©Operative Dentistry, 2020, **45-6**, 618-623

# The Effect of a Charcoal-based Powder for Enamel Dental Bleaching

MC Franco • JLS Uehara • BM Meroni • GS Zuttion • MS Cenci

### Clinical Relevance

Charcoal based-powders are not effective for dental bleaching.


## SUMMARY

**Charcoal-based dentifrices for dental whitening are a novelty in the market. Manufacturers claim that such charcoal-based products have whitening, remineralization, antimicrobial, and antifungal properties of charcoal in such products. However, there is no substantial scientific evidence for these claims. This laboratory randomized study was designed to evaluate the whitening properties of a charcoal-based toothpowder. A total of 45 bovine dental enamel discs were randomly distributed into three groups ($n$=15): group 1, mechanical brushing with a 1450-ppm F toothpaste (control group); group 2, mechanical brushing with an activated charcoal-based powder; group 3, bleaching per the standard protocol using 10% carbamide peroxide. The surface roughness and color of each specimen were analyzed at baseline and after 14 days of experiment. The surface of one randomly selected specimen from each group was examined using a scanning electron microscope (SEM). The Kruskal-Wallis test was used to compare groups at a significance level of 5%. Only group 3 promoted a statistically significant effect on ΔE compared with groups 1 and 2 ($p<0.001$ and $p=0.003$, respectively). No statistically significant difference was found between groups for surface roughness ($p>0.05$). SEM revealed a more irregular surface in group 1 specimens compared with group 2 and 3 specimens. The charcoal-based powder did not seem to have any bleaching effect.**



Marina Christ Franco, PhD student, Restorative Dentistry, Federal University of Pelotas, Rio Grande do Sul, Brazil

Juliana Lays Stolfo Uehara, PhD student, Restorative Dentistry, Federal University of Pelotas, Pelotas, Brazil

Bárbara Meirelles Meroni, graduate student, Federal University of Pelotas, Pelotas, Brazil

Giovanna Sacco Zuttion, graduate student, Federal University of Pelotas, Pelotas, Brazil

*Maximiliano S Cenci, Graduate Program in Dentistry, Department of Operative Dentistry Federal University of Pelotas, Pelotas, Brazil

*Corresponding author: R Gonçalves Chaves 457, Pelotas, N/A 96015560, Brazil; e-mail: cencims@gmail.com


https://doi.org/10.2341/19-122-L

## INTRODUCTION

White teeth are regarded as a perfect pattern of esthetic beauty in contemporary society.[1,2] According to data from published literature, 30% of patients have a certain degree of dissatisfaction with their dental color.[3,4] Therefore, the dental bleaching procedure is a popular esthetic treatment in dental practice.[3,4] This procedure is conservative, safe, and effective and is performed using gels containing hydrogen peroxide or carbamide peroxide at differ-

ent concentrations. Dental bleaching can be accomplished at the dental clinic or in the patient's home by following a dentist's instructions.[1,4,5] There are also low-cost alternatives available in the market to treat tooth discoloration without the dentist's supervision. In the last few years, the availability of a number of alternative whitening agents, such as prefabricated trays, whitening strips, and paint-on applications, has considerably increased.[4,6]

The use of charcoal for oral health was recorded for the first time in ancient Greece by Hippocrates. Charcoal was used in many parts of the world and different cultures as a cleaning agent. Natural charcoal powder was used as a single-agent dentifrice. However, studies have shown that charcoal may not be beneficial in dental cleaning or against dental caries.[7,8]

Charcoal-based toothpastes and toothpowders for dental whitening are widely available for purchase from pharmacies, supermarkets, and e-commerce sites. Although manufacturers promise the whitening, remineralization, antimicrobial, and antifungal properties of charcoal-based dentifrices, there is no substantial scientific evidence for these properties.[8] This laboratory study aimed to evaluate whether activated charcoal powder has a bleaching/whitening effect on the dentition. We tested two hypotheses: 1) traditional bleaching procedure with carbamide peroxide is more effective in changing tooth color teeth than whitening with charcoal-based powder and 2) the use of charcoal-based powder increases enamel surface roughness.

## METHODS AND MATERIALS

### Experimental Design

This laboratory randomized study was designed to evaluate the whitening properties of a charcoal-based toothpowder compared with dental bleaching with a gold standard protocol using 10% carbamide peroxide. The control group was treated with a 1450-ppm F toothpaste. A total of 45 enamel discs were randomly divided into three groups ($n$=15): group 1, mechanical brushing using a 1450-ppm F toothpaste (control group); group 2, mechanical brushing using an activated charcoal-based toothpowder; group 3, bleaching protocol with 10% carbamide peroxide. Before- and after-treatment samples were spectrophotometrically evaluated to determine the change in color. In addition, potential deleterious effects of the treatments were assessed by surface roughness changes and scanning electronic microscopy (SEM) images.

### Sample Size Calculation

G*Power 3.1.9.4 software (Heinrich-Heine Düsseldorf University, Düsseldorf, Germany) was used to determine the sample size based on a previous study[9] using the following parameters: 95% power, 0.40 effect size, and three experimental groups. A minimum sample size of 15 specimens per group ($n$=45) was assessed to be appropriate.

### Specimen Preparation

Forty-five enamel discs were cut from the buccal surface of fresh bovine incisors using a water-cooled trephine drill. To obtain standardized enamel discs with a diameter of 5 mm and thickness of 2.5 mm, the surfaces were ground using #600-grit silicon carbide papers. Subsequently, all the specimens were polished by wet grinding, sequentially, with #1200-, #1500-, and #2000-grit silicon carbide papers to obtain a polished and standardized surface. The specimens were then numbered and randomly allocated in acrylic matrices, which immobilized them on the brushing machine, according to a list generated by RANDOM.ORG.

### Roughness Measurements

The surface roughness of each specimen was analyzed using a roughnessmeter (Hommel Tester T1000, Hommel-Etamic, Schwenningen, Germany) at baseline and after 14 days of the experiment. Multidirectional readings were made for each specimen from the center of the surface. Three readings were made for each specimen, and the mean was calculated.

### Color Stability Evaluation

The specimen color was assessed at baseline and after 14 days using a spectrophotometer (X-Rite SP60 Series, X-Rite Inc, Grand Rapids, Michigan USA) and D65 light against a white background. To standardize the color measurement, the spectrophotometer pointer was positioned parallel to the enamel surface of each specimen. The shade was determined according to spectrophotometric parameters by considering L*, a*, and b* values. L* represents values from 0 (black) to 100 (white), a* represents the amount of red and green, and b* represents the amount of yellow and blue. The difference in color before and after treatment was provided by delta E ($\Delta E$), calculated by CIEDE2000[10].

Table 1: *Components of Products Used According to the Manufacturer's Information*

| Product | Manufacturer | Composition |
|---|---|---|
| Colgate Maximum anticaries protection | Palmolive Company, New York, NY, USA | 1500 ppm of fluoride, calcium carbonate, sodium lauryl sulfate, sodium saccharin, tetrasodium pyrophosphate, sodium silicate, polyethylene glycol, sorbitol, carboxymethyl cellulose, methylparaben, propylparaben, aromatic composition and water; contains sodium monofluorophosphate |
| Whitemax | Dermavita, Brusque, SC, Brazil | Charcoal powder (activated carbon), kaolin, aroma, citrus aurantium dulcis peel oil |
| Whiteness Perfect | FGM Odontology Products, Joinville, SC, Brazil | Carbamide peroxide, neutralized carbopol, potassium nitrate, sodium fluoride, humectant (glycol), deionized water |

### Mechanical Brushing and Whitening Protocol

Group 1 and group 2 specimens were submitted to mechanical brushing cycles in a Multifunctional Oral Cavity Simulator (Federal University of Pelotas, Pelotas, Brazil). Briefly, this device comprises a Multifunctional Oral Mouth Simulator originally designed to allow continuous flow for biofilm growth with modifications to enable brushing simulation.[11] Brushing simulation was performed with a load of 4.5 N using soft-bristle brushes (Sanifill Eco Dent, Interbros GmbH, Schönau, Germany) at 0.6 Hz (36 cycles/min for three minutes).[12] In group 1 (control group), a toothpaste slurry (Colgate–maximum anticaries protection, 1450 ppm F, Palmolive Company, New York, NY, USA) was prepared with distilled water at a 1:3 (w/v) proportion and applied during the brushing cycles. In group 2, a charcoal-based powder for dental whitening (Whitemax, Barueri, Brazil) was applied on previously wet brushes with water. Group 3 specimens were submitted to a gold standard protocol for dental bleaching with 10% carbamide peroxide (Whiteness Perfect, FGM, Joinville, SC, Brazil) for 3 h/day. The whitening gel was removed after three hours using abundant water. Information of the groups and products used, including manufacturers and product components, is provided in Table 1.

After the bleaching procedure and mechanical brushing cycles, the specimens were stored in distilled water at 37°C for 23 hours until the next exposure to whitening protocol and new brushing. This process was repeated daily for 14 days.

Table 2: *Results for ΔE Values Based on Treatment Groups*[a]

| | Median (Quartiles 25%-75%) | Mean (SD) |
|---|---|---|
| Control | 0.74 A (0.83-1.69) | 0.95 (0.51) |
| Charcoal-based powder | 1.24 A (0.83-1.69) | 1.28 (0.50) |
| Carbamide peroxide | 2.36 B (2.00-3.60) | 2.65 (1.11) |

[a] *Means followed by equal letters indicate no statistically significant differences in each column (p>0.05).*

### Surface Morphology

The surface of one randomly selected specimen from each group was examined for finished surface morphology. The specimens were subjected to vacuum in a sputter coater (SCD 050 Sputter Coater, Capovani Brothers Inc, New York, USA) to deposit a thin layer of gold before submitting to SEM (JSM 5600LV, JEOL, Tokyo, Japan).

### Statistical Analysis

The data obtained were double entered and analyzed using SPSS Statistics software (SPSS, Inc, Cary, NC, USA). Descriptive analysis was performed by estimating the mean and SD for all groups. Data of all parameters were examined for normality using the Shapiro-Wilk test. Because the color evaluation data presented nonparametric distributions, the Kruskal-Wallis test was used to compare groups. Surface roughness was evaluated using one-way analysis of variance (ANOVA), followed by Tukey post hoc tests. For all analyses, an $\alpha$ value of 0.05 was used to determine statistical significance.

## RESULTS

The Kruskal-Wallis test results for ΔE are presented in Table 2. Statistical differences were observed between group 3 and group 1 ($p<0.001$) and between group 3 and group 2 ($p=0.003$). No statistically significant difference was observed between group 1 and group 2 ($p=0.546$).

No statistically significant difference was noted between the groups for surface roughness (group 1 vs group 2: $p=0.623$; group 1 vs group 3: $p=0.157$; group 2 vs group 3: $p=0.613$; Table 3).

Figure 1 is an SEM image of enamel surface (A, group 2; B, group 1; and C, group 3). Photomicrographs of representative areas were taken at 35×

Table 3: *Mean, SD, and Confidence Interval for Roughness (ra) Evaluation Based on Treatment Groups*[a]

| | Mean | SD | Confidence Interval (95%) |
|---|---|---|---|
| Control | 140.14 A | 41.37 | (117.23-163.05) |
| Charcoal-based powder | 128.57 A | 25.36 | (114.53-142.62) |
| Carbamide peroxide | 116.80 A | 33.33 | (98.34-135.26) |

[a] *Means followed by equal letters indicate no statistically significant differences in each column (p>0.05).*

and 500× magnification for all groups. SEM characterization of the enamel surfaces after different surface treatments revealed a more irregular surface in group 1 specimens (Figure 1B) compared with group 2 and group 3 specimens. Group 2 and group 3 specimens (Figure 1A and 1C, respectively) seemed to have a smooth surface.

## DISCUSSION

This study showed that the charcoal-based toothpowder was not effective for dental bleaching, corroborating the first hypothesis. To the best of our knowledge, only one study[13] has assessed the potential whitening effects of charcoal powder to date. Four groups were tested in that study: water (negative control), activated charcoal (experimental group), coconut oil (positive control), and hydrogen peroxide (positive control). The study concluded that activated charcoal and coconut oil were not effective for dental bleaching, corroborating the results of our study.

The at-home dental bleaching under professional supervision using 10% carbamide peroxide and custom trays is safe and presents excellent esthetic results. Therefore, it is considered the gold standard for treating tooth discoloration.[2] Although associated with high cost and need for professional supervision, dental bleaching with 10% carbamide peroxide is the most preferred procedure in dental practice.[14] The interest for low-cost alternatives to dental bleaching and the search for organic and natural ingredients brought attention to charcoal-based preparations.

Charcoal is used for several medical indications, including poisoning and drug overdose. Charcoal is also recognized as a food ingredient and a food coloring agent in oriental countries for its claimed health benefits.[15–17] Its use for dental cleaning has been known for many years in different cultures.[7] In the last few years, a few charcoal-based products were disseminated as an organic and safe alternative to conventional dental bleaching techniques. The use

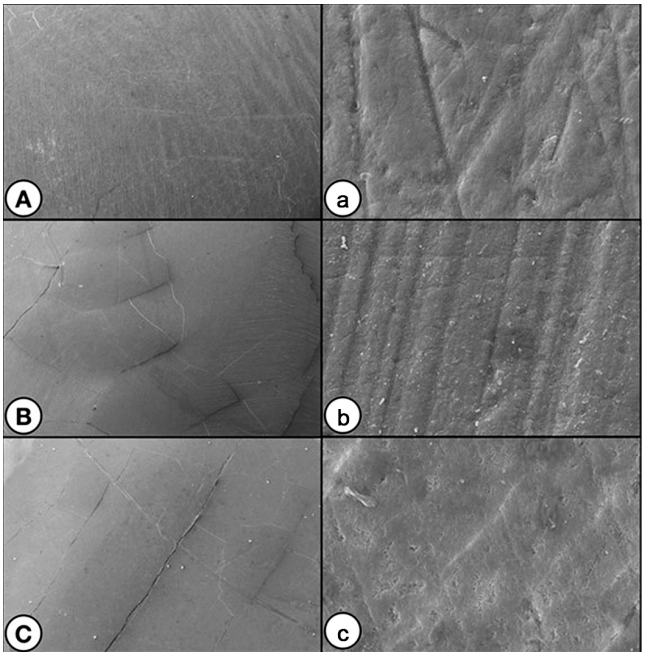


Figure 1. *Scanning microscopy of enamel surface per group (A/a group 2; B/b group 1; and C/c group 3) at 35x (uppercase letters) and 500x magnification (lowercase letters).*

of these products claimed to result in whiter teeth with affordable cost and without professional supervision. However, there are no studies in the literature on the beneficial effects of charcoal on teeth.[7, 8]

A few studies have presented inconclusive results regarding the effect of charcoal on oral hygiene, evaluating outcomes for caries, enamel abrasion, halitosis, and periodontal disease.[8] Limited information is available regarding controlled clinical studies that may provide evidence for the use of these products. A laboratory study evaluated the bleaching effect of a charcoal-based toothpaste and demonstrated a small whitening effect.[9] However, this was a subjective color evaluation using the VITA Classical Shade Guide.

In our results, only group 3 presented a statistical difference in the final color for ΔE parameters. There was no difference in the final color in group 1 and group 2 specimens. This might be because of the absence of a whitening agent in the charcoal-based powder and the apparent feeling of whiter teeth due to the contrast with the dark color of the powder.

Considering the parameters established by Paravina and others,[18] the acceptability threshold is a ΔE of 1.8. Accordingly, only group 3, with a ΔE of 2.65, showed a significant color change. According to these

parameters, a ΔE of 0.8 is considered clinically perceptible. Thus, the color change promoted by the charcoal-based powder, although not statistically detectable, was clinically perceptible, but it is not comparable to a bleaching effect. This slight color change may have been caused by enamel wear, which typically occurs following the use of abrasive toothpastes and could be easily confused as whitening conferred by the substance.[18–20]

In this study, enamel roughness was also evaluated. We examined whether the abrasiveness of the charcoal-based powder causes alteration in the enamel roughness. However, there was no statistical difference between the groups in enamel roughness. Similar results were found in a review by Demarco and others,[4] which concluded that dental bleaching with 10% carbamide peroxide has no harmful effects on enamel roughness. However, no study to this date has evaluated the effects of charcoal powder on the enamel surface.

SEM revealed a smooth surface in group 2 and group 3 specimens. This might have been due to a greater loss of tooth enamel. Therefore, both treatments seem to promote a certain degree of damage in the tooth enamel. However, SEM is a qualitative analysis, which does not allow data collection. Quantitative surface analysis such as profilometry may present more specific results in such studies.[21]

## CONCLUSION

The charcoal-based toothpowder had a certain degree of whitening effect, but it was not as effective as dental bleaching. The study results indicate that charcoal might not have any dental bleaching properties. However, further studies are warranted to determine the effect of charcoal on the dental surface.

#### Acknowledgements

This study was partially financed by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior, Brasil (CAPES) Finance Code 001 and the National Council for Scientific and Technological Development (CNPq, Brazil). The funders had no role in the study design, data collection and analysis, decision to publish, or preparation of the manuscript.

#### Regulatory Statement

This study was conducted in accordance with all the provisions, guidelines and policies of the Universidade Federal de Pelotas.

#### Conflict of Interest

The authors of this manuscript certify that they have no proprietary, financial, or other personal interest of any nature or kind in any product, service, and/or company that is presented in this article.

*(Accepted 27 September 2019)*

#### REFERENCES

1. Bernardon JK, Sartori N, Ballarin A, Perdigão J, Lopes G, & Baratieri LN (2010) Clinical performance of vital bleaching techniques *Operative Dentistry* **35(1)** 3-10.
2. de Geus J, Wambier L, Kossatz S, Loguercio A, & Reis A (2016) At-home vs in-office bleaching: a systematic review and meta-analysis *Operative Dentistry* **41(4)** 341-356.
3. Martin J, Rivas V, Vildósola P, Moncada L, Oliveira Junior OB, Saad JRC, Fernandez E, & Moncada G (2016) Personality style in patients looking for tooth bleaching and its correlation with treatment satisfaction *Brazilian Dental Journal* **27(1)** 60-65.
4. Demarco FF, Meireles SS, Sarmento HR, Dantas RVF, Botero T, & Tarquinio SBC (2011) Erosion and abrasion on dental structures undergoing at-home bleaching *Clinical, Cosmetic and Investigational Dentistry* **3** 45-52.
5. Magalhães Vaz M, Lopes LG, Cardoso PC, Souza JB De, Batista AC, Costa NL, Torres ÉM, & Estrela C (2016) Inflammatory response of human dental pulp to at-home and in-office tooth bleaching *Journal of Applied Oral Science* **24(5)** 509-517.
6. Demarco FF, Meireles SS, & Masotti AS (2009) Over-the-counter whitening agents: a concise review. *Brazilian Oral Research* **23(1)** 64-70.
7. Fischman SL (1997) The history of oral hygiene products: how far have we come in 6000 years? *Periodontology 2000* **15(Oct)** 7-14.
8. Brooks JK, Bashirelahi N, & Reynolds MA (2017) Charcoal and charcoal-based dentifrices: a literature review *Journal of the American Dental Association* **148(9)** 661-670.
9. Vaz VTP, Jubilato DP, de Oliveira MRM, Bortolatto JF, Floros MC, Dantas AAR, & de Oliveira OB Jr (2019) Whitening toothpaste containing activated charcoal, blue covarine, hydrogen peroxide or microbeads: which one is the most effective *Journal of Applied Oral Science* **27** e20180051.
10. Sharma G, Wu W, & Dalal EN (2005) The CIEDE2000 Color-Difference Formula: Implementation Notes, Supplementary Test Data, and Mathematical Observations Color research and application *Color Research and Application* **30(1)** 21-30.
11. Maske TT, Brauner K V, Nakanishi L, Arthur RA, van de Sande FH, & Cenci MS (2016) An in vitro dynamic microcosm biofilm model for caries lesion development and antimicrobial dose-response studies *Biofouling* **32(3)** 339-348.
12. Schroeder T, Barcellos P, Romanini G, Marina B, & Franco C (2019) Factors affecting the color stability and staining of esthetic restorations *Odontology* 2019;107(4): 507-512.
13. Chi C, Chun M, Gullo A, Teddy D, Hwang E, Oyoyo U, & Kwon SR (2018) Color monitoring: comparison between visual and instrumental methods with do-it-yourself

whitening *Journal of California Dental Association* **46(11)** 715-720.

14. Pérez M del M, Ghineaa R, Rivasa MJ, Ana Y, Ionescua AM, Paravinab RD, & Herrera LJ (2015) Development of a customized whiteness index for dentistry based on CIELAB color space *Dental Materials* **32(3)** 461-467.
15. Juurlink DN (2015) Activated charcoal for acute overdose: a reappraisal *British Journal of Clinical Pharmacology* **81(3)** 482-487.
16. Jia Z, Luo S, Zhong Y, Li X, & Chen J (2015) Acute and 28-day sub-acute oral toxicity evaluation of two dietary bamboo charcoal powders in Sprague-Dawley rats *Journal of Huazhong University of Science and Technology. Medical sciences* **35(2)** 192-199.
17. Karonidis A, Delikonstantinou I, & Tsoutsos D (2011) Use of Actisorb* dressings over a skin-grafted infected wound *Burns* **37(2)** 360-361.
18. Paravina RD, Ghinea R, & Herrera LJ (2015) Color difference thresholds in dentistry *Journal of Esthetic and Restorative Dentistry* **27(Supplement 1)** S1-9.
19. Macdonald E, North A, Maggio B, Sufi F, Mason S, Moore C, Addy M, & West NX (2010) Clinical study investigating abrasive effects of three toothpastes and water in an in situ model *Journal of Dentistry* **38(6)** 509-516.
20. Nakamura M, Kitasako Y, Nakashima S, Sadr A, & Tagami J (2015) Impact of toothpaste on abrasion of sound and eroded enamel: an in vitro white light interferometer study American Journal of Dentistry **28(5)** 268-272.
21. Prencipe M, Vandeven M, N Feldman B, & R Schemehorn B (2016) A comparative study of laboratory dentifrice abrasion measuring methods *Journal of Clinical Dentistry* **27(4)** 105-109.