In vitro evaluation of the abrasiveness of a commercial low-abrasive dentifrice and an experimental dentifrice containing vegetable oil

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Abstract

Toothpastes usually contain detergents, humectants, water, colorant, fluoride and thickeners (e.g.: silica). Tooth wear has a multi-factorial etiology and the use of abrasive dentifrices is related to abrasion of dental tissues during toothbrushing. This study evaluated *in vitro* the abrasiveness of a commercial silica gel low-abrasive dentifrice compared to an experimental dentifrice containing vegetable (almond) oil. Distilled water served as a control group. Acrylic specimens (8 *per* group) were submitted to simulated toothbrushing with slurries of the commercial dentifrice, experimental dentifrice, almond oil and water in an automatic brushing machine programmed to 30,000 brush strokes for each specimen, which is equivalent to 2 years of manual toothbrushing. Thereafter, surface roughness (Ra) of the specimens was analyzed with a Surfcorder SE 1700 profilometer. Data were analyzed statistically by ANOVA and Tukey's test at 5% significance level. There was no statistically significant difference ($p>0.05$) in the surface roughness after brushing with water, almond oil or experimental dentifrice. The commercial dentifrice produced rougher surfaces compared to the control and abrasive-free products ($p<0.05$). Further studies are necessary to confirm the potential benefits of using vegetable oil in toothpastes as an alternative to abrasives in an attempt to minimize the tooth wear caused by toothbrushing.

Key Words:
toothpaste, dentifrice, abrasives, toothbrushing, vegetable oil, tooth wear.

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Introduction

Toothbrushing with toothpaste is the most common form of oral hygiene practice[1], avoiding dental plaque and gingival bleeding[2]. Toothpastes usually contain detergents, humectants, water, colorant, fluoride and thickeners (e.g.: silica). High-quality dentifrices contain silica, which is considered as a reference abrasive for a more effective removal of dental biofilm and stains, according to the ISO 11609:1995 standard (Dentistry-Toothpastes: Requirements, test methods and marking)[3-5].

Studies have suggested a strong correlation between tooth wear and the cleaning power of dentifrices[4]. Concern has been expressed about the wear of dental tissues and restorative materials due to the abrasiveness of currently available dentifrices[6-8]. Several authors have evaluated surface roughness *in vitro* using automatic brushing machines to simulate toothbrushing[3,6,9-14].

The surface roughness resulting from toothbrushing with abrasive toothpastes represents an important oral health problem[10]. Many authors have investigated the safety and efficacy of toothbrushes and toothpastes on hard and soft oral tissues and have expressed concern about the multi-factorial etiology of tooth wear and gingival recession involving complex inter-related processes[15].

A significant percentage of the population shows considerable levels of tooth wear caused by abrasive dentifrices, consumption of acid food and drinks and diseases, such as asthma, diabetes and xerostomy[16,17]. Patients with tooth wear present dentinal hypersensitivity, which causes pain on toothbrushing and ingestion of cold, hot or acid drinks, rougher dental surface, which facilitates the adherence of dental biofilm and increases the risks of development of caries and periodontal diseases (gingivitis and bone loss)[10]. Tooth wear has complex consequences to the patients and can require expensive treatment involving restorative, endodontic, surgical and/or prosthetic procedures.

Finding a substitute for abrasives in toothpaste formulation is of ultimate importance. Vegetable oil has been used for toothbrushing as an alternative to abrasives in dentifrice formulation demonstrating an effective removal of dental plaque[18]. A recent study has reported that an experimental almond oil dentifrice (Titoil) with no abrasives or antiplaque agents did not interfere with salivary flow and successfully reduced dental plaque, improved the salivary buffer capacity and decreased salivary *S. mutans* counts. More specific studies are necessary to understand its efficacy on toothpaste[19].

Nowadays, the population has natural teeth until a more advanced age and thus the harmful effect of toothpaste abrasives on tooth wear is more clearly evidenced, accentuating the problem of cervical abrasion[20-21]. Cervical abrasion should be avoided by using dentifrices without abrasives which, unfortunately, are not currently available in the market.

The objective of this study is to evaluate *in vitro* the abrasiveness of a commercial silica gel low-abrasive dentifrice and an experimental dentifrice containing vegetable (almond) oil.

Material and Methods

Thirty-two acrylic rectangular specimens were prepared following the internationally acceptable standards for brushing tests (47x20x2mm, hardness 20; Perspex; Amari Plastics plc, Weybridge, UK)[14] and subjected to simulated toothbrushing in an automatic brushing machine (Equilabor; Equipamentos para Laboratório, Piracicaba, SP, Brazil), modification of the British Standards Institution (1981): British Standard No. 5136: Specification for Toothpastes.[9] This brushing machine has four brushing arms (Fig. 1) each one holding two brushing heads fixed with cyanoacrylate adhesive (Super Bonder®, Loctite, Itapevi, SP, Brazil) which run over 8 receptacles that houses the specimens and are filled with 12 g of slurry for the brushing test (Fig. 2). The machine has a linear movement mechanism with 47-mm strokes and a variable speed of 0 to 350 cycles *per* minute. In this study, the specimens were subjected to a linear toothbrush abrasion movement with a rate of 250 brush strokes (forth and back) *per* minute, totalizing 30,000 brush strokes for each specimen. Brushing abrasion run at a 200-g load imposed by metallic weights with 32 soft-bristled toothbrushes (Kolynos Master, Brazil) to simulate the toothbrushing force of an adult[11,12,22]. Two hours of brushing were performed in the presence of slurries (96 g) of the following products with distilled water (1:1 w/w): a commercial silica gel low-abrasive dentifrice (Tandy Tutti-Frutti, Kolynos do Brasil Ltda São Paulo/); an experimental dentifrice containing almond oil (Titoil; authors' preparation at the Department of Preventive and Community Dentistry, Dental School of Araçatuba, UNESP, Brazil); and almond oil (Drogasil, São Paulo, SP, Brazil). Distilled water served as a control group. The toothbrushes and the slurries were replaced at every change of specimen.

After brushing, the specimens of all four groups were cleaned with biodegradable detergent and tap water and dried with compressed air stream. Profilometry was employed to assess surface roughness (Profilometre Surfcorder SE 1700; Kosaka Laboratory Ltd., Tokyo, Japan). For each specimen, roughness was determined as the average of 5 random measurements made on specimen surface[12,23]. Data were submitted to statistical analysis of variance (ANOVA) and Tukey's test for comparison of the four groups. Significance level was set at 5%.

The brushed specimens were photographed with a camera (Pentax 35M, lens ´0.25 magnification, Tokyo, Japan) coupled to a stereomicroscope at ´1.6 magnification (Carl Zeiss, Jena

GmbH, Germany)[23] to illustrate the differences in surface roughness after toothbrushing. The photographs were analyzed qualitatively by a single observer blinded to the groups.

Results

The average surface roughness means measured after simulated toothbrushing of the acrylic specimens with the tested products are presented in Table 1. Simulated toothbrushing with the commercial silica gel low-abrasive dentifrice produced statistically significant rougher surfaces ($p<0.05$) compared to the other tested substances: water, almond oil and almond oil experimental dentifrice. However, water almond oil and almond oil experimental dentifrice did not differ significantly from each other ($p>0.05$).

Similar findings were obtained in the qualitative analysis. The examination of photographs of 4 specimens, one from each group, revealed that the specimen brushed with the commercial dentifrice presented significantly deeper grooves than the specimens brushed with water, almond oil or almond oil experimental dentifrice, which, in turn, produced grooves of similar depths on the acrylic specimens.

Table 1. Average surface roughness (*Ra*; µm) measured after simulated toothbrushing of the acrylic specimens with the tested products.

Substance	Mean ± SD
Distilled water (control; n=8)	0.07 ± 0.02b
Titoil (n=8)	0.07 ± 0.02b
Almond Oil (n=8)	0.10 ± 0.06b
Commercial dentifrice (n=8)	1.85 ± 1.22a

Different letters indicate statistically significant difference at 5% (ANOVA and Tukey's test). SD= standard deviation.

Discussion

The use of an almond oil-containing dentifrice for toothbrushing in this study was motivated by the promising results of previous laboratorial and clinical studies that used almond oil as a substitute of abrasives in dentifrices, reducing dental plaque and *S. mutans* counts and improving saliva flow and buffer capacity[18,19]. The findings of these investigations disagree with those of studies that relate the cleaning potential of dentifrices with the amount of abrasives present in their formulation[3,6]. 97929486

The goal of this study was to evaluate comparatively the abrasiveness of a commercial low-abrasive dentifrice and an almond oil-based experimental dentifrice after simulated toothbrushing by the analysis of the surface roughness on acrylic blocks. The commercial dentifrice used in this study contains silica, which is a reference standard for abrasiveness assays and is representative of high-quality dentifrice formulations[5].

Statistical analysis of post-toothbrushing roughness data by ANOVA and Tukey's test[11,12,23] showed that the commercial silica gel low-abrasive dentifrice produced rougher surfaces than the almond oil-based products. In this first study combining simulated toothbrushing and surface roughness analysis, almond oil and the almond oil-containing dentifrice (Titoil) had similar abrasiveness. In addition, both substances produced similar surface roughness as that of water (control), confirming that almond oil is not an abrasive agent.

In order to establish the depth of loss, further studies on toothpaste abrasion during toothbrushing should include the surface roughness profile on the specimen before and after brushing[12,24,25]. This is one of the limitations of this study, since differences between final and initial surface roughness may have influenced significantly the results.

The brushing machine and acrylic specimens used in the present study were selected as they have been used in several studies that evaluated toothpaste abrasion due to their high degree of standardization and reproducibility[5,10-12,14,23]. More recent methods for *in vitro* surface roughness testing have involved other substrates, such as enamel and dentin, for conducting the experiments[24]. *In situ* studies on toothpaste abrasion have also been conducted with the placement of enamel blocks in intraoral appliances or denture teeth. The enamel specimens are in contact with saliva where remineralization processes are well established[25]. The substances tested *in vitro* in this study may not cause the same surface roughness after toothbrushing on enamel, dentin, restorative material and prostheses when patients are performing oral hygiene.

This study tested four different substances with the same standard toothbrushes showing that the different surface roughness values were produced by the different slurries. This result demonstrate that the toothbrushes *per se* are not responsible for tooth wear, but the dentifrices have a direct participation[22,26].

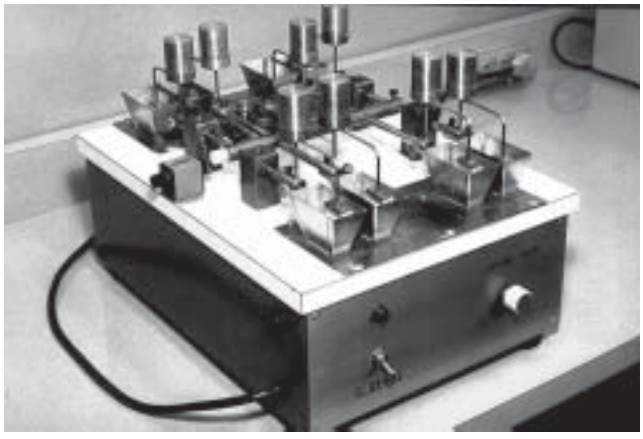

Fig. 1 - *Automatic brushing machine*

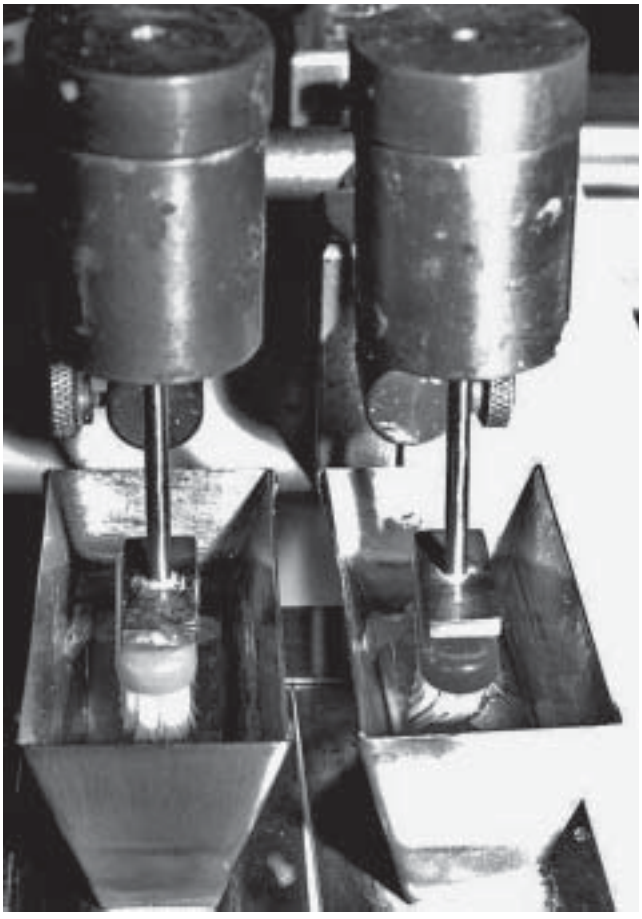

Fig. 2 - *Specimens fixed on the machine's receptacles*

The results of the present study showed that after toothbrushing with a commercial dentifrice containing silica there was significantly more surface roughness compared to brushing with almond oil substances, which agree with previous investigations that demonstrated that abrasive toothpastes can be potentially harmful, causing tooth wear and abrasion of restorations and prostheses[5,10].

Photographs with a stereomicroscope have been used elsewhere for analysis of surface roughness[22,26]. In the present study, the photographs showed deeper grooves after simulated toothbrushing with the commercial dentifrice (Fig. 6) compared to brushing with water, almond oil or almond oil-containing dentifrice (Figs. 3-5). These results are consistent with the higher surface roughness values recorded with the profilometer in the specimens brushed with the commercial dentifrice.

Further studies are necessary to confirm the potential benefits of using vegetable oil in dentifrice formulations as an alternative to the addition of abrasives in an attempt to improve the efficacy of toothbrushing in oral hygiene and minimize or perhaps avoid negative side effects such as tooth wear.

In conclusion, there was no significant difference in the

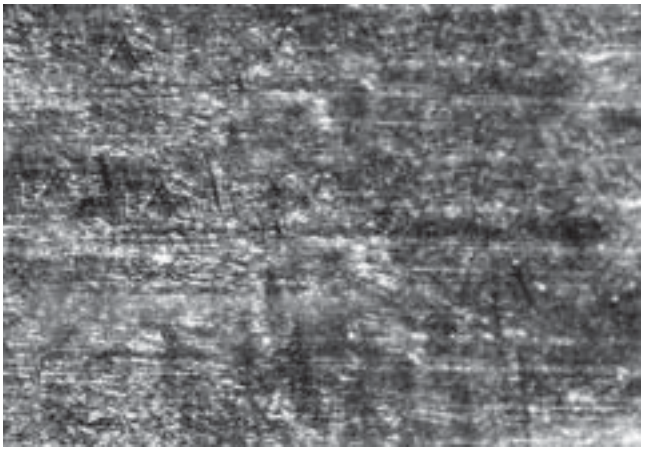

Fig. 3 - *Grooves produced by water*

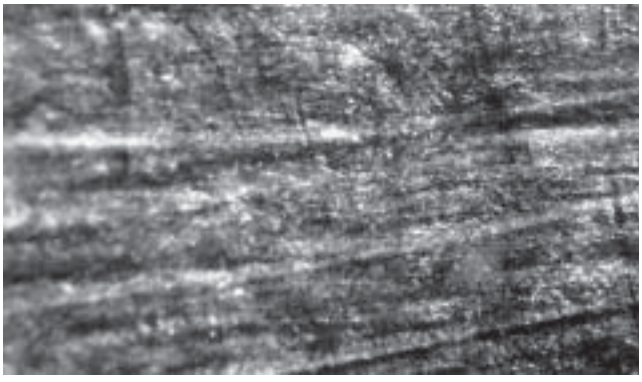

Fig. 4 - *Grooves produced by almond oil*

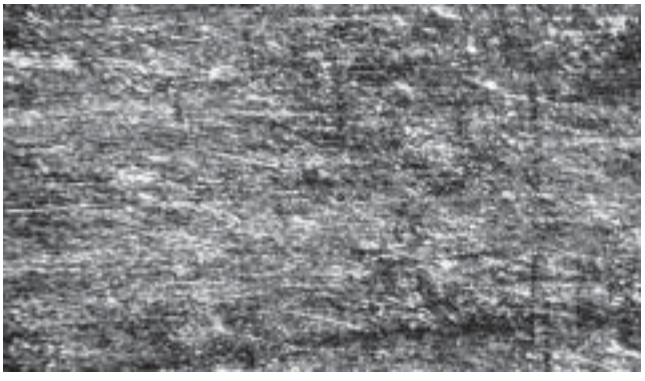

Fig. 5 - *Grooves produced by the experimental dentifrice containing vegetable oil (Titoil)*

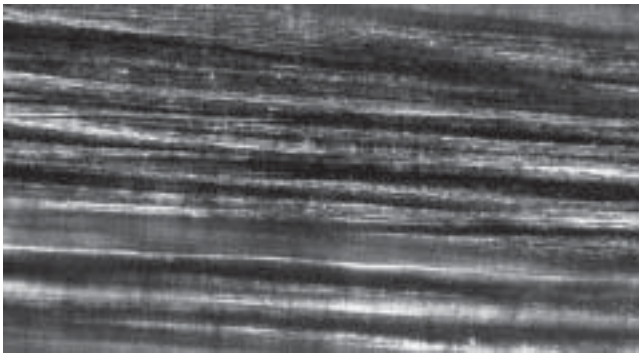

Fig. 6 - *Grooves produced by the commercial low-abrasive dentifrice (Tandy)*

surface roughness means produced by Titoil, almond oil or water (control), which, however, were significantly lower than the one produced by the commercial silica gel low-abrasive dentifrice.

References

1. Löe H, Kleinman DV. Dental Plaque Control Measures and Oral Hygiene Practices. Oxford: IRL Press; 1986; 332p.
2. Bueno MAM, Toledo S, Sallum EA, Nociti Junior FH. Influência da escovação dental orientada na redução do sangramento gengival, em áreas próximas a restaurações metálicas. Rev ABO Nac. 1998; 6: 44-7.
3. Andrade Junior ACC, Andrade MRTC, Machado WAS, Fischer RG. Abrasividade de dentifrícios: Revisão de literatura. Rev Periodontia. 1997; 6: 25-30.
4. Baxter PM, Davis WB, Jackson J. Toothpaste abrasive requirements to control naturally stained pellicle. J Oral Rehabil. 1981; 8: 19-26.
5. Hefferren JJ, Schemehon B, Storek A, Lerck M, Li N. Silica as a reference for laboratory dentifrice assessment methods: multiple collaborative study. J Clin Dent. 2007; 8: 12-6.
6. Stookey G, Muhler J. Laboratory studies concerning the enamel and dentin abrasion properties of common dentifrice polishing agents. J Dent Res. 1968; 47: 524-32.
7. Glantz PO, Larsson LA. Surface roughness of composite resins before and after toothbrushing. Acta Odont Scand. 1972; 30: 335-47.
8. Prampero AL, Lara EHG, Tostes RCA, Ogasawara MS, Panzeri H. Relação das escovas com dentifrícios: estudo da interação de escovas dentais de diferentes tipos de cerdas com preparações básicas para dentifrícios. RGO. 1992; 40: 298-302.
9. Slop D, Rooij JF, Arends J. Abrasion of enamel. I. An in vitro investigation. Caries Res. 1983; 17: 242-8.
10. Heath J, Wilson J. Abrasion of restorative materials by toothpaste. J Oral Rehabil. 1976; 3: 121-38.
11. Patrão FGD, Sinhoreti MAC, Consani S, Correr Sobrinho L, Milan FM. Avaliação *in vitro* da rugosidade produzida por escovas dentais e dentifrícios em resina para base de prótese. Rev Fac Odontol Univ Passo Fundo. 1998; 3: 7-14.
12. Correr Sobrinho L, Francisco MU, Consani S, Sinhoreti MAC,Consani RLX. Influência da escovação na rugosidade de superfície de materiais restauradores estéticos. PGR Pós-Grad Rev Fac Odontol São Jose dos Campos. 2001; 4: 47-55.
13. Lara EHG, Panzeri H, Ogasawara MS, Ciampo JOD, Moraes JT. Avaliação laboratorial dos dentifrícios comerciais. Rev ABO Nac. 1996; 4: 176-80.
14. Addy M, Goodfield S, Harrison A. The use of acrylic to compare the abrasivity and stain removal proprieties of toothpastes. Clin Mater. 1991; 7: 219-25.
15. Addy M. Evaluation of clinical trials of agents and procedures to prevent caries and periodontal disease: choosing products and recommending procedures. Int Dent J. 1995; 45: 185-96.
16. Shaw L, al-Dlaigan YH, Smith A. Childhood asthma and dental erosion. J Dent Child. 2000; 67: 102-6.
17. Al-Dlaigan YH, Shaw L, Smith AJ. Is there a relationship between asthma and dental erosion? A case control study. Int J Paediatric Dent. 2002; 12: 189-200.
18. Aguiar AAA, Moraes Filho FC. A interferência do óleo vegetal na aderência da placa bacteriana dental. Rev Cienc Odontol. 1998; 1: 21-5.
19. Aguiar AAA, Saliba NA. Toothbrushing with vegetable oil: a clinical and laboratorial analysis. Braz Oral Res. 2004; 18: 168-73.
20. Meneghim MC, Pereira AC, Silva FRB. Prevalência da cárie radicular e condição periodontal em uma população idosa institucionalizada de Piracicaba – SP. Pesqui Odontol Bras. 2002; 16: 50-6.
21. Fransson C, Berglundh T, Lindhe J. The effect of age on the development of gingivitis. Clinical, microbiological and histological findings. J Clin Periodontal. 1996; 23: 379-85.
22. Lima FAP, Góes MF, Consani S. Avaliação "in vitro" da ação abrasiva de escovas dentais. Odonto. 1998;3:23-7.
23. Santos PH. Avaliação da porosidade interna e da rugosidade de superfície de resinas compostas para dentes posteriores submetidas à escovação. [Master's thesis]. Piracicaba-SP: Piracicaba Dental School/UNICAMP; 2000. 180p.
24. Moore C, Addy M. Wear of dentin in vitro by toothpaste abrasives and detergents alone and combined. J Clin Periodontol. 2005; 32: 1242-6.
25. Joiner A, Pickles MJ, Tanner C, Weader E, Doyle P. An in situ model to study the toothpaste abrasion of enamel. J Clin Periodontol. 2004; 31: 434-8.
26. Figueiredo MC, Bello D. Avaliação comparativa entre a eficácia de uma escova alternativa e uma escova convencional na remoção de placa dentária. Rev Fac Odontol Univ Passo Fundo. 1999; 4: 13-20.