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Effect of two types of charcoal toothpaste on the enamel surface roughness of permanent teeth

Jaber Yaghini[1], Ahmad Moghareabed[1], Faezeh Hatam[2], Forooz Keshani[3]

[1]Department of Periodontics, Dental Implants Research Center, School of Dentistry, Dental Research Institute, Isfahan University of Medical Sciences, Isfahan, Iran, [2]Department of Oral and Maxillofacial Pathology, Students Research Committee, School of Dentistry, Isfahan University of Medical Sciences, Isfahan, Iran, [3]Department of Oral and Maxillofacial Pathology, Dental Research Center, School of Dentistry, Dental Research Institute, Isfahan University of Medical Sciences, Isfahan, Iran

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Address for correspondence:
Dr. Forooz Keshani, Department of Oral and Maxillofacial Pathology, Dental Research Center, School of Dentistry, Dental Research Institute, Isfahan University of Medical Sciences, Isfahan, Iran.
E-mail: f_keshani@dnt.mui.ac.ir

ABSTRACT

Background: Charcoal in the composition of some kinds of toothpaste has created concerns regarding abrasiveness and subsequent complications. Considering the popularity of charcoal toothpaste, and the manufacturers' claims that no porosity is caused by activated carbon, this study aimed to compare the effects of two charcoal kinds of toothpaste and three conventional tubes of toothpaste on enamel surface roughness of permanent primary teeth.

Materials and Methods: This *in vitro* experimental study evaluated 75 teeth mounted in acrylic resin. Teeth were divided into five groups (n = 15). The primary surface roughness of teeth was measured by a profilometer. The teeth were then subjected to wear test in a V8 cross-brushing machine with Bencer and RP charcoal toothpaste, Crest 7, Colgate Optic White, and Bencer fresh mint toothpaste. After rinsing and drying specimens, their secondary surface roughness was measured. The mean changes in the roughness profile of specimens were analyzed by a one-sample Kolmogorov–Smirnov test at a 0.05 significance level.

Results: There was no significant difference in the mean surface roughness of specimens before and after the wear test (P > 0.05). The difference in the mean wear of five types of toothpaste was not significant either (P = 0.597). The mean changes in surface roughness were 0.0685 μm for Bencer charcoal, −0.0620 μm for RP charcoal, 0.0765 μm for Crest 7, 0.1137 μm for Colgate Optic White, and 0.1052 μm for Bencer fresh mint toothpaste.

Conclusion: Numerous kinds of toothpaste investigated in this study did not reveal any difference in terms of wear index; however, more studies are needed to evaluate the effectiveness and efficiency of these types of toothpaste.

Key Words: Charcoal, dental enamel, permanent dentition, toothpaste

INTRODUCTION

Tooth discoloration is a common complaint of patients seeking esthetic dental treatments. Changes in tooth color can be due to intrinsic or extrinsic factors such as the use of chemicals or intake of colored foods and drinks.[1] Conventionally, several methods are available for color correction of vital and nonvital teeth such as correction of superficial discoloration by polishing or the use of abrasive toothpaste, vital and

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nonvital tooth bleaching, and prosthetic veneering and crowns.[2] The use of abrasive types of toothpaste is one suggested technique for tooth whitening at home. However, they should be minimally abrasive in order to no longer damage tooth structure.[3]

Tooth wear or abrasion can occur by the effect of abrasive agents presented in the composition of various toothpaste or acidic products that dissolve the enamel hydroxyapatite.[3] At present, commercially available toothpaste includes a combination of abrasives, detergents, and one or more therapeutic agents.[3] The abrasive agent is the most important constituent of any toothpaste. The abrasiveness of toothpaste depends on the hardness of its abrasive agents, as well as the size and shape of abrasive particles. Abrasive agents can be divided into five groups, including carbonates, phosphates, silicates, aluminum abrasives, and organic abrasives.[4,5] Tooth abrasion increases the enamel surface roughness, and subsequently, the adhesion of bacteria to the enamel surface, since oral microorganisms have a high tendency to accumulate on rough enamel and cementum surfaces.[3] Furthermore, Nogueira *et al*.[6] found that increased enamel surface roughness increased bacterial adhesion to the enamel surface.

Charcoal or activated carbon is a constituent of some toothpaste. Activated carbon refers to a group of materials with high internal surface area and porosity and a high potential for the absorption of chemical gases and liquids. It is produced by the pyrolysis of any carbon-containing material and is then activated.[7]

The use of charcoal as toothpaste has long been practiced in Africa and parts of Asia.[7,8] Furthermore, charcoal may be incorporated in toothpaste as a detergent for more efficient cleaning of interproximal areas. However, it can also serve as an abrasive due to its composition and size of particles. Thus, it may increase the enamel surface roughness.[3] Pertiwi *et al*.,[3] in 2017, confirmed that carbon increases the enamel surface roughness. A systematic review by Brooks *et al*.,[9] in 2017, concluded that adequate clinical evidence is not available to ensure the safety or efficacy of activated charcoal for tooth bleaching or oral hygiene. Febriani *et al*.,[10] in 2019, evaluated activated charcoal as a natural tooth-bleaching agent and found that activated charcoal can be used as a natural tooth-bleaching agent. The application of activated carbon on the enamel surface changed the tooth color, which is due to the negative charge of carbon ions, which absorb positively charged stains. In 2019, Kini *et al*.[11] compared plaque removal and abrasion caused by toothbrushes with charcoal and nylon bristles and found that toothbrushes with charcoal bristles caused less wear and had higher plaque removal efficacy than nylon bristles. Sanusi *et al*.,[12] in 2019, evaluated the effect of three commercial abrasives, namely perlite, baking soda, and activated charcoal powder, and reported that perlite was the most effective abrasive particle and caused maximum abrasion and deepest scratches compared with the other two particle types. They demonstrated that long-term use of activated charcoal particles and application of excessive force during toothbrushing can result in enamel wear. Franco *et al*.,[13] in 2020, found no significant difference in surface roughness between conventional toothpaste and charcoal powder. Palandi *et al*.[14] reported that a combination of charcoal powder and toothpaste did not increase the enamel surface roughness.

Considering the extensive publicity regarding the use of charcoal toothpaste and the manufacturers' claims regarding no porosity caused by the activated carbon, as well as the gap of information on this issue, this study aimed to assess the effects of two charcoal toothpaste on enamel surface roughness of permanent anterior teeth in terms of abrasiveness to help consumers in selection of appropriate toothpaste.

MATERIALS AND METHODS

This *in vitro* experimental study was conducted on extracted sound permanent anterior teeth of systemically healthy adults (for the reason of orthodontia, periodontal disease, etc.). The extracted teeth were collected from dental offices and clinics in Isfahan city. The teeth had to have a sound enamel surface with no caries, cracks, discoloration, or enamel defects. Bencer and RP charcoal toothpaste, Crest 7, Colgate Optic White, and Bencer fresh mint conventional toothpaste were evaluated in this study. The composition and manufacturing countries of toothpaste are presented in Table 1. Bencer and RP charcoal toothpaste and Crest 7, Colgate Optic White, and Bencer fresh mint conventional toothpaste were evaluated in this study due to the following reasons: (I) considering the fact that this study aimed to assess charcoal toothpaste, two commonly used charcoal toothpaste in Iran, namely Bencer and RP,

Table 1: Composition of toothpaste

Type of toothpaste	Manufacturing country	Composition
Bencer charcoal	Iran	Activated charcoal, sodium bicarbonate, tetrapotassium pyrophosphate, PEG8, sodium lauryl sulfate, sodium saccharine, sorbitol, glycerine, silodent
RP charcoal	Iran	Activated charcoal, sodium bicarbonate, tetra-potassium pyrophosphate, PEG8, sodium lauryl sulfate, sodium saccharine, sorbitol, glycerine, silodent
Colgate Optic White	Poland	Pentasodium triphosphate, potassium pyrophosphate, aqua, silica hydrate, PEG12, sodium lauryl sulfate, aroma, cellulose gum, cocamidopropyl betaine, sodium fluoride, sodium saccharine, sorbitol, glycerine, sodium hydroxide, xanthine gum
Crest 7	Germany	Sodium fluoride, silica hydrate, aqua, sorbitol, sodium lauryl sulfate, cellulose gum, aroma, sodium saccharine, triclosan, CI77891, PEG6, tetrapotassium pyrophosphate, disodium pyrophosphate, tetrasodium phosphate, carbomer
Bencer fresh mint	Iran	Dicalcium phosphate, glycerin dihydrate, sorbitol, silica, sodium lauryl sulfate, essence, polyethylene glycol, sodium carboxymethyl cellulose, sodium monofluorophosphate, tetrasodium pyrophosphate, methylparaben sodium saccharine, propylparaben menthol, deionized water

were evaluated. (II) Since the aim of this study was to assess the effect of carbon in the composition of charcoal toothpaste on surface roughness, ADA-approved toothpaste with a composition close to that of charcoal toothpaste (as much as possible) was selected. Thus, Crest 7 and Colgate Optic White were used in this study. (III) Considering the assessment of Bencer charcoal toothpaste, Bencer fresh mint was also assessed as a control toothpaste produced by the same manufacturer.

The sample size was calculated to be 75 teeth. The teeth were divided into 5 groups of 15. For statistical analysis of the data, the mean roughness profile of each toothpaste group was calculated before and after the wear test. The difference between the two mean values indicated the mean rate of enamel wear in micrometers for each type of toothpaste.

Specimen preparation

The collected teeth were sectioned into tooth blocks measuring 3 mm × 5 mm × 5 mm, by an automatic cutting machine. Their upper surface had sound enamel. The blocks were mounted in round-shaped molds with 25 mm diameter and 6 mm thickness containing autopolymerizing acrylic resin (Acropars 200 without cadmium; Marlik, Tehran, Iran) that blocks' upper surface were at the level of the acrylic surface.[15]

Measuring the baseline roughness profile

The specimens were placed in a profilometer (Surtronic 25, Taylor Hobson Company, England). The baseline roughness profile of each specimen was measured by the movement of the diamond probe of the device on a hypothetical line by 4 mm and recorded in micrometers. This was repeated on four hypothetical lines with a 1-mm distance from each other. The mean value of the four roughness profiles was calculated and reported as the baseline roughness profile of the respective specimen in micrometers. Next, the obtained values were arranged in an ascending order and assigned to 15 groups of 5. Next, one specimen from each group was randomly selected to create 5 groups of 15. This was done to minimize the difference in baseline surface roughness values of the specimens in groups. Furthermore, the groups were coded from A to E, and the paths of movement of the profilometer probe and three-body wear toothbrush, which were perpendicular to each other, were marked.

Wear test

The three-body wear test was performed in the presence of toothpaste, enamel specimen, and toothbrush and with the back-and-forth movement of V8 cross-brushing machine (Sabri Enterprises, Downers Grove, IL, USA). Since the path of the profilometer's movement had to be perpendicular to the path of wear, the specimens were rotated by 90° according to the previous markings. Eight toothbrushes (Soft Sparkle S4, Iran) were placed in the device and the specimens were fixed in their places below the toothbrushes; 30 g of each toothpaste was dissolved in 40 ml of water for 5 min and transferred into glass tubes adjacent to the toothbrushes and the specimens. Furthermore, 10 ml of 0.5% sodium carboxymethyl cellulose was added to the solution as artificial saliva. Bencer charcoal toothpaste was used for Group A, RP charcoal toothpaste was used for Group B, Crest 7 was used in Group C, Colgate Optic White was used in Group D, and Bencer fresh mint was used in Group E.

The toothbrushes performed 15,000 strokes at a speed of 100 rapids/min with 130 gear force on

the specimens, which corresponded to 18 months of toothbrushing. It should be noted that due to the deposition of abrasive after 2500 strokes, the toothbrushes were replaced with new ones.

Measuring the secondary roughness profile

After rinsing and drying, the specimens were placed in the profilometer after a 90° rotation relative to their baseline position. The mean secondary roughness profile of each specimen was measured again on the same four hypothetical lines and recorded as explained earlier. Three specimens were excluded from the study due to crack formation after the wear test.

Since the data were not normally distributed in some groups according to the one-sample Kolmogorov–Smirnov test, the Kruskal–Wallis test was used to analyze the data at a 0.05 level of significance.

This study was the result of the research with the ethical code IR.MUI.RESEARCH.REC.1398.683 in Isfahan University of Medical Sciences.

RESULTS

The aim of this study was to determine and compare the effect of two types of charcoal toothpaste in Iran on the surface roughness of anterior tooth enamel in adults. The samples included 75 healthy dental samples that were divided into 5 groups of 15 (A, B, C, D, and E).

The mean baseline and secondary roughness profiles of the groups are presented in Table 2.

Table 3 mentions the baseline and secondary roughness profiles. The five groups were not significantly different regarding the roughness profile ($P = 0.597$).

Due to the lack of a normal distribution condition in some groups, the Kruskal–Wallis test was performed on data and showed that there was no significant difference between the mean roughness changes of the five groups ($P = 0.597$).

Table 2: Mean±standard deviation baseline and secondary roughness profile based on the type of toothpaste

Group	Baseline roughness profile (before wear) (µm)	Secondary roughness profile (after wear) (µm)
Bencer charcoal	1.29±1.05	1.22±1.03
RP charcoal	1.22±1.12	1.29±1.35
Crest 7	1.24±0.99	1.16±0.93
Optic White Colgate	1.24±1.02	1.13±0.94
Bencer fresh mint	1.36±1.27	1.26±1.18

Table 3: Mean±standard deviation difference of baseline and secondary roughness profiles based on the type of toothpaste

Group	Mean difference (µm)
Bencer charcoal	0.0685±0.07
RP charcoal	−0.0620±0.39
Crest 7	0.0765±0.09
Optic White Colgate	0.1137±0.12
Bencer fresh mint	0.1052±0.15

DISCUSSION

The current results showed no significant difference in the mean surface roughness of specimens before and after the wear test. Furthermore, the change in roughness profile after the wear test for the Bencer charcoal, RP charcoal, Crest 7, Colgate Optic White, and Bencer fresh mint was 0.0685, −0.0620, 0.0765, 0.1137, and 0.1052, respectively. The maximum change in roughness occurred in the Colgate Optic White group. This finding was in agreement with the result of Ramadhan *et al.*,[16] who stated that the higher the complexity and the diversity of abrasives in a toothpaste, the greatest the resultant wear would be. Considering the greater diversity of the abrasive agents – various and sundry abrasive materials that could be used in the composition of different kinds of toothpaste to increase tooth whitening which has been a challenge among virtually all people – in Colgate Optic White, it had slightly higher abrasiveness than other kinds of toothpaste.[16] The Kruskal–Wallis test showed no significant difference in the mean surface roughness of the five groups ($P = 0.597$). Similarly, Franco *et al.*[13] found no significant difference in surface roughness between the conventional toothpaste and charcoal powder, which was in agreement with the present results. The findings of Palandi *et al.*,[14] in 2020, are in line with the present results that charcoal powder did not increase the enamel surface roughness when combined with toothpaste. Sanusi *et al.*,[12] in 2019, demonstrated that long-term use of activated charcoal particles and application of excessive force during toothbrushing can result in enamel wear. In the present study, those types of toothpaste which incorporate charcoal caused a small change in surface roughness; however, it was not significant and had no significant difference with other groups. Plus, it

should be noted that Sanusi *et al*.[12] evaluated acrylic specimens, which have a lower hardness than enamel and are more susceptible to wear. This difference explains the greater wear of specimens in their study. Pertiwi *et al*.[3] compared the abrasive effect of carbon with distilled water, which has no abrasive agent; thus, in comparison with distilled water, charcoal toothpaste increased the enamel surface roughness. However, they found no significant difference in surface roughness when charcoal toothpaste was compared with Strong® Formula toothpaste. The present study also found no significant difference in enamel surface roughness among the tested numerous toothpaste.

Brushing force is another factor that can affect the dental hard tissue and is the main cause of tooth wear.[10] Thus, V8 cross-brushing machine was used in this study to eliminate the effect of this confounding factor and apply equal force on all specimens. The toothbrushing movements of the machine are horizontal, which simulate the scrubbing technique, because it is the most widely used toothbrushing technique among children and adults.[17] Plus, the fact that, the use of this device eliminated the effect of some other confounders such as toothbrushing technique, pressure applied to the toothbrush, hardness of toothbrush bristles, and direction and frequency of different movements of toothbrush.[10] Therefore, the only remaining parameter causing tooth wear was the type of toothpaste. Having said that, clinical *in vivo* studies on tooth wear are not feasible due to the need for patients' follow-up, multifactorial nature of tooth wear, and having no fixed reference points in the oral cavity.[18]

In contrast to the majority of previous studies on tooth wear as a result of using various toothpaste, no changes were made in the enamel surface in this study. Thus, specimens in the present study had a higher resemblance to tooth enamel in the oral cavity. In other studies, the enamel surface of extracted teeth was flattened and polished since the profilometer used in such studies could not scan convex surfaces. However, the profilometer used in this study was capable of scanning convex surfaces; thus, the surfaces were not modified.

CONCLUSION

Various toothpaste evaluated in this study were not significantly different in terms of enamel surface wear, and no significant difference was found in levels of enamel surface roughness of specimens in the five toothpaste groups after the wear test. Although the abrasiveness of charcoal toothpaste was not significantly different from that of other toothpaste, other properties of these kinds of toothpaste such as their bleaching efficacy, plaque removal efficacy, and antiplaque efficacy should be investigated in future studies.

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Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or non-financial in this article.

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