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ORIGINAL RESEARCH

The influence of water temperature during toothbrushing on root dentine: An *in vitro* study

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ABSTRACT

Background/Aims: The use of cold water during toothbrushing can cause dentine sensitivity and, to avoid this painful stimulus, some patients used to rinse their mouths with warm water when brushing. Thus, the objective of this study was to determine the effect of water temperature on the dental root surface during toothbrushing.
Materials and Methods: Fragments of bovine dental roots were submitted to 15,000 strokes in a toothbrushing machine using a slurry of toothpaste/water, medium brushes, and a 200-g load. They were randomly divided into two groups: toothbrushing with cold water or with hot water. Tooth wear was measured by loss of weight and by tissue height.
Statistical Analysis: The weight and height data obtained in 17 and 10 replicas respectively are presented as mean ± standard error of mean. The data were compared using the Kolgomorov–Smirnof (Lilliefors) test followed by one-way ANOVA. The level of significance was 5% ($P < 0.05$).
Results: There were no significant differences between the two experimental groups. The mean percentages of weight losses were 5.61 ± 1.66 for cold water and 6.25 ± 1.98 for hot water. The mean dentine height losses were 51.02 ± 15.92 μm for cold water and 63.54 ± 17.75 μm for hot water.
Conclusion: The use of warm water during toothbrushing promoted root dentine wear similar to that produced by the use of cold water. The results suggest that warm or cold water may be used during toothbrushing without any additional damage to the patients' dental hard tissues.

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Dental tissue loss is usually related to caries or non carious lesions. In non carious lesions, different processes can cause the loss, such as abfraction, attrition, erosion, abrasion, and/or their combination.[1] Abrasion is the result of mechanical and pathological wear of the dental surface, caused mainly by the toothbrushing process.[2] The amount of tooth wear caused by toothbrushing depends on the toothbrushing technique,[3] force of brushing,[4] the frequency and the duration of the process,[2] and the type of brush and dentifrice used.[5] Dental tissue loss occurs mostly in cervical areas, exposing dentine tubules and thereby predisposing them to dentine sensitivity.

Dentine sensitivity is a relatively common condition. Its prevalence varies between 17% and 50%,[6,7] depending on the population and the method used. Dentine sensitivity is characterized by a higher number of open and wider dentinal tubules per area when compared with non sensitive dentine.[8] In this condition, a short, sharp pain presenting variable intensity may occur.[9] This symptom may be induced by thermal, dehydrating, tactile, chemical, or osmotic stimuli.[5,10] The most common source of this pain is cold,[6,11,12] which, in turn, is frequently associated with toothbrushing.[6] This led to the observation by our group in the general clinic that patients with dentine sensitivity usually reported that they brushed their teeth with warm water, especially in cold days, in order to minimize discomfort. However, the influence of this habit on dental tissue loss during toothbrushing is unknown.

Harte and Manly,[13] in an *in vitro* study of toothbrushing, observed that when they performed the tests at 37°C, dental wear was 28% less severe compared with the toothbrushing tests performed at room temperature. In this case, the rise in temperature had a positive influence on dental tissue loss. The explanation given by the authors for this was that high temperatures caused a softening of the brush bristles. However, the amount of wear caused by toothbrush bristles of different hardness is controversial. Dyer *et al.*[14] showed that soft brushes produced more wear than medium or hard brushes. In view of this, the temperature of the water used during toothbrushing could also play a role in the amount of tooth wear.

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Because the treatment for dentine sensitivity includes identifying and eliminating the predisposing etiologic factors,[15] determining the influence of water temperature on dental tissue loss during toothbrushing would allow one to correctly instruct patients who have non carious cervical lesions associated with dentine sensitivity. This information would contribute to a better quality of life. Thus, the aim of the present study was to determine the *in vitro* effect of water temperature in dental root surface tissue loss during toothbrushing.

MATERIALS AND METHODS

The wear of the dental roots was evaluated by measuring changes in the weights and heights of bovine teeth specimen.

Sample preparation

Fifty-four bovine incisors were scraped to remove any remaining debris. Then, they were stored in distilled water under refrigeration (4°C). The crown and the apical portion of the root were then discarded and, from the remaining dental roots, 15mm-long fragments were obtained. The pulp remnants were removed and both ends of the root canal in the fragments were sealed with a composite resin (Filtek Z 250, 3M do Brasil, SP, Brazil) to avoid water accumulation inside the root canal. The dental root specimens were randomly divided into two experimental groups (n = 27): One for toothbrushing with cold water (CW) and the other for toothbrushing with hot water (HW). The wear of the 27 samples in each group was analyzed by measuring changes in weight (n = 17) and in dental root surface height (n = 10). The samples were randomly divided for those two analyses.

Weight measurements

Firstly, the samples (n = 17 per group) were waterproofed using an adhesive system (Prime and Bond 2.1, Densply – Petrópolis, RJ, Brazil). This adhesive was applied on all the surfaces of these samples after etching with 37% phosphoric acid, except for one of the surfaces that was designated to be brushed.

Next, these samples were dehydrated using absorbent paper followed by incubation in a vacuum desiccator chamber containing silica for 72 h. After dehydration, the samples were weighed twice on an analytical scale (AB204, Mettler Toledo-Switzerland) with a precision of 0.001 g. The mean obtained from the two weight measurements was considered as the initial weight (IW). After this, the samples were submitted to toothbrushing as described below. After completing all the toothbrushing strokes, the samples were again dehydrated and weighed twice. The mean of the two weight measurements obtained after toothbrushing was considered as the final weight (FW).

The changes in the dental root weights were presented as percentage wear. This percentage was obtained using the following mathematical formula: IW – FW × 100/IW.

Surface height measurements

For measuring the changes in height, the remaining samples (n = 10 per group) had their surfaces brushed and planed in an automatic lapping and polishing machine, with a sequence of abrasive paper discs of decreasing grit: 120, 240, and 400 under running water. The polished surfaces of the samples were submitted to toothbrushing by the machine as described below. After all toothbrushing strokes had been completed, the samples were embedded in bakelite (Sultrade – São Paulo, SP, Brazil) in order to obtain the profiles of the brushed surface to be analyzed under a light microscope coupled to a computer imaging program (Leica Qwin Colour RGB, Tokyo, Japan). For these measurements, the images were magnified 50 times. Figure 1 illustrates the measurements of the brushed surfaces. Briefly, from the dental root surface that was not submitted to toothbrushing located at the periphery of the brushed surface, a line was drawn. Then, perpendicular to this first line, five lines were drawn at the center of the deepest grooves. The mean distance from the ends of the grooves to the first line was considered the height loss of each sample.

Toothbrushing simulation

Toothbrushing was performed in an automatic machine with back and forth movements. Each group was submitted to 15,000 strokes with a 200 g load, using a medium brush (Colgate Classic, Colgate–Palmolive - São Caetano do Sul, SP, Brazil) and a dentifrice slurry consisting of one part by weight of dentifrice (Colgate Máxima Proteção Contra as Cáries, Colgate–Palmolive) and two parts of water. In the Cold Water group (CW), the slurry was cooled to 5°C and in the Hot Water group (HW), warmed to 50°C. Every 200 strokes, the dentifrice slurry was renewed. During the experiment, the room temperature of 21°C was maintained constant. Considering the possible softening of the toothbrush bristles, the brushes were changed after 7500 strokes.

For the samples used in the height measurements, the toothbrushes were especially prepared. These brushes had the bristles of the two lateral rows removed, leaving only the two central rows [Figure 2]. This adapted brush wore the dental surface in a single direction and, at the periphery of the brushed area, the initial profile of the surface was conserved.

Statistical analysis

The weight and height data obtained in 17 and 10 replicas respectively are presented as mean ± standard error of mean. The data were compared by the Kolgomorov–Smirnof (Lilliefors) test followed by one-way ANOVA. The level of significance was 5% ($P < 0.05$).

RESULTS

Figure 3 illustrates the results obtained after weighing the teeth of the two experimental groups. The mean percentage of

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the weight losses were 5.61 ± 1.66 for teeth brushed with cold water and 6.25 ± 1.98 for teeth brushed with hot water. The statistical comparison of the weight data showed no differences between the two experimental groups ($P > 0.05$).

The root surface wear was obtained by subtracting the dental root surface height observed after toothbrushing from the original height of this surface in the peripheral region of the brushed area. The mean root surface wear of the two experimental groups is graphically represented in Figure 4. The statistical comparison between root surface wear of teeth brushed with cold water (51.02 ± 15.92) was similar to that of teeth brushed with hot water (63.54 ± 17.75; $P > 0.05$).

DISCUSSION

The wear of dentine bovine root after toothbrushing was not dependent on the water temperature because dental wear observed when warm water (50°C) was used was similar to that of toothbrushing with cold water (5°C).

In spite of the extensive existent literature on dentine sensitivity and oral hygiene, little evidence is available as regards the effect of water temperature during toothbrushing on the development of dental tissue loss. Evidence suggests[8] that patients suffer the painful symptoms of dentine sensitivity when the dentine is exposed and the dentinal tubule system is open to the oral cavity to allow stimuli to trigger a neural response in the pulp via a hydrodynamic mechanism. A large number of patients with sensitivity reported that they brushed their teeth with warm water to avoid pain. It is known that temperature can influence dental hard tissue loss.[13] This could be related to the softening of toothbrush bristles caused by high temperatures.[13] Based on this information, the hypothesis was raised that warm water used during the toothbrushing process could also influence dental hard tissue loss, either by modifying the stiffness of the bristles or by influencing the mechanical wear itself.

With regard to toothbrush bristles, it is well known that temperature can modify toothbrush bristle morphology.[16] However, the influence of the brush stiffness on toothbrushing

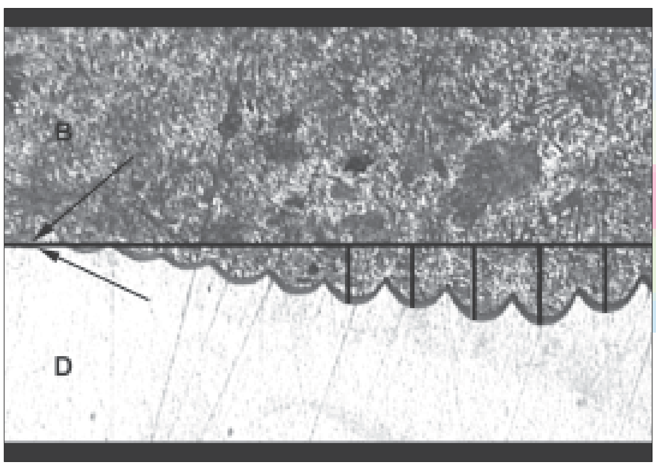

Figure 1: Photomicrograph of a sample after the toothbrushing strokes showing the lines used for the measurements of the brushed surface height loss. The conserved profile is shown between the arrows. (D, dentine; B, Bakelite) (Original magnification ×50)

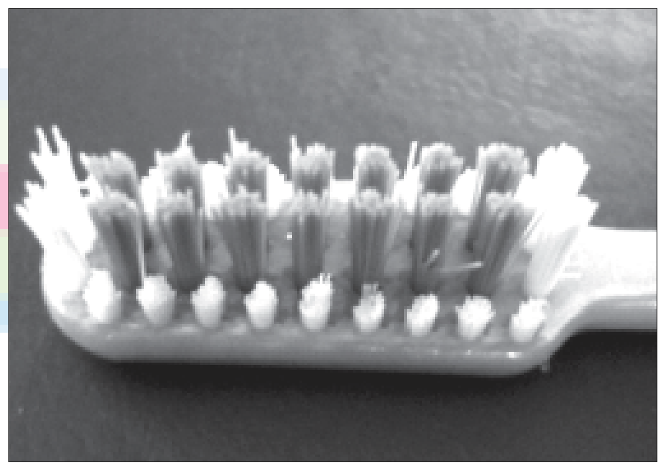

Figure 2: Photograph of the especially designed toothbrush used in the height loss experiment. This brush presents only bristles at the two central rows

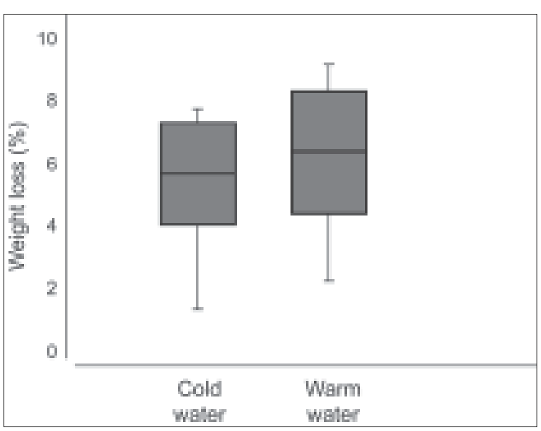

Figure 3: Graphic representation of the mean percentages (± SEM) of the weight losses for both experimental groups

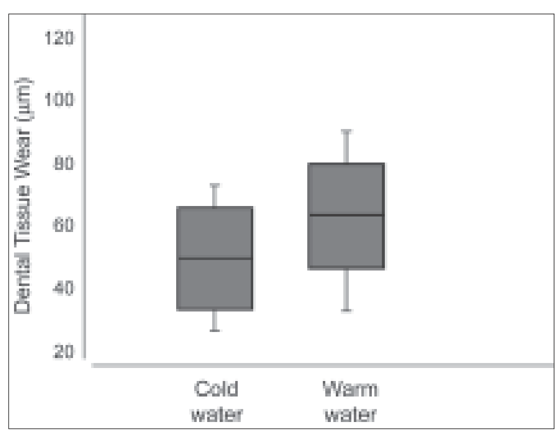

Figure 4: Graphic representation of the dental tissue wear showing the mean (± SEM) of the height losses for both experimental groups

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wear is controversial. De Boer *et al.*[17] found that soft brushes produce less wear than medium or hard brushes. On the other hand, Dyer *et al.*[14] showed that soft brushes produced more wear than medium or hard brushes because they cause greater retention of toothpaste by their thinner and dense tufts. In addition, the tufts are also more flexible, increasing the contact area with the surface. As no difference was found between the two experimental groups in this study, temperature may not have an important influence on the brush bristles stiffness or the effect of brush bristles stiffness on the wear caused by toothbrushing is not so important. In agreement with the latter statement, some authors claimed that during a lifetime of use, the differences between the effects of the stiffness of the bristles on dental tissue abrasion were considered insignificant.[14,18]

The changes in dentine surface were measured by weight loss and height measurements. The weight measurement of dried specimens before and after brushing was chosen as the method for analyzing the dentine wear, based on the existent methods to evaluate *in vitro* toothpaste abrasion.[19-21] To complement this method, it was decided to use a morphological method using the optical reading under a microscope with an imaging program. The optical reading method is frequently used in mechanical engineering laboratory procedures, for instance, to measure the layer of oxides formed on metal surfaces. To measure the dental tissue loss by this method, some adaptations were made to the samples and brushes. The surfaces of the samples were planned before they were submitted to the strokes and the brushes had the row of lateral tufts removed, with only the central rows remaining. These remaining rows were capable of producing localized and measurable wear in the dentine. As the initial surfaces were plane, the localized wear preserved the original profile of the samples in their adjacencies. In the present study, this method had shown to be suitable for performing *in vitro* measurements to determine toothpaste abrasion.

The temperatures used in this study, 5°C for cold water and 50°C for hot water, respectively, represent the water from a common faucet on cold days and the maximum temperature reached by showers and faucets with hot water. However, as was observed by Eisenburger and Addy,[22] *in vitro* conditions should be carefully extrapolated to conditions *in vivo*, because the temperature that reaches the tooth surface is not necessarily the same as that of the slurry used. In addition, using *in vitro* conditions, it is difficult to simulate important factors such as the temperature of the mouth, the action of saliva, and the demineralization/remineralization processes. The tests were performed in bovine dentine but, in agreement with the studies of Imfeld,[23] the results found in *in vitro* abrasion tests in bovine dentine can be extrapolated to human dentine because a great deal of similarity was observed between the two substrates.

Based on the results obtained in this study, it was concluded that water temperature during toothbrushing is not a determinant factor in dental tissue loss. This study may assure clinicians that water temperature does not negatively influence dental root wear by toothbrushing. Thus, the clinicians can advise and encourage their patients to brush their sensitive teeth with warm water.

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