made it possible to determine even minimal traces of contamination.

The reservoir of the irrigator was filled with a solution of antiseptic washer heated in some cases to +43°C, in others — до +65°C. On the exit of the tip, the solution cooled down by 6°C to the temperature +37°...+38°C and +59°...+60°C, respectively. This range is justified by enhancement of bleaching and cleaning. On the other hand, this temperature is safe for the oral and pharyngeal mucosa. Nevertheless, in clinical conditions it is more convenient to use solution temperature +37°...+38°C, and to use the upper values to accelerate the experiment.

At first, after measurement in complete darkness, a light source was turned on. Using this light source, and also a photo sensor connected to a highly sensitive ammeter with wires, the intensity of light passing through a transparent model was determined. At the same time, the light source and the photo sensor were installed and fixed against each other at a distance that allowed placing the model between them. The intensity of the light passing through the plates was determined by the strength of current generated in the photo sensor. The strength of current in the control measurement for transparent plates was taken for 100% of the light intensity.

Similar measurements were conducted after application of the tooth plaque imitator and also after bathing of the plates for two minutes with antiseptic solution to clean the model. For each mouthwash, 3 experiments were conducted, after which the average parameter of light intensity was determined.

Between experiments, the models were cleaned with a single-bundle toothbrush, interdental brushes, were rinsed and wiped dry with filter paper and soft non-woven fabric. After application of the imitator, the intensity decreased to 81%–83%, on average to 82.0 ± 0.5%.

RESULTS

A study of antiseptic cleaners (Table 1) showed that, firstly, different temperatures of heating the solution did not change its cleaning capacity ($p > 0.05$); secondly, the cleaning capacity of distilled water was the lowest being significantly inferior to all other tested solutions ($p < 0.05$–0.001); thirdly, Rotokan®, Furacilin® and Iodinol® demonstrated low target qualities. In addition, the latest cleaners are colored, and Iodinol® could cause a burn of the gingival cuff in case of increased reaction to it and allergic reactions. Hydrogen peroxide had an average degree of efficiency. Besides, it dries the oral mucosa, so it was *excluded from the list of the optimal means*.

Chlorhexidine bigluconate showed the highest cleaning effect. Miramistin® and cetylpyridinium chloride were slightly inferior to it. However, this was not statistically confirmed ($p > 0.05$). In addition, the latter can cause ulcers on the mucous membrane and the appearance of spots on the teeth, and Miramistin® is the most expensive of the above three antiseptics. Therefore, *the first candidate for number one modern dental cleaner still remains chlorhexidine bigluconate*. At the same time, one should note the empirically determined capacity of cetylpyridinium chloride to effectively clean plaque polymer surfaces, so in some cases it was used by us as an alternative antiseptic and cleaner.

Table 1. Intensity of Light Passing through Model with Use of Different Cleaners

No.	Cleaner	Light Intensity (%)		p
		at t° = 65° (59°)C	at t° = 43° (37°)C	
1	Distilled water	84.67 ± 0.58	84. 33 ± 0.34	> 0.05
2	Rotokan®	89.33 ± 1.25	88.00 ± 1.00	> 0.05
3	Furacilin ®	90.50 ± 0.68	89.67 ± 1.05	> 0.05
4	Hydrogen peroxide	93.67 ± 0.75	92.66 ± 1.28	> 0.05
5	Iodinol®	91.67 ± 0.80	91.33 ± 1.10	> 0.05
6	Chlorhexidine bigluconate	96.30 ± 0.68	95.70 ± 0.74	> 0.05
7	Cetylpyridinium chloride	94.70 ± 0.64	94.31 ± 0.62	> 0.05
8	Miramistin®	94.30 ± 0.90	93.70 ± 1.10	> 0.05

Chlorhexidine bigluconate solution significantly surpassed hydrogen peroxide ($p < 0.05$), Iodinol® ($p < 0.02$), Furacilin® ($p < 0.02$), and also Rotokan® ($p < 0.01$) in the cleaning capacity.

DISCUSSION

The problem of the cleaning capacity of mouthwashes is multi-faceted. On the one hand, almost all antiseptic solutions known in dentistry (Iodinol®, chlorhexidine bigluconate, Rotokan®) may encolour teeth by themselves. This problem is solved by different ways, including the addition of special anti-discoloration formulas in the mouthwashes. On the other hand, they possess different basic antiseptic and cleaning properties.

The aim of meta-analysis by B. van Swaaij, et al. (2020) was to study antimicrobial properties of mouthwashes containing chlorhexidine bigluconate and substances preventing discoloration of teeth (*anti-discoloration system*, ADS). It was shown that in case of impossibility of using a toothbrush, the anti-discoloration system reduces the side effect of chlorhexidine bigluconate (discoloration of teeth) while retaining its antiseptic properties [11].

We have shown a good cleaning capacity of chlorhexidine bigluconate. The analysis of the numerous data of international studies of the clinical effectiveness of mouthwashes with chlorhexidine [7–16] and our results speak in favor of choice of this particular solution as the main solution for hygiene of the mouth cavity. But with that, the scientific literature reports local side effects of chlorhexidine bigluconate such as accelerated tartar formation, impairment of taste sensations (hypogeusia), appearance of burning feeling [7–16].

It is for this reason that we propose cetylpyridinium chloride be actively used in clinical practice as the solution with the second highest cleaning capacity. A. S. Arutyunov, et al. (2018) [8] proposed its use in patients with postoperative defects of the oral cavity. In previous studies, we also noted its good cleaning capacity in patients using an implanted structure with a small number of supports and a polymer lining [7].

The work of N. Charadram, et al. (2021) on the development of a unified standard of oral care for elderly patients admitted to long-term care facilities, highlights the results of the consensus achieved by dentists of different countries on some aspects of individual oral hygiene. So, recommendations for elderly patients include removal of dentures at night and keeping them dry, brushing the teeth, interdental spaces and mucous membrane twice a day using toothpaste containing fluoride (5,500 ppm) [4].

The issue of using mouthwash by elderly patients has not been solved. Therefore, our experimental work makes a contribution to search for the optimal mouthwash, also for elderly patients. The described method received the patent of the Russian Federation for invention No. 2019121293 [20]. The result of the experiment was the choice of 0.05% chlorhexidine bigluconate solution as the optimal cleaner for oral hygiene that appeared superior to distilled water and the remaining 6 antiseptic mouthwashes in its basic cleaning action and the absence of side effects.

CONCLUSION

The described method may be used in the search, development and evaluation of new pharmacological,

hygienic, cosmetic means and medical technologies intended for emergency cleaning of the open surfaces of teeth, dentures, implants, orthodontic devices, sports gum-shields.

In the analysis of the obtained results, it was assumed that reduction of the strength of photocurrent evidenced increased content of light-absorbing biomaterial on the surface of the object under study.

The proposed design of the experiment and the used dental plaque simulator not only increased the speed, safety and accuracy of the study, excluding infection of the researcher with infectious diseases, but also standardized the screening technology, ensuring its independence from the need to examine laboratory animals and human volunteers. The described method received the patent of the Russian Federation for invention No. 2019121293.

The 0.05% solution of chlorhexidine bigluconate surpassed distilled water and the remaining 6 solutions of antiseptic mouthwashes in its main cleaning purpose and the absence of side effects.

ADDITIONAL INFORMATION

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Contribution of the authors: *R. A. Rozov* — research concept and design, text writing; *V. N. Trezubov* — processing of the material, writing the text; *V. D. Vagner* — collection and processing of material, statistical processing, writing the text; *A. L. Urakov* — research design and editing; A. P. Reshetnikov — conception and editing. All authors made a substantial contribution to the conception of the work, acquisition, analysis, interpretation of data for the work, drafting and revising the work, final approval of the version to be published and agree to be accountable for all aspects of the work.

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