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ЕЖЕМЕСЯЧНЫЙ НАУЧНЫЙ ЖУРНАЛ

Медицинские новости Грузии

საქართველოს სამედიცინო სიახლენი

GEORGIAN MEDICAL NEWS

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GMN: Georgian Medical News is peer-reviewed, published monthly journal committed to promoting the science and art of medicine and the betterment of public health, published by the GMN Editorial Board since 1994. GMN carries original scientific articles on medicine, biology and pharmacy, which are of experimental, theoretical and practical character; publishes original research, reviews, commentaries, editorials, essays, medical news, and correspondence in English and Russian.

GMN is indexed in MEDLINE, SCOPUS, PubMed and VINITI Russian Academy of Sciences. The full text content is available through EBSCO databases.

GMN: Медицинские новости Грузии - ежемесячный рецензируемый научный журнал, издаётся Редакционной коллегией с 1994 года на русском и английском языках в целях поддержки медицинской науки и улучшения здравоохранения. В журнале публикуются оригинальные научные статьи в области медицины, биологии и фармации, статьи обзорного характера, научные сообщения, новости медицины и здравоохранения. Журнал индексируется в MEDLINE, отражён в базе данных SCOPUS, PubMed и ВИНИТИ РАН. Полнотекстовые статьи журнала доступны через БД EBSCO.

GMN: Georgian Medical News – საქართველოს სამედიცინო სიახლენი – არის ყოველთვიური სამეცნიერო სამედიცინო რეცენზირებადი ჟურნალი, გამოიცემა 1994 წლიდან, წარმოადგენს სარედაქციო კოლეგიისა და აშშ-ის მეცნიერების, განათლების, ინდუსტრიის, ხელოვნებისა და ბუნებისმეტყველების საერთაშორისო აკადემიის ერთობლივ გამოცემას. GMN-ში რუსულ და ინგლისურ ენებზე ქვეყნდება ექსპერიმენტული, თეორიული და პრაქტიკული ხასიათის ორიგინალური სამეცნიერო სტატიები მედიცინის, ბიოლოგიისა და ფარმაციის სფეროში, მიმოხილვითი ხასიათის სტატიები.

ჟურნალი ინდექსირებულია MEDLINE-ის საერთაშორისო სისტემაში, ასახულია SCOPUS-ის, PubMed-ის და ВИНИТИ РАН-ის მონაცემთა ბაზებში. სტატიების სრული ტექსტი ხელმისაწვდომია EBSCO-ს მონაცემთა ბაზებიდან.

WEBSITE

www.geomednews.com

К СВЕДЕНИЮ АВТОРОВ!

При направлении статьи в редакцию необходимо соблюдать следующие правила:

1. Статья должна быть представлена в двух экземплярах, на русском или английском языках, напечатанная через **полтора интервала на одной стороне стандартного листа с шириной левого поля в три сантиметра**. Используемый компьютерный шрифт для текста на русском и английском языках - **Times New Roman** (**Кириллица**), для текста на грузинском языке следует использовать **AcadNusx.** Размер шрифта - **12**. К рукописи, напечатанной на компьютере, должен быть приложен CD со статьей.

2. Размер статьи должен быть не менее десяти и не более двадцати страниц машинописи, включая указатель литературы и резюме на английском, русском и грузинском языках.

3. В статье должны быть освещены актуальность данного материала, методы и результаты исследования и их обсуждение.

При представлении в печать научных экспериментальных работ авторы должны указывать вид и количество экспериментальных животных, применявшиеся методы обезболивания и усыпления (в ходе острых опытов).

4. К статье должны быть приложены краткое (на полстраницы) резюме на английском, русском и грузинском языках (включающее следующие разделы: цель исследования, материал и методы, результаты и заключение) и список ключевых слов (key words).

5. Таблицы необходимо представлять в печатной форме. Фотокопии не принимаются. **Все цифровые, итоговые и процентные данные в таблицах должны соответствовать таковым в тексте статьи**. Таблицы и графики должны быть озаглавлены.

6. Фотографии должны быть контрастными, фотокопии с рентгенограмм - в позитивном изображении. Рисунки, чертежи и диаграммы следует озаглавить, пронумеровать и вставить в соответствующее место текста **в tiff формате**.

В подписях к микрофотографиям следует указывать степень увеличения через окуляр или объектив и метод окраски или импрегнации срезов.

7. Фамилии отечественных авторов приводятся в оригинальной транскрипции.

8. При оформлении и направлении статей в журнал МНГ просим авторов соблюдать правила, изложенные в «Единых требованиях к рукописям, представляемым в биомедицинские журналы», принятых Международным комитетом редакторов медицинских журналов - http://www.spinesurgery.ru/files/publish.pdf и http://www.nlm.nih.gov/bsd/uniform_requirements.html
В конце каждой оригинальной статьи приводится библиографический список. В список литературы включаются все материалы, на которые имеются ссылки в тексте. Список составляется в алфавитном порядке и нумеруется. Литературный источник приводится на языке оригинала. В списке литературы сначала приводятся работы, написанные знаками грузинского алфавита, затем кириллицей и латиницей. Ссылки на цитируемые работы в тексте статьи даются в квадратных скобках в виде номера, соответствующего номеру данной работы в списке литературы. Большинство цитированных источников должны быть за последние 5-7 лет.

9. Для получения права на публикацию статья должна иметь от руководителя работы или учреждения визу и сопроводительное отношение, написанные или напечатанные на бланке и заверенные подписью и печатью.

10. В конце статьи должны быть подписи всех авторов, полностью приведены их фамилии, имена и отчества, указаны служебный и домашний номера телефонов и адреса или иные координаты. Количество авторов (соавторов) не должно превышать пяти человек.

11. Редакция оставляет за собой право сокращать и исправлять статьи. Корректура авторам не высылается, вся работа и сверка проводится по авторскому оригиналу.

12. Недопустимо направление в редакцию работ, представленных к печати в иных издательствах или опубликованных в других изданиях.

При нарушении указанных правил статьи не рассматриваются.

REQUIREMENTS

Please note, materials submitted to the Editorial Office Staff are supposed to meet the following requirements:

1. Articles must be provided with a double copy, in English or Russian languages and typed or compu-ter-printed on a single side of standard typing paper, with the left margin of **3** centimeters width, and **1.5** spacing between the lines, typeface - **Times New Roman** (**Cyrillic**), print size - **12** (referring to Georgian and Russian materials). With computer-printed texts please enclose a CD carrying the same file titled with Latin symbols.

2. Size of the article, including index and resume in English, Russian and Georgian languages must be at least 10 pages and not exceed the limit of 20 pages of typed or computer-printed text.

3. Submitted material must include a coverage of a topical subject, research methods, results, and review.

Authors of the scientific-research works must indicate the number of experimental biological species drawn in, list the employed methods of anesthetization and soporific means used during acute tests.

4. Articles must have a short (half page) abstract in English, Russian and Georgian (including the following sections: aim of study, material and methods, results and conclusions) and a list of key words.

5. Tables must be presented in an original typed or computer-printed form, instead of a photocopied version. **Numbers, totals, percentile data on the tables must coincide with those in the texts of the articles.** Tables and graphs must be headed.

6. Photographs are required to be contrasted and must be submitted with doubles. Please number each photograph with a pencil on its back, indicate author's name, title of the article (short version), and mark out its top and bottom parts. Drawings must be accurate, drafts and diagrams drawn in Indian ink (or black ink). Photocopies of the X-ray photographs must be presented in a positive image in **tiff format**.

Accurately numbered subtitles for each illustration must be listed on a separate sheet of paper. In the subtitles for the microphotographs please indicate the ocular and objective lens magnification power, method of coloring or impregnation of the microscopic sections (preparations).

7. Please indicate last names, first and middle initials of the native authors, present names and initials of the foreign authors in the transcription of the original language, enclose in parenthesis corresponding number under which the author is listed in the reference materials.

8. Please follow guidance offered to authors by The International Committee of Medical Journal Editors guidance in its Uniform Requirements for Manuscripts Submitted to Biomedical Journals publication available online at: http://www.nlm.nih.gov/bsd/uniform_requirements.html
http://www.icmje.org/urm_full.pdf
In GMN style for each work cited in the text, a bibliographic reference is given, and this is located at the end of the article under the title "References". All references cited in the text must be listed. The list of references should be arranged alphabetically and then numbered. References are numbered in the text [numbers in square brackets] and in the reference list and numbers are repeated throughout the text as needed. The bibliographic description is given in the language of publication (citations in Georgian script are followed by Cyrillic and Latin).

9. To obtain the rights of publication articles must be accompanied by a visa from the project instructor or the establishment, where the work has been performed, and a reference letter, both written or typed on a special signed form, certified by a stamp or a seal.

10. Articles must be signed by all of the authors at the end, and they must be provided with a list of full names, office and home phone numbers and addresses or other non-office locations where the authors could be reached. The number of the authors (co-authors) must not exceed the limit of 5 people.

11. Editorial Staff reserves the rights to cut down in size and correct the articles. Proof-sheets are not sent out to the authors. The entire editorial and collation work is performed according to the author's original text.

12. Sending in the works that have already been assigned to the press by other Editorial Staffs or have been printed by other publishers is not permissible.

Articles that Fail to Meet the Aforementioned Requirements are not Assigned to be Reviewed.

ავტორთა საყურადღებოდ!

რედაქციაში სტატიის წარმოდგენისას საჭიროა დავიცვათ შემდეგი წესები:

1. სტატია უნდა წარმოადგინოთ 2 ცალად, რუსულ ან ინგლისურ ენებზე,დაბეჭდილი სტანდარტული ფურცლის 1 გვერდზე, 3 სმ სიგანის მარცხენა ველისა და სტრიქონებს შორის 1,5 ინტერვალის დაცვით. გამოყენებული კომპიუტერული შრიფტი რუსულ და ინგლისურენოვან ტექსტებში - **Times New Roman (Кириллица)**, ხოლო ქართულენოვან ტექსტში საჭიროა გამოვიყენოთ **AcadNusx.** შრიფტის ზომა – 12. სტატიას თან უნდა ახლდეს CD სტატიით.

2. სტატიის მოცულობა არ უნდა შეადგენდეს 10 გვერდზე ნაკლებს და 20 გვერდზე მეტს ლიტერატურის სიის და რეზიუმეების (ინგლისურ, რუსულ და ქართულ ენებზე) ჩათვლით.

3. სტატიაში საჭიროა გაშუქდეს: საკითხის აქტუალობა; კვლევის მიზანი; საკვლევი მასალა და გამოყენებული მეთოდები; მიღებული შედეგები და მათი განსჯა. ექსპერიმენტული ხასიათის სტატიების წარმოდგენისას ავტორებმა უნდა მიუთითონ საექსპერიმენტო ცხოველების სახეობა და რაოდენობა; გაუტკივარებისა და დაძინების მეთოდები (მწვავე ცდების პირობებში).

4. სტატიას თან უნდა ახლდეს რეზიუმე ინგლისურ, რუსულ და ქართულ ენებზე არანაკლებ ნახევარი გვერდის მოცულობისა (სათაურის, ავტორების, დაწესებულების მითითებით და უნდა შეიცავდეს შემდეგ განყოფილებებს: მიზანი, მასალა და მეთოდები, შედეგები და დასკვნები; ტექსტუალური ნაწილი არ უნდა იყოს 15 სტრიქონზე ნაკლები) და საკვანძო სიტყვების ჩამონათვალი (key words).

5. ცხრილები საჭიროა წარმოადგინოთ ნაბეჭდი სახით. ყველა ციფრული, შემაჯამებელი და პროცენტული მონაცემები უნდა შეესაბამებოდეს ტექსტში მოყვანილს.

6. ფოტოსურათები უნდა იყოს კონტრასტული; სურათები, ნახაზები, დიაგრამები - დასათაურებული, დანომრილი და სათანადო ადგილას ჩასმული. რენტგენოგრამების ფოტოასლები წარმოადგინეთ პოზიტიური გამოსახულებით **tiff** ფორმატში. მიკროფოტოსურათების წარწერებში საჭიროა მიუთითოთ ოკულარის ან ობიექტივის საშუალებით გადიდების ხარისხი, ანათალების შეღებვის ან იმპრეგნაციის მეთოდი და აღნიშნოთ სურათის ზედა და ქვედა ნაწილები.

7. სამამულო ავტორების გვარები სტატიაში აღინიშნება ინიციალების თანდართვით, უცხოურისა – უცხოური ტრანსკრიპციით.

8. სტატიას თან უნდა ახლდეს ავტორის მიერ გამოყენებული სამამულო და უცხოური შრომების ბიბლიოგრაფიული სია (ბოლო 5-8 წლის სიღრმით). ანბანური წყობით წარმოდგენილ ბიბლიოგრაფიულ სიაში მიუთითეთ ჯერ სამამულო, შემდეგ უცხოელი ავტორები (გვარი, ინიციალები, სტატიის სათაური, ჟურნალის დასახელება, გამოცემის ადგილი, წელი, ჟურნალის №, პირველი და ბოლო გვერდები). მონოგრაფიის შემთხვევაში მიუთითეთ გამოცემის წელი, ადგილი და გვერდების საერთო რაოდენობა. ტექსტში კვადრატულ ფჩხილებში უნდა მიუთითოთ ავტორის შესაბამისი N ლიტერატურის სიის მიხედვით. მიზანშეწონილია, რომ ციტირებული წყაროების უმეტესი ნაწილი იყოს 5-6 წლის სიღრმის.

9. სტატიას თან უნდა ახლდეს: ა) დაწესებულების ან სამეცნიერო ხელმძღვანელის წარდგინება, დამოწმებული ხელმოწერითა და ბეჭდით; ბ) დარგის სპეციალისტის დამოწმებული რეცენზია, რომელშიც მითითებული იქნება საკითხის აქტუალობა, მასალის საკმაობა, მეთოდის სანდოობა, შედეგების სამეცნიერო-პრაქტიკული მნიშვნელობა.

10. სტატიის ბოლოს საჭიროა ყველა ავტორის ხელმოწერა, რომელთა რაოდენობა არ უნდა აღემატებოდეს 5-ს.

11. რედაქცია იტოვებს უფლებას შეასწოროს სტატია. ტექსტზე მუშაობა და შეჯერება ხდება საავტორო ორიგინალის მიხედვით.

12. დაუშვებელია რედაქციაში ისეთი სტატიის წარდგენა, რომელიც დასაბეჭდად წარდგენილი იყო სხვა რედაქციაში ან გამოქვეყნებული იყო სხვა გამოცემებში.

აღნიშნული წესების დარღვევის შემთხვევაში სტატიები არ განიხილება.

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COMPARATIVE ANALYSIS OF ENAMEL SURFACE WEAR INDUCED BY TWO CONCENTRATIONS OF ZIRCONIA PARTICLE TOOTHPASTE UNDER TWO ELECTRIC TOOTHBRUSHING MODALITIES

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Abstract.

Background: Dental enamel, the outermost layer of human teeth, is a mineralized tissue that must endure repetitive forces, wear, and corrosion resulting from everyday oral activities like chewing. Its high mineral content provides the strength and hardness necessary for proper tooth function. However, over time, wear, fractures, or cavities often lead to the need for dental repairs. Additionally, unlike other human tissues, dental enamel lacks significant regenerative or self-repair capabilities, making tooth restorations more essential.

Objective: To evaluate the effects of two electric toothbrush modalities and two different concentrations of zirconia-containing whitening toothpaste on enamel surface roughness.

Materials and Methods: Forty extracted lower third molars were divided into four groups based on toothpaste concentration (3% and 4% zirconia) and brushing mode (active and soft). Each tooth was brushed for 5 minutes using an oscillating electric toothbrush. Enamel surface roughness was measured before and after brushing using a contact profilometer.

Results: Brushing with 4% zirconia toothpaste in active mode resulted in the highest increase in enamel surface roughness, particularly in Rz and Rq values. Conversely, the soft mode, especially with 4% zirconia toothpaste, demonstrated a protective trend, where post-brushing roughness values decreased in some metrics. However, these changes did not reach statistical significance across any group ($p > 0.05$).

Conclusion: While higher concentrations of zirconia in whitening toothpaste and increased brushing force may influence enamel surface roughness, the observed changes were not statistically significant. Further research is needed to determine safe concentrations and brushing techniques to minimize enamel wear.

Key words. Enamel, tooth wear, zirconia, toothpaste, toothbrush.

Introduction.

Enamel, the outermost layer of human teeth, is a mineralized tissue that must endure repetitive forces, wear, and corrosion resulting from everyday oral activities like chewing. Its high mineral content provides the strength and hardness necessary for proper tooth function [1]. However, over time, wear, fractures, or cavities often lead to the need for dental repairs. Additionally, unlike other human tissues, dental enamel lacks significant regenerative or self-repair capabilities, making tooth restorations more essential [2].

Toothbrushing abrasion is one element in the multifactorial process of tooth wear [3]. While brushing is generally considered a minor factor in the abrasion of intact enamel and dentin [4], it has been shown that it may be a significant contributor to the development of erosive lesions. Specifically, the abrasion of eroded enamel and dentin is influenced by the toothpaste's abrasivity and concentration [5] but also by the type of toothbrush used and the force applied during brushing [6-8].

Toothpastes are effective formulations for incorporating active ingredients that target various oral diseases. They are also among the most commonly used products for daily oral hygiene. Consequently, toothpastes are marketed for a broad range of specific purposes, including the prevention of erosive tooth wear. The efficacy of toothpastes in preventing erosion can vary significantly, even with the same active ingredient or combinations of ingredients [9]. In vitro studies [10-12] that have investigated the effects of active substances in toothpastes, using toothpaste slurries without additional brushing abrasion, demonstrate a wide range of outcomes, from no effect to a reduction in substance loss of up to 50%.

Toothpastes formulated for whitening are increasingly popular due to their ability to enhance the aesthetic appearance of teeth. These toothpastes typically contain mild abrasives, chemical agents, or a combination of both, which work to remove surface stains and discoloration caused by foods, beverages, and smoking [13]. Common whitening agents include hydrogen peroxide [14], carbamide peroxide [15], or sodium bicarbonate, which help to break down or lift the stains from the enamel [16].

An intriguing ingredient found in some whitening toothpastes is diamond particles, which may lead to greater enamel wear compared to traditional abrasives [17].

Recently, a new toothpaste featuring zirconia particles has garnered significant attention in the dental industry for its potential to make a notable impact. Developed by Dermaflore Inc. in St-Denis-sur-Richelieu, Quebec, Canada, this toothpaste uses zirconium compounds as the active abrasive ingredient [18].

Whitening toothpastes are marketed as convenient alternatives to professional treatments, providing gradual improvements with regular use. The effectiveness of stain removal depends on the size, hardness, and quantity of abrasives, as well as the amount of toothpaste used. Anti-tartar agents can also reduce stain adherence and remove extrinsic stains [19].

In addition to choosing the right toothpaste, selecting the appropriate toothbrush is crucial for maintaining good oral

hygiene and preventing enamel wear caused by excessive brushing force.

Electric toothbrushes are popular for their ability to clean teeth effectively, offering more strokes per minute than manual brushing. However, concerns have arisen about their potential to cause enamel wear, especially if used with excessive force. The high-speed motion and harder bristles, along with abrasive toothpaste, can lead to enamel thinning, increasing the risk of tooth sensitivity and structural damage [20,21].

The pressure applied during brushing is another key factor. Although many electric toothbrushes feature pressure sensors, users may still apply too much force, leading to enamel and dentin erosion, and gum recession. This can expose sensitive areas of the teeth, worsening the effects of wear [22].

To minimize risks, it's important to use the correct brushing technique, avoid excessive pressure, and choose a toothbrush with soft bristles. Regular dental visits are also essential to monitor enamel health and ensure effective brushing without causing damage.

This study aims to evaluate the impact of zirconia-containing toothpaste on enamel roughness under different brushing modes and concentrations.

Materials and Methods.

Sample Collection:

A total of 40 extracted lower third molars were obtained for this study. The inclusion criteria for the samples were as follows:

Age range: Teeth from individuals aged between 18 and 40 years, as this age group typically presents healthy, non-eroded enamel.

Absence of visible defects: Only teeth free from visible cracks, caries, or other structural abnormalities were included to ensure uniformity in the baseline condition of the enamel.

No history of dental treatment: Teeth that had not been subjected to restorative treatments, bleaching procedures, or previous exposure to acidic environments were included to minimize external influences on enamel wear.

Non-erupted teeth: Only fully erupted lower third molars with complete roots were selected to ensure standardized surface area and enamel thickness.

Healthy enamel: Teeth with no signs of pre-existing enamel erosion, hypoplasia, or abnormal wear were included to provide a baseline of natural enamel integrity.

The selected teeth were stored in a sterile saline solution at 4°C until use, to preserve their natural structure and prevent dehydration.

Experimental Groups:

The 40 samples were randomly assigned to two groups based on the concentration of zirconia particles in the toothpaste:

• Group 1: Toothpaste with 3% zirconia concentration (n = 20)

• Group 2: Toothpaste with 4% zirconia concentration (n = 20)

Each group was further divided into two subgroups of 10 samples each, based on the electric toothbrush mode applied (Prokudent Akku-Zahnbürste, Germany).

Subgroup 1A: Toothbrushing with the active mode of the electric toothbrush

Subgroup 1B: Toothbrushing with the soft mode of the electric toothbrush

Subgroup 2A: Toothbrushing with the active mode of the electric toothbrush (4% zirconia concentration)

Subgroup 2B: Toothbrushing with the soft mode of the electric toothbrush (4% zirconia concentration)

Toothpaste Preparation:

The toothpaste formulations were prepared with zirconia particles incorporated at concentrations of 3% and 4%. The zirconia particles, as specified by the manufacturer, were evenly incorporated into a base paste to ensure consistency throughout the experiment. The toothpaste formulation consisted of several phases: Phase A included 27.44% water (solvent) and 43.00% sorbitol 70% (humectant). Phase B contained 3% or 4% zirconium oxide (abrasive) and 9.50% hydrated silica (abrasive). Phase C included 7.00% glycerin (humectant) and 0.30% xanthan gum (thickener). Phase D incorporated 0.52% HE Menthe Verte (flavoring), 0.20% sodium saccharin (sweetener), 0.17% sodium benzoate (preservative), 0.20% coconut oil (emollient), and 1.17% sodium lauryl sulfate (surfactant). This formulation ensured consistent zirconia concentration and optimized the paste's texture and effectiveness process.

Electric Toothbrushing Protocol:

The tooth samples were subjected to electric toothbrushing using an oscillating electric toothbrush with two distinct settings:

• Active mode: A higher-speed, intensive brushing setting.

• Soft mode: A lower-speed, gentler brushing setting.

Each tooth was brushed for 5 minutes in accordance with standard brushing recommendations, simulating typical daily brushing habits.

Profilometric Measurements.

The surface roughness of the enamel was measured using a a contact profilometer (Mitutoyo P1300) with an accuracy of 0.001 mm and. Initial baseline measurements were taken at perpendicular angles before the toothpaste application to assess the pre-brushing surface roughness. After fixation of the specimens into silicone cubes (Zhermack Zetaplus C Silicone kit, Zhermack SpA, Italy), profilometric measurements were repeated to evaluate changes in surface roughness following the brushing procedure. The profilometer was calibrated before each measurement to ensure accuracy, and surface roughness values (Ra, Rq, and Rz) were recorded for each sample. Rz represents the maximum height of the roughness profile, while Rq indicates the root mean square roughness, which accounts for overall surface irregularities.

Statistical analysis:

Data processing was performed using InStat free version. Descriptive statistics, including arithmetic mean, standard deviation, median, minimum, and maximum values, were calculated for all surface roughness parameters (Ra, Rz, Rq).

The normality of the data distribution was assessed using the Shapiro-Wilk test. Based on the distribution results, paired comparisons (before and after brushing) were analyzed using either the Paired T-test (for normally distributed data) or the Wilcoxon Matched Pairs Signed-rank test (for non-normally distributed data).

To compare differences among multiple groups (toothpaste concentration and brushing mode), a one-way ANOVA was

performed. Effect sizes (Cohen's d) were calculated for each comparison to assess the magnitude of differences, with values interpreted as small (d = 0.2), moderate (d = 0.5), and large (d ≥ 0.8). Statistical significance was set at $P < 0.05$.

Results.

The study's results provide a detailed examination of the changes in enamel surface roughness (Ra, Rz, and Rq) following toothbrushing with zirconia-containing toothpaste at two concentrations (3% and 4%) and two electric toothbrush modes (active and soft).

The study demonstrated observable changes in enamel surface roughness (Ra, Rz, Rq) following toothbrushing with zirconia-containing toothpaste. However, these changes did not reach statistical significance across any group ($p > 0.05$).

Effect size analysis revealed moderate to large values (Cohen's d=0.78d to 1.06) for subgroups 1A (3% zirconia, active mode) and 2A (4% zirconia, active mode). These findings suggest that brushing with higher concentrations of zirconia toothpaste under the active mode setting has a meaningful impact on enamel surface roughness. Largest increase in enamel roughness metrics, particularly for Rz and Rq values, was also shown at active toothbrushing mode at 4% concentration of the zirconia containing toothpaste.

Conversely, the soft mode subgroups (1B and 2B) exhibited smaller or even negative effect sizes, particularly in 2B (4% zirconia, soft mode), where reductions in surface roughness were observed. This indicates that softer brushing settings may mitigate potential abrasive effects of zirconia toothpaste.

Table 1 presents the results of a one-way ANOVA used to test the mean differences across groups. None of the metrics (Ra, Rz, Rq) show statistically significant differences between the conditions (Before vs. After) across the groups ($p > 0.05$). Additionally, the low F-statistics suggest that the variance explained by differences in toothpaste concentration and brushing mode is minimal. In Figure 1, "False" represents no statistically significant difference, while "True" indicates a statistically significant difference. The bar graph intervals have been standardized to ensure consistency across all groups.

The contour plots in Figures 2, 3, 4 and 5, represent the enamel surface roughness before and after brushing with two

Table 1. *Presents the results of a one-way ANOVA used to test the mean differences across groups.*

Group	Metric	Mean Before	SD Before	Mean After	SD After	T-Stat	P-Value	Cohen's *d*
1A	Ra	0.634	0.184	0.944	0.386	-1.985	0.118	0.94
1A	Rz	2.798	0.777	4.632	2.180	-1.914	0.128	0.91
1A	Rq	0.764	0.210	1.208	0.526	-1.997	0.117	0.95
1B	Ra	0.896	0.127	1.128	0.560	-1.052	0.352	0.50
1B	Rz	4.190	0.631	5.318	2.634	-1.017	0.367	0.48
1B	Rq	1.092	0.148	1.304	0.696	-0.743	0.499	0.35
2A	Ra	0.788	0.128	1.116	0.303	-2.240	0.089	1.06
2A	Rz	3.790	0.479	5.110	1.481	-1.650	0.174	0.78
2A	Rq	0.968	0.150	1.368	0.382	-2.093	0.104	0.99
2B	Ra	1.280	0.662	0.918	0.170	1.336	0.253	-0.63
2B	Rz	6.590	3.515	4.540	0.856	1.448	0.221	-0.69
2B	Rq	1.610	0.847	1.124	0.191	1.435	0.225	-0.68

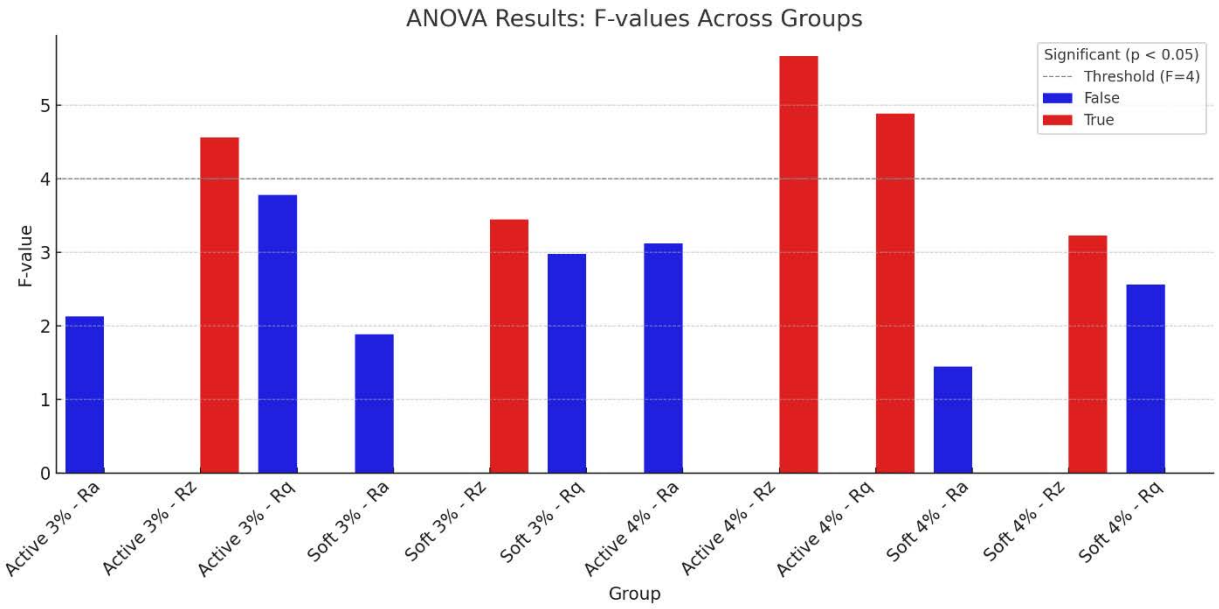

Figure 1. *One-way Anova results.*

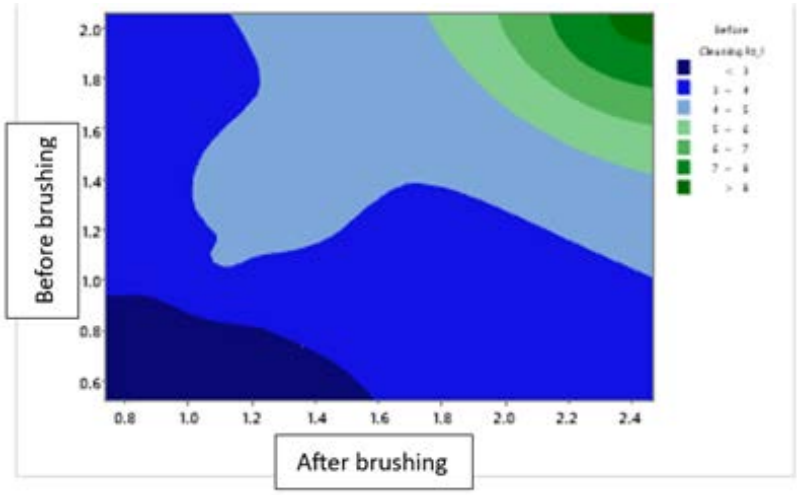

Figure 2. *Contour plot of enamel surface roughness before and after brushing with 3% toothpaste in the soft mode.*

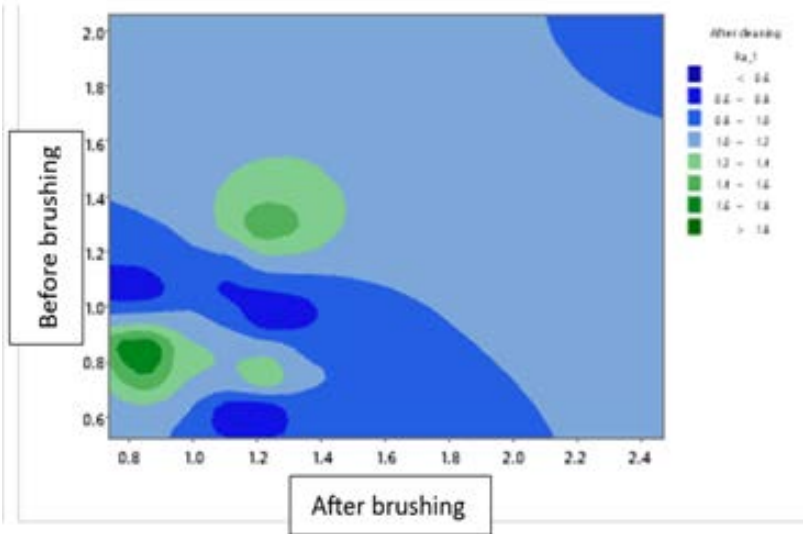

Figure 3. *Contour plot of enamel surface roughness before and after brushing with 3% toothpaste in the active mode.*

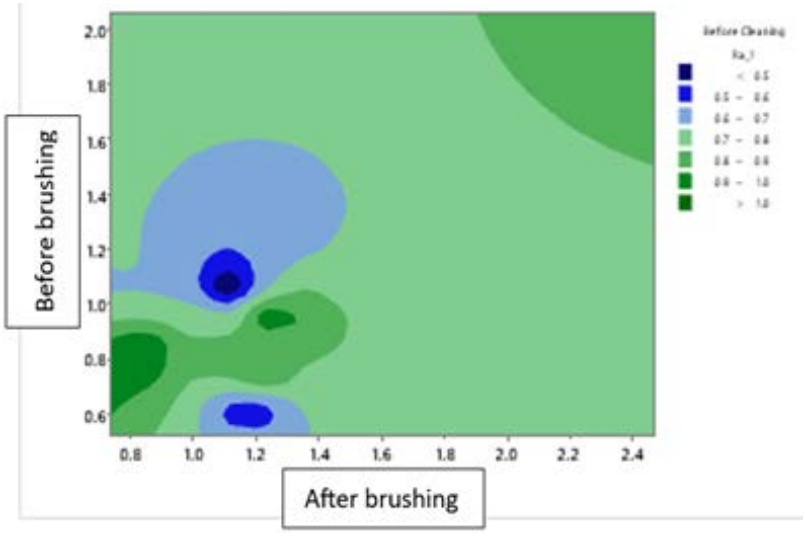

Figure 4. *Contour plot of enamel surface roughness before and after brushing with 4% toothpaste in the soft mode.*

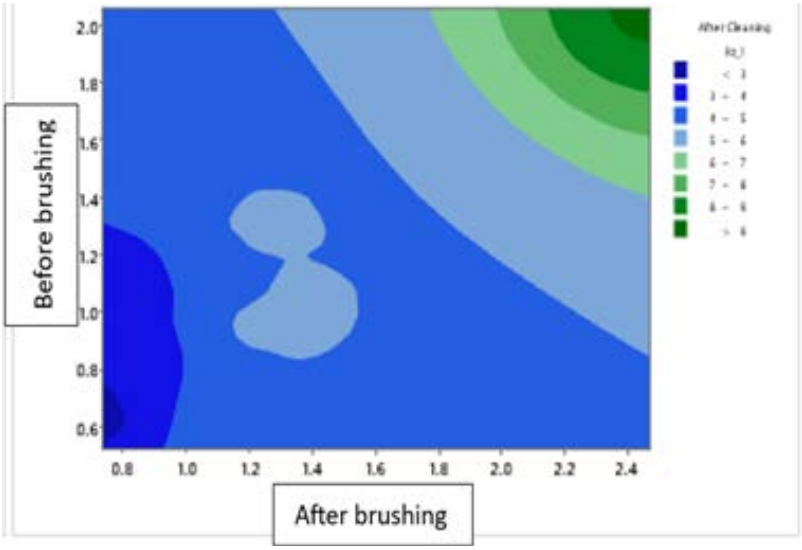

Figure 5. *Contour plot of enamel surface roughness before and after brushing with 4% toothpaste in the active mode.*

concentrations of the toothpaste, in two brushing modalities. The color gradient corresponds to the "Number of revolutions," indicating enamel roughness levels, where lighter shades represent lower roughness (< 3,000 revolutions), while darker shades indicate higher roughness (> 6,000 revolutions). There are significant regions with darker shading, indicating higher enamel roughness after brushing with active mode at both percentages (Figures 3 and 5), while roughness levels seem reduced at soft mode at both percentages, as evident by the increased presence of lighter shades (Figures 2 and 4), where some areas retain moderate roughness, while others exhibit more uniform smoothness.

Discussion.

The toothbrush is essential for plaque removal, vital for disease prevention and oral health. Advances in toothbrush technology have led to electric alternatives, offering convenience and aiding those with disabilities or children. However, improper use can harm teeth and gums, with abrasion being the most common injury. Dental abrasion, the pathological wear of teeth, is influenced by toothpaste abrasivity, toothbrush type, and brushing force.

In this study, the effects of two electric toothbrush modalities and two different concentrations of zirconia-containing whitening paste on the enamel surface were evaluated. The findings provide insight into how these variables influence enamel integrity, contributing to a better understanding of their potential benefits and risks in oral care practices.

Zirconium whitening paste is a relatively new development in dentistry and is currently undergoing laboratory testing.

Our study used a daily-use electronic toothbrush, unlike the previous study [18] which employed a high-force electric micromotor. This distinction ensures our findings better reflect real-world brushing conditions.

The active mode of the electric toothbrush consistently resulted in higher surface roughness values compared to the soft mode. This finding aligns with the hypothesis that increased mechanical force amplifies the abrasive effects of zirconia particles. The soft mode, particularly with 4% zirconia toothpaste, demonstrated a protective trend, where post-brushing roughness values decreased in some metrics. These results emphasize the role of brushing dynamics in moderating enamel wear when using abrasives.

The 4% zirconia toothpaste exhibited slightly higher roughness values than the 3% formulation under active brushing conditions. While the differences were not statistically significant, the observed trend suggests a dose-dependent effect of zirconia particles on enamel surface roughness.

Our findings align with previous research that has shown that higher zirconium concentrations in toothpaste increase enamel surface roughness and abrasive dentin wear. According to Stavileci M. et al. [18], the dentin's abrasive capacity rises with increasing zirconium levels in whitening toothpaste.

When evaluating the abrasiveness of toothpaste and toothbrushes, it’s noteworthy that certain whitening ingredients, including activated carbon, can increase enamel roughness [23]. Pertiwi et al. [24] confirmed this effect, while Brooks et al. found insufficient evidence to ensure the safety or efficacy of activated charcoal for whitening or hygiene [25]. Febriani et al. [26] observed that activated charcoal can whiten teeth by attracting stains through its negative charge. Kini et al. reported that toothbrushes with charcoal bristles caused less enamel wear and removed plaque more effectively than nylon-bristled brushes [27].

In 2019, Sanusi et al. assessed the effects of three commercial abrasives: perlite, baking soda, and activated charcoal powder. Their findings revealed that perlite was the most abrasive, creating the deepest scratches and causing the greatest enamel wear among the three [28].

Given the negative effects of abrasive active ingredients, the demand for a whitening toothpaste that offers maximum efficacy with minimal side effects is growing steadily. Consequently, future research should prioritize evaluating the effectiveness of zirconia particles in in vivo studies, particularly focusing on determining the safe concentrations for their use.

Conclusion.

This study examined how zirconia-containing whitening toothpaste and electric toothbrush settings affect enamel surface roughness. While no statistically significant differences were found, trends suggest that higher zirconia concentrations and aggressive brushing may increase enamel roughness. Conversely, using a soft brushing mode may mitigate abrasive effects. These findings highlight the importance of selecting appropriate toothpaste formulations and brushing techniques to maintain enamel integrity. Further research is needed to determine safe zirconia concentrations and to assess long-term impacts on enamel health.

Conflict of interest: The authors have no conflicts of interest to declare.

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Russian

Цель исследования:

Целью данного исследования является оценка воздействия двух режимов электрической зубной щетки и двух различных концентраций отбеливающей зубной пасты с добавлением циркония на шероховатость эмали.

Материалы и методы: Сорок экстрагированных нижних третьих моляров были разделены на четыре группы в зависимости от концентрации пасты (3% и 4% циркония) и режима чистки (активный и мягкий). Каждый зуб чистился 5 минут с использованием осциллирующей электрической зубной щетки. Шероховатость эмали измерялась до и после чистки с помощью контактного профилометра.

Результаты:

Чистка зубов пастой с 4% циркония в активном режиме привела к наибольшему увеличению шероховатости эмали, особенно по значениям Rz и Rq. Напротив, мягкий режим чистки, особенно с 4% пастой с цирконием,

продемонстрировал защитную тенденцию, при которой после чистки показатели шероховатости уменьшались по некоторым параметрам. Однако наблюдаемые изменения не имели статистической значимости в любой из групп ($p > 0,05$).

Заключение:

Хотя более высокие концентрации циркония в отбеливающей пасте и увеличенная сила чистки могут влиять на шероховатость эмали, наблюдаемые изменения не были статистически значимыми. Необходимы дополнительные исследования для определения безопасных концентраций циркония и методов чистки для минимизации износа эмали.

Ключевые слова: эмаль, износ зубов, цирконий, зубная паста, зубная щетка

Georgian

კვლევის მიზანი:

ამ კვლევის მიზანია ორი ელექტრო საშხაპე მოდალობის და ორი სხვადასხვა კონცენტრაციის ცირკონი содержащи თეთრი პასტის ზემოქმედების შეფასება კბილის ემალის ზედაპირის ჭარბი სიმტკიცეზე.

მაღაზია და მეთოდები:

ორმოცი ამოღებული ქვედა მესამე კბილის კბილის შედგენილი ოთხ ჯგუფად, რომელიც ეფუძნება პასტის კონცენტრაციას (3% და 4% ცირკონი) და დასუფთავების რეჟიმს (აქტიური და რბილი). თითოეული კბილის დასუფთავება მიმდინარეობდა 5 წუთის განმავლობაში ფოკუსირებულ ელექტრო საშხაპე საშუალებებით. ემალის ზედაპირის სიმკვრივე შეფასდა დასუფთავების წინ და შემდეგ საკონტაქტო პროფილომეტრით.

შედეგები:

4% ცირკონის პასტით აქტიური რეჟიმში დასუფთავება გამოიწვია ემალის ზედაპირის სიმკვრივის ყველაზე დიდ ზრდას, განსაკუთრებით Rz და Rq მნიშვნელობებში. პირიქით, რბილი რეჟიმი, განსაკუთრებით 4% ცირკონის პასტით, აჩვენა დამცავი ტენდენცია, როდესაც დასუფთავების შემდეგ სიმკვრივის მნიშვნელობები ზოგიერთ მეტრიკაში შემცირდა. თუმცა, ეს ცვლილებები არ მიაღწია სტატისტიკურ მნიშვნელობას არც ერთ ჯგუფში ($p > 0,05$).

დასკვნა:

მიუხედავად იმისა, რომ ცირკონის მაღალი კონცენტრაციები თეთრ პასტებში და ზეთისხილის გაძლიერებული ძალა შეიძლება გავლენა მოახდინოს ემალის ზედაპირის სიმკვრივეზე, □□ებული ცვლილებები არ იყო სტატისტიკურად მნიშვნელოვანი. საჭიროა დამატებითი კვლევები ცირკონის უსაფრთხო კონცენტრაციებისა და დასუფთავების ტექნიკის დადგენისათვის ემალის износის მინიმუმისათვის.

გასაღები სიტყვები: ემალი, კბილის износ, ცირკონი, პასტა, საშხაპე