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ORIGINAL ARTICLE

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Clinical evaluation of three toothbrush models tested by schoolchildren

Abstract: *Aim:* The aim of this single-blind cross-over study was to compare the performance of three different toothbrush models in the control of dental biofilm and maintaining a healthy gingival condition. *Methods:* Twenty-seven schoolchildren (aged 9–10 years) participated in the study. Three toothbrushes with different bristle arrangements were used: T1 – bristles on the same plane, straight arrangement; T2 – bristles on different planes, straight arrangement; T3 – bristles on different planes, straight and circular arrangement. The participants were then randomly divided into three groups for brushing with one of the three toothbrushes. Each experimental period lasted 15 days each, with three daily brushings and a 7-day washout interval was used between periods. The oral hygiene and gingival bleeding indices were recorded by a single, calibrated examiner blind to the brush used. Bristle wear was measured with a digital calliper at the end of each period. The data were analysed using parametric (ANOVA and Student's *t*-test) and non-parametric (Cochran's Q and McNemar) tests. *Results:* The toothbrushes achieved similar results ($P > 0.05$) for the clinical parameters investigated. The three models exhibited a similar degree of bristle wear ($P > 0.05$). *Conclusion:* The arrangement of the bristles had little influence over the removal of biofilm and gingival conditions. Thus, there is no clinical justification for replacing conventional toothbrushes with more expensive models.

Key words: dental biofilm; gingivitis; oral hygiene; toothbrush: electric/manual

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Introduction

Among all available means of oral hygiene, toothbrushing is the most common and often the only method employed by adults and children. The aim of toothbrushing is the removal of dental biofilm, thereby preventing its evolution into more pathogenic forms and thus reducing the risk of caries and gingivitis (1–4).

The mechanical action of manual brushing is an efficient method for controlling dental biofilm. However, there are factors that influence the effectiveness of this procedure, such as the dexterity of the individual, frequency, duration and toothbrush design (5–8). Three factors (dexterity, frequency and duration of brushing) are dependent on the individual and are directly related to his/her motor skills and learning capacity as well as behavioural and motivational factors. For oral health professionals, it can be difficult to change patient behaviour to maximize the efficacy of toothbrushing, as the majority of individuals use self-developed techniques and brush for shorter periods than what is commonly recommended (8–11).

The third factor (toothbrush design), however, undergoes constant change, as evidenced by the technological evolution in toothbrushes in the last few years (7, 10, 12–14). Changes in the physical and mechanical properties of toothbrushes, such as differences in the materials employed, arrangement of the bristles, angle and shape of the head and handle, may contribute to an increase in the effectiveness of brushing, thereby minimizing the limitations of individuals regarding oral hygiene. Moreover, differentiated toothbrushes with stimulating materials and textures may also be a motivating agent and foster an increase in the time spent brushing (1, 5, 9, 11, 15, 16).

Among the changes, the arrangement of the bristles merits special attention. There are variations to be considered regarding the thickness, stiffness, arrangement and tips of the bristles. Moreover, variations in the shape of the head and handle of the toothbrush may permit a better handling of the toothbrush, enabling better access to all regions of the oral cavity (5, 11, 12, 15, 17, 18).

However, the industry encourages the use of toothbrushes with innovative characteristics hoping to sell more toothbrushes. Although these innovative toothbrushes cost more, the question remains whether they perform any better than their conventional counterpart (1, 13, 16, 19).

There is no convincing clinical evidence in the literature regarding the efficacy of different toothbrush designs when compared with conventional models, in terms of dental biofilm removal (a widespread claim) or, indeed, any aspect of oral health. There are reports of a greater removal of dental biofilm (2, 5, 7, 13, 17, 18) as well as studies that have found no differences (10, 11, 15, 19). In addition, there is as yet no precise indication of the most effective toothbrush for children. Besides being relatively scarce, studies involving children centre on the comparison of manual and electric toothbrushing and do not provide data for determining the increased efficacy, if any, of the new toothbrush models currently available on the market (3, 20, 21).

As oral health professionals need the support of results from studies to provide adequate orientation for their patients, the aim of this study was to compare the performances of three different toothbrush models in the control of dental biofilm and maintaining a healthy gingival condition in schoolchildren.

Materials and methods

Subjects

The sample was made up of students between 9 and 10 years of age enrolled at a public school in the city of Ponta Grossa, PR, Brazil. After the clinical examination of 120 children, 30 male and female volunteers were selected. The following were the inclusion criteria: good systemic health; normal motor and cognitive development; and teeth in the mixed dentition phase. Children in orthodontic treatment or exhibiting any impairment that would interfere in the toothbrushing pattern, such as caries, teeth with endodontic problems or crown fractures, were excluded from the study. Parents/guardians of the children were informed as to the objectives of the study and signed terms of informed consent. The study received approval from the ethics committee of the Ponta Grossa State University (protocol # 1498/07).

Pre-experiment phase

Twenty-one days prior to beginning the study, the participants were provided with a conventional toothbrush (flat bristles) and fluoridated dentifrice (Colgate Máxima Proteção Anticáries®; Colgate-Palmolive Ind. e Com. Ltda, São Paulo, SP, Brazil). During this period, three daily brushings were performed under the supervision of a researcher (AMSM), but with no interference in the technique employed; the initial clinical parameters (dental biofilm and gingival inflammation) were then recorded.

Clinical parameters

The amount of dental biofilm was recorded based on the Simplified Oral Hygiene Index (22), which offers four scores: 0 – no debris or stain present; 1 – soft debris covering not more than 1/3 of the tooth surface, or presence of extrinsic stains without other debris regardless of surface area covered; 2 – soft debris covering more than 1/3, but not more than 2/3 of the exposed tooth surface; 3 – soft debris covering more than 2/3 of the exposed tooth surface (Fig. 1). The gingival condition was determined by the absence or presence of marginal gingival bleeding marginal upon probing (WHO 621 periodontal probe; Seffiro Stainless, Lascod, SpA, Italy) (23). The clinical examinations were performed by a single examiner (MLS), calibrated for the plaque index (Kappa = 0.87). For the gingival bleeding index, training was carried out with clinical photos and a discussion regarding the parameters with a second researcher (ACRC) after the analysis of 10 patients with the

Fig. 1. Scores of dental biofilm (Simplified Oral Hygiene Index): 0 – no debris or stain present; 1 – soft debris covering not more than 1/3 of the tooth surface; 2 – soft debris covering more than 1/3, but not more than 2/3, of the exposed tooth surface; 3 – soft debris covering more than 2/3 of the exposed tooth surface.

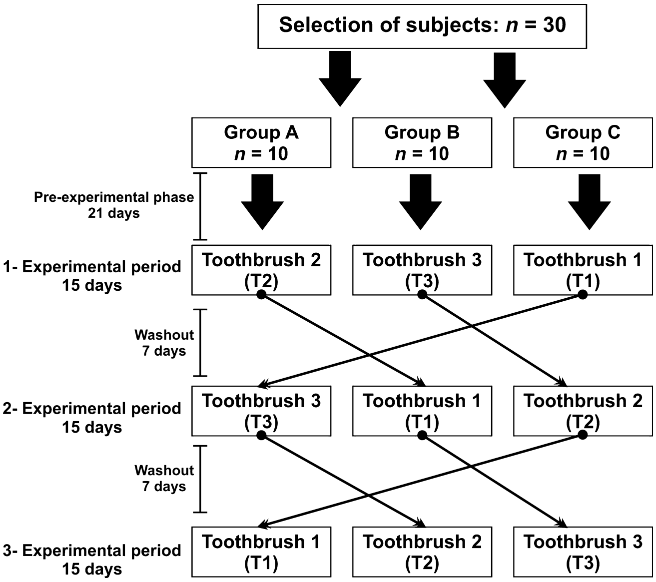

Fig. 2. Schematic representation of cross-over model.

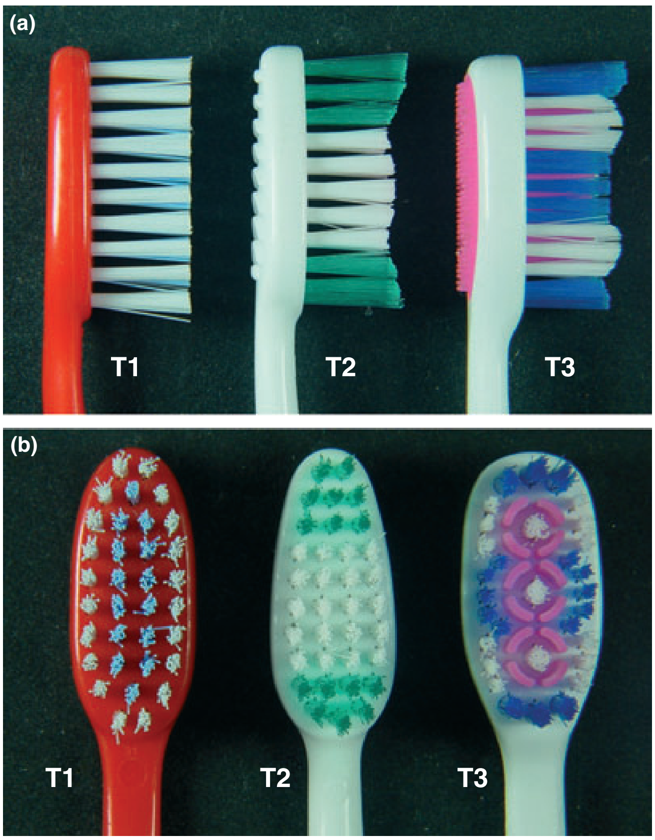

Fig. 3. (a) Side view of the three brushes. (b) Front view of brushes. T1 – bristles on same plane, straight arrangement (Colgate Classic®); T2 – bristles on different planes, straight arrangement (Colgate Extra Clean®); T3 – bristles on different planes, straight and circular arrangement (Colgate 360°®).

same conditions as the participants in the study. The vestibular and lingual surfaces of teeth 11, 21, 31, 41, 16, 26, 36 and 46 were examined.

Experimental design

The experimental design of the research followed the blind cross-over clinical trial (Fig. 2). The sample was randomly divided into three groups (A, B and C), each of which used one of the three toothbrushes tested. The following toothbrushes were used: Toothbrush 1 (T1) – bristles on the same plane, straight arrangement (Colgate Classic®; Colgate-Palmolive Ind. e Com. Ltda); Toothbrush 2 (T2) – bristles on different planes, straight arrangement (Colgate Extra Clean®; Colgate-Palmolive Ind. e Com. Ltda); Toothbrush 3 (T3) – bristles on different planes, straight and circular arrangement (Colgate 360°®; Colgate-Palmolive Ind. e Com. Ltda) (Fig. 3). The experimental periods lasted 15 days, with three daily brushings with fluoridated dentifrice (two performed at school under supervision and one performed at home). A washout interval of 7 days occurred between the periods, in which all the participants went back to using the conventional toothbrush and dentifrice employed in the pre-experiment phase to avoid a possible carry-over effect. All children used the three toothbrushes.

At the beginning and end of each experimental period, oral hygiene and gingival bleeding indices were determined for all individuals by a researcher blind to the toothbrush model being used. At the end of the trial, the toothbrushes were collected and the divergence in bristles was measured using a digital calliper (0.01–150 mm Mitutoyo®; Mitutoyo Sul Americana Ltda, Suzano, SP, Brazil). The wear index (WI) of each

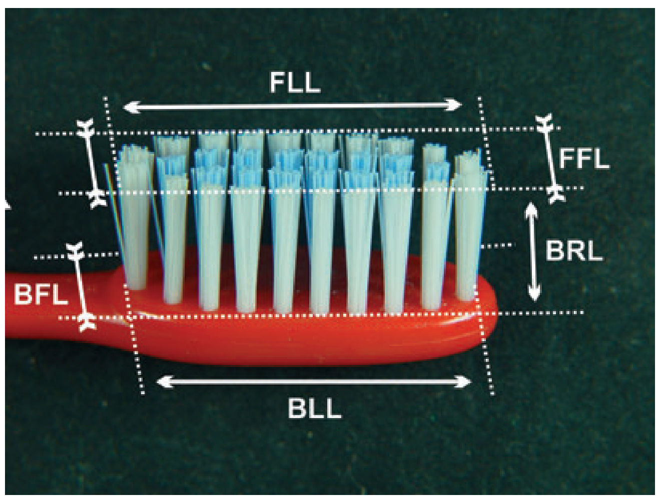

Fig. 4. Toothbrush dimension measurements (wear index, WI). BLL, lateral length at base; FLL, free lateral length; BFL, frontal length at base; FFL, free frontal length; BRL, bristle's length. WI is defined by equation: $\mathrm{WI} = \frac{\mathrm{FLL{-}BLL + FFL{-}BFL}}{\mathrm{BRL}}$.

brush was obtained by applying the equation proposed by Rawls and adapted by Sforza *et al.* (4) (Fig. 4).

Statistical methods

The comparison between the initial and final results of the oral hygiene and gingival bleeding indices were performed using repeated measures analysis of variance (ANOVA) and Cochran's Q test respectively. The initial and final scores (oral hygiene and gingival bleeding) within a single experimental protocol were compared using the paired Student's *t*-test and McNemar's test respectively. Comparison among toothbrushes (WI) was tested by repeated measures ANOVA. The normality of the data distribution (oral hygiene and WI) was confirmed using the Shapiro-Wilks test and the homogeneity of variance was tested using Levene's test. All calculations were performed on the Statistical Package for the Social Sciences® version 17.0 for Windows (SPSS Inc., Chicago, IL, USA) and GraphPad Prism version 5.00 for Windows (GraphPad Software, San Diego, CA, USA) software programs, with the level of significance set at 0.05.

Results

Three of the thirty children who began the trial were excluded because of consecutive absences during the experimental periods. Thus, the final sample was made up of 27 children.

The initial oral hygiene and gingival bleeding parameters did not exhibit significant differences ($P > 0.05$; repeated measures ANOVA and Cochran's Q test respectively), thereby indicating that the clinical conditions were comparable at the beginning of the three experimental periods, as were the final oral hygiene and gingival indices of the participants who used the three toothbrush models ($P > 0.05$; repeated measures ANOVA and Cochran's Q test respectively) (Figs 5 and 6).

Fig. 5. Mean and standard error of scores on the initial and final Simplified Oral Hygiene Index obtained with the toothbrushes: T1 (bristles on same plane, straight arrangement); T2 (bristles on different planes, straight arrangement) and T3 (bristles on different planes, straight and circular arrangement) after 15 days of use. Inter-group comparison: initial – $P = 0.1605$ (ns); final – $P = 0.5672$ (ns), repeated measures ANOVA. Intra-group comparison (initial versus final): T1 – $P = 0.6322$ (ns); T2 – $P = 0.1325$ (ns); T3 – $P = 0.5679$ (ns), paired Student's *t*-test. ns, non-significant.

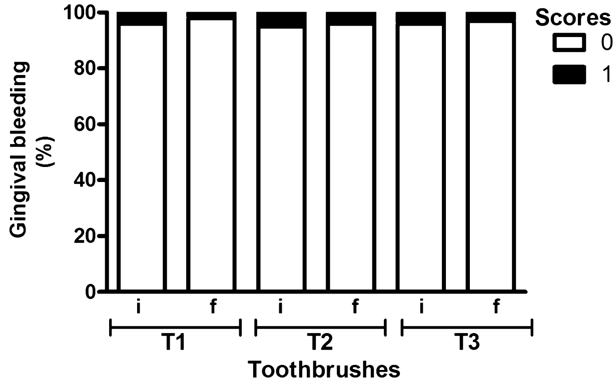

Fig. 6. Frequency distribution (%) of initial (i) and final (f) gingival bleeding index obtained with the toothbrushes: T1 (bristles on same plane, straight arrangement), T2 (bristles on different planes, straight arrangement) and T3 (bristles on different planes, straight and circular arrangement) after 15 days of use. Inter-group comparison: initial – $P = 0.5538$ (ns); final – $P = 0.4412$, Cochran's Q test. Intra-group comparison (initial versus final): T1 – $P = 0.5034$ (ns); T2 – $P = 0.8551$; T3 – $P = 0.8145$ (ns), McNemar's test; 0 – absence of bleeding; 1 – presence of bleeding; ns, non-significant.

Fig. 7. Mean and standard error of wear index obtained with the toothbrushes: T1 (bristles on same plane, straight arrangement), T2 (bristles on different planes, straight arrangement) and T3 (bristles on different planes, straight and circular arrangement) after 15 days of use; non-significant differences ($P = 0.7976$; repeated measures ANOVA).

The comparison (intra-group) among the indices of initial and final oral hygiene and gingival bleeding showed no significant differences ($P > 0.05$) in all groups (paired Student's *t*-test and McNemar's test respectively) (Figs 5 and 6).

There were no significant differences ($P = 0.7976$; repeated measures ANOVA) in bristle wear between the toothbrushes used (Fig. 7).

Discussion

The results of this study suggest that the arrangement of the bristles of a toothbrush has little or no influence for the indices commonly used to determine oral hygiene status. Similar results have been described by other researchers, who tested different toothbrush models in studies of adolescents, adults or children (10, 11, 15, 19). However, other studies have demonstrated the superiority of different models of toothbrush (2, 5, 7, 12, 13, 17). Any claims should be made cautiously because of the different methodologies used and the toothbrush models tested.

Toothbrushing requires learning and training so that an individual may develop skill for maintaining dental biofilm levels within the limits compatible with oral health (1, 3, 6, 8, 14). In this study, the decision was made to include individuals in an age group whose cognitive and psycho-motor development allowed them to perform toothbrushing without assistance from a parent/guardian. Moreover, all subjects had been in a school oral health programme for at least 1 year that involved instructions (non-professional) on oral hygiene and weekly brushing sessions supervised by the educator. The values of plaque index obtained in this study were comparable with others (24–26). Therefore, there is little doubt regarding the toothbrushing skills of the participants in this study. The initial period of 21 days of supervised brushing with fluoridated dentifrice also could have contributed. Moreover, it should be stressed that at the end of this period, there was homogeneity in the sample with regard to the criteria evaluated.

The indices employed considered specific teeth and surfaces in each volunteer, centring attention on teeth that had already completely erupted and on surfaces that are more prone to the build-up of dental biofilm. These indices were capable of identifying variations even in a sample with low degrees of plaque and gingival bleeding. The parameters used are considered adequate for the evaluation of oral health conditions (3, 9, 20).

No attempts were made to change the normal toothbrushing pattern of the children as the variable under scrutiny was brush design and not brushing technique. This choice is believed to have been adequate, as the brushes had different designs. The aim of many new toothbrush formats is an attempt to compensate for any inadequacy in the technique or skill of the handler (1, 5, 9, 11, 15, 16).

However, there may have been a greater motivation among the children throughout the trial because of the stimulation provided by these new modern toothbrushes, with their differentiated bristle arrangement and handle (novelty effect). In an attempt to minimize this effect as well as other uncontrollable variables, such as the learning curve throughout the experiment, the 'Hawthorne' effect (receptivity of the child to the procedure), the cross-over study design was adopted (3, 14, 20).

Although the period of brush use was only 15 days (totalling 45 brushings per participant), little wear was found on the bristles and no difference was detected between the different models with respect to bristle wear.

Based on the three analyses carried out (dental biofilm, gingival bleeding and bristle wear), it cannot be said that any model of toothbrush was superior. Therefore, the choice could be made for the lowest cost, as the new models do not offer any clinical additional benefits. The limited number of toothbrushes tested (all from the same manufacturer) should be considered. It is possible that there are differences in the quality of the bristles among different manufacturers, which might have an influence over wear, either reducing or prolonging the usefulness of the brush; but, this factor is not necessarily linked to toothbrush design. It appears that the commercial appeal to the 'new style' has no clinical justification and this study upholds the paradigm that the handler continues to be the principal agent of brushing effectiveness (3, 10).

The three brushes were capable of effectively removing dental biofilm. The arrangement and size of the bristles had no influence over oral hygiene. Thus, there is no justification for using more expensive toothbrush models on schoolchildren. This point is especially important in communities where cost is a relevant factor.

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