

Efficacy of Two Different Toothbrushes on Plaque Control: A Randomized Clinical Study

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Academic Editors: Alessandro Leite Cavalcanti and Wilton Wilney Nascimento Padilha

Received: 21 August 2018 / Accepted: 27 November 2018 / Published: 05 December 2018

Abstract

Objective: This parallel, randomized, examiner-blind clinical trial aimed to evaluate the efficacy of two different toothbrushes (manual and sonic) on plaque control in adolescents. **Material and Methods:** This study enrolled 56 volunteers, randomly allocated to two different groups: group A (n = 28) for the manual toothbrush (Curaprox 5460 Ultra Soft®) and group B (n = 28) for the sonic toothbrush (Edel White®). Mean age was 17.2 ± 1.1 years. A calibrated periodontist performed a periodontal evaluation to assess the presence of plaque with the Turesky Modification of the Quigley Hein Plaque Index (PI) and the gingival inflammation with the Silness & Loe Gingival Index (GI). Adolescents received instructions about the mechanical control of plaque at baseline (T0), with a reexamination after 3 months (T1) and 6 months (T2). Non-parametric Mann Whitney test was used to compare the differences between the two toothbrush groups and the Friedman test was used for the comparisons between times. **Results:** There has been PI reduction concerning the study times (T0, T1 and T2, $p < 0.05$), but not between the groups A and B ($p > 0.05$). As for GI there has been no significant difference between the groups and between the study times ($p > 0.05$). **Conclusion:** Both toothbrushes were efficient in the control of supragingival plaque (visible biofilm).

Keywords: Dental Plaque; Toothbrushing; Dental Devices, Home Care; Oral Health; Gingivitis.

Introduction

Periodontal disease is a plaque-dependent disease and its stagnation can lead to inflammatory processes in the supporting tissue, triggering the destruction of protective tissue (gingivitis) and supporting tissue (periodontitis) [1]. One of the most severe and advanced consequences of periodontitis is the irreversible loss of the supporting tissues of the teeth, which can lead to loss of teeth [2]. Periodontal disease is the second-leading cause of tooth loss [3] and, overall, it is thought to account for up to 30-35% of all tooth extractions, and, because of cumulative effects or from the disease itself, these losses increase with the individual's age [4]. Severe periodontitis affects from 5 to 20% of the adult population, and most children and adolescents present signs of gingivitis [5]. In Brazil, gingival bleeding and calculus are more common in adolescents while the most severe forms of periodontal disease have found to be prevalent in adults [6].

Its negative effects on the quality of life of the population are known [7] and functional aspects of the stomatognathic system, such as chewing, swallowing and speaking, can be compromised by periodontal disease, as well as smile aesthetic and personal self-esteem [3,8,9].

Disease prevention is closely linked to simple routine actions, and it has been proved that the disorganization and constant removal of the biofilm is capable of influencing disease onset and progress [10,11]. Then, more broadly, there is health promotion, which involves empowering people and communities to make healthy choices to improve their health [12], highlighting the importance of oral-health education in this process [11,13]. Instructions with audiovisual resources considerably improve the information assimilation by patients [14]. Educational actions lead to an improvement in oral health, as well as promoting changes in knowledge and attitudes [11].

Regular removal of plaque with a manual toothbrush is the method most commonly used for oral hygiene - when correctly and enough performed, can remove properly the supragingival plaque [15]. However, in the case of routine procedures, current statistical data suggest that a simplification of oral hygiene procedures at home could be useful [16].

In this context, power toothbrushes were introduced in the 1960s and continued to evolve in terms of performance and design, and many of the models currently available on the market incorporated a timer to automatically track brushing time and turn the toothbrush off after two full minutes of brushing and contributing to proper removal of plaque [17]. Although some promising studies show sonic toothbrushes to be comparable or more effective than manual toothbrushes [18-21], there are not yet enough studies available on sonic toothbrushes and the outcomes do not show significant differences between manual and sonic devices on plaque reduction [22]. The scientific literature does not present enough evidence on the joint effects of oral hygiene motivation and type of toothbrush and there is no consensus on the effectiveness of manual toothbrushes compared to electrical ones in terms of reduction of dental plaque [23].

The objective of this study was to evaluate the clinical performance of two different toothbrushes (manual and sonic) on plaque control and their effects on periodontal health.

Material and Methods

Study Design

This randomized masked clinical trial analyzed two types of toothbrushes: manual and sonic. Outcome measures were Gingival (GI) and Plaque (PI) indexes.

Sampling Selection

Volunteers, students from *Centro de Formação e Integração Social (CAMP)*, São Bernardo do Campo, SP, Brazil, were invited by the investigators to take part in the research, informed of the procedures to which they underwent and about their benefits. They were informed about the follow-up procedures, being free to leave the experiment at any time, if they wished so. Volunteers decided freely whether to join the research. In positive case, their participation began only after the signature of a written informed consent and an assent form.

The calculation of the sample size of 28 students for each group was based on literature [23,24]. This sample size provided minimum 0.80 power and 5% significance and minimum 0.77 effect [25,26]. The sample size was run in the G*Power software (Heinrich-Heine-Universität Düsseldorf, Germany).

After agreeing to take part in the research, the volunteers were individually taken into a private room, where a thorough clinical examination was performed, following a well-founded history taking, allowing their selection. A questionnaire survey supported the history taking for everyone. Parents or legal guardians signed the questionnaires for participants under 18 years of age.

Clinical examination was performed through visual examination and palpation to detect soft-tissue lesions. Dental explorer No. 5 and oral mirror were used for caries evaluation, and CPI probe and oral mirror for periodontal status.

Volunteers should be in (1) good general health, (2) having a minimum of twenty permanent natural teeth, excluding third molars. Subjects were excluded if they presented (1) advanced periodontal disease, with oral lesions or periodontal pockets ≥ 3 mm, periodontal insertion loss or gingival recession ≥ 2 mm, (2) limited manual dexterity, (3) active caries, (4) medical conditions limiting their salivary function or immunological condition, and if they were (5) fixed orthodontic appliances users, (6) pregnant women or (7) smokers.

After the selection, numbers associated to each volunteer were put into an urn, allowing a draw to compose the study groups. 56 participants, of both genders, aged between 15 and 20 years, were split into two groups (A and B): Group A (n = 28) – manual toothbrush (Curaprox 5460 Ultra Soft®, Curaden Swiss do Brasil Imp. Exp. LTDA, São Caetano do Sul, Brazil) and Group B (n = 28) – sonic toothbrush (Edel White®, Scanderra GmbH, Zürich, Switzerland).

For randomization, as per Figure 1, each volunteer removed from an urn a paper with his or her respective group. This urn had 28 papers for each one of the two groups. Another dentist performed the randomization, which did not involve trial investigators.

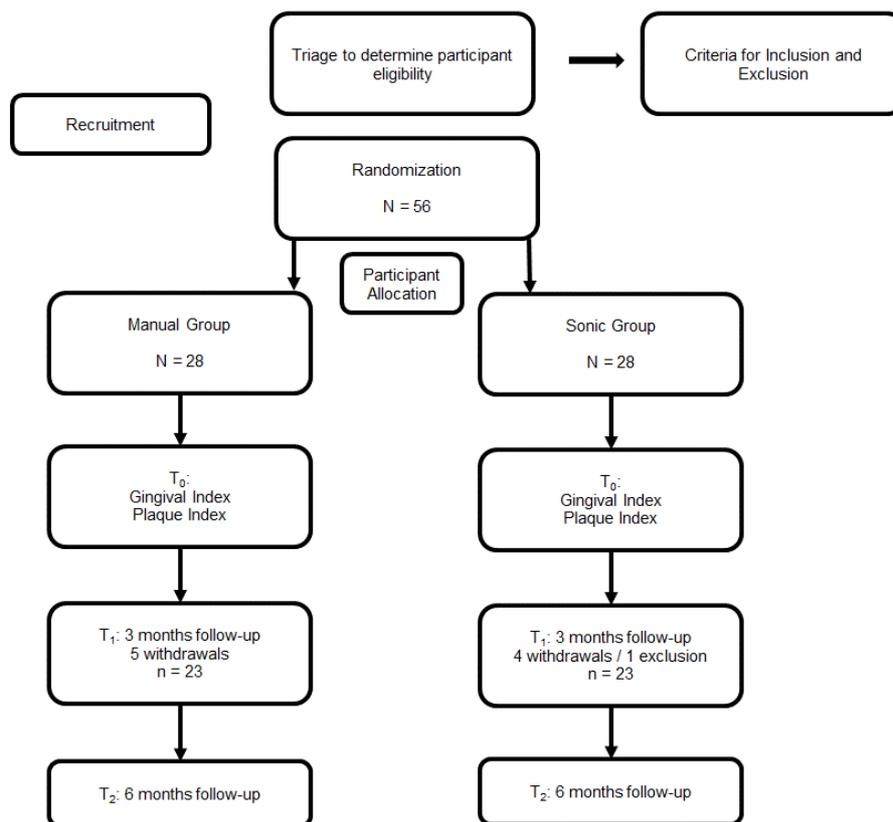


Figure 1. Flow diagram of study design showing the randomization of participants.

Experimental Procedures

After the randomization, volunteers were taken to a room corresponding to their groups, where they received, from a periodontist with no clinical involvement in the trial, the kit with manual toothbrushes or sonic toothbrushes respectively, dentifrice (Colgate 1450ppm fluoride – basic dentifrice with no antiplaque agent, Colgate-Palmolive Company, São Paulo, Brazil) and Colgate dental floss (Colgate-Palmolive Company, São Paulo, Brazil). Each group of participants (A or B) was instructed on its tooth brushing technique, through a tutorial video session, with complimentary instructions being given thereafter by the same periodontist. Study participants agreed to refrain from the use of all oral hygiene procedures, including chewing gum, for 12 hours prior to each evaluation. Study participants also agreed to refrain from the use of mouthwashes and gels during the trial period.

Group (A) instructions (T0):

Bass technique for manual toothbrush (Curaprox 5460 Ultra Soft®):

- Place the head of the toothbrush against the teeth, then tilt the bristle tips to a 45-degree angle against the gum line (cervical margin of the tooth);
- Press the bristle tips slightly to penetrate the gingival sulcus, as well as the interdental niches. Vibrate the brush back and forth with short strokes without moving the bristle tips far from

their original positions. Consistently advance in sets of two teeth, spending approximately four seconds by each set, until two minutes are reached for both dental arches;

- Clean either the vestibular region (external – between the teeth, lips and cheeks), as the palatine and lingual regions (internal), twice a day;
- In the occlusal region, press the bristles lightly against the occlusal surface, on the cusps and occlusal fissure sites, vibrating the brush back and forth with short strokes, advancing by dental groups (molars, premolars, canines e incisors) thoroughly, until the whole arch is covered.

Group (B) instructions (T0):

Manufacturer's instructions for the sonic toothbrush:

- Edel White Sonic Generation® is a rechargeable hydro-active toothbrush. The sonic waves that move with a speed of up to 45.000 strokes per minute allow the bristle tips to vibrate gently and penetrate even the smallest dental spaces. Edel White Sonic Generation® has different brushing modes, which can be selected by repeatedly pushing the MODE SELECTION button. The toothbrush remembers the last chosen mode so that it does not have to be selected the next time the device is activated (Memory function). The selected mode for this trial was the Intensive mode;
- When selecting the Intensive mode, the upper two Led-lights glow;
- Gently place the brush against the teeth at a slight angle (approximately 45º) towards the gum line (cervical margin of the tooth);
- Consistently advance in sets of two teeth, spending approximately four seconds by each set, until two minutes are reached for both dental arches;
- Clean either the vestibular region (external – between the teeth, lips and cheeks), as the palatine and lingual regions (internal), twice a day;
- In the occlusal region, press the bristles lightly against the occlusal surface, on the cusps and occlusal fissure sites, keeping the brush in position, advancing by dental groups (molars, premolars, canines e incisors) thoroughly, until the whole arch is covered;
- Quadrant Timer – the quadrant timer is a 30-second interval timer that briefly interrupts the brushing to signal the recommended change to the next quadrant. It reminds the user to brush the four-quadrants or his mouth equally and thoroughly, for a better overall cleaning;

Participants received instructions for proper floss use, also through video tutorials:

- Be sure to wash the hands before reaching for the floss;
- Break off a piece about 45 centimeters long. Wrap most of the floss around either the middle finger or the index finger of one hand, and a small amount onto the middle or index finger of the other hand;

- Gently slide the floss between the teeth in a zigzag motion and be careful not to let the floss snap or “pop” between teeth;
- Make a C shape with the floss as it is wrapped around the tooth. Then carefully pull the floss upward from the gum line to the top of the tooth;
- As the floss is moved from one tooth to the next, unroll a fresh section of floss from the finger of one hand while rolling the used floss onto the finger of the other hand, using the thumb as a guide;
- Floss each tooth front and back sides.

Manual toothbrush and sonic toothbrushes refills were replaced in T1, and dentifrice and floss were replenished as well. A calibrated examiner, blinded to the patients' group allocation, evaluated them at T0 = baseline, T1 = 3 months and T2 = 6 months [24] according to the following criteria - Clinical examination: (1) A new clinical examination was conducted after participants' enrollment in study groups, this time to assess Gingival and Plaque indexes (with the use of a CPI probe and oral mirror for periodontal status); (2) All teeth were evaluated, excluding third molars. When a tooth was missing, the adjacent tooth was evaluated; and (3) The gingival sulcus surrounding each tooth was probed and measured at 6 locations (3 buccal = MB, B, DB e 3 lingual or palatal = ML/MP, L/P, DL/DP).

Gingival Index (GI)

Silness & Løe Gingival Index (1963) [27]: Score 0 = Normal gingiva. Score 1 = Mild inflammation - slight change in color, slight edema. No bleeding on probing. Score 2 = Moderate inflammation - redness, edema and glazing; bleeding on probing. Score 3 = Severe inflammation - marked redness and edema. Ulceration. Tendency to spontaneous bleeding. Probing depth (PD – distance from the gingival margin to the bottom of the sulcus) and clinical attachment level (CAL – distance between cemento-enamel junction and bottom of the sulcus) were also measured. All measurements were taken at six sites around all teeth, excluding the third molars. The presence of bleeding on probing (BoP) was recorded almost 10s after each PD measurement.

Plaque Index (PI)

The dental plaque on the teeth was disclosed with a 0.5% basic fuchsin mouthwash. The crown surfaces of the anterior and posterior teeth were divided into 3 thirds: (1) Cervical third: the vestibular, lingual or palatal surface closest to the cervix; (2) Middle third: closest to the center of the tooth; and (3) Incisal or occlusal third: the third of an anterior tooth closest to incisal edge or the third of a posterior tooth closest to the occlusal surface.

Turesky Modification of the Quigley Hein Plaque Index (1970) [28]: PI was represented as: Score 0 = No plaque. Score 1 = Separate flecks of plaque at the cervical margin of the tooth. Score 2 = A thin continuous band of plaque (up to one mm) at the cervical margin of the tooth. Score 3 = A

band of plaque wider than one mm but covering less than one third of the crown of the tooth. Score 4 = Plaque covering at least one-third but less than two-thirds of the crown of the tooth. Score 5 = Plaque covering two-thirds or more of the crown of the tooth. PI for the tooth surfaces stained by the disclosing agent was scored. The trial ended after 6 months, when it reached the length of follow-up goal.

Statistical Analysis

Data did not meet the assumptions of a parametric test. Hence, Mann Whitney nonparametric analysis was used for comparing the two toothbrushes, and Friedman test to compare the times. R* software (The R Foundation) with a significance level of 5% was used in the analyses.

Ethical Aspects

The present randomized experimental study was approved by the Research Ethics Committee of the São Leopoldo Mandic School of Dentistry and Research Center (CAAE 56711116.1.0000.5374), according to the Resolution No. 466/12 of the National Council of Health, which defines guidelines for researches involving human beings. This trial is registered at ClinicalTrials.gov, number NCT03099551.

Results

Fifty-six adolescents, mean age 17.2 ± 1.1 years, volunteered for this study, 54% female. Of the total Group A sample, 5 volunteers left the study in T1. From Group B, 4 volunteers left in T1 and 1, prescribed with corticosteroid, was excluded. After T1, new sample size was $n = 23$ for each study group. Table 1 presents the demographic information for both groups.

Table 1. Distribution according to gender and age.

Variables	Groups		p-value
	Manual Toothbrush (N = 28)	Sonic Toothbrush (N = 28)	
Gender			
Male	11	39.3	15
Female	17	60.	13
Age (Mean and SD)	17.34 ± 1.07		17.18 ± 1.16
			0.4783

Table 2 shows GI and PI results. No statistically significant difference was observed in GI between the two toothbrush groups and the visits ($p > 0.05$). Both groups showed a significant reduction in PI, after 3 months ($p < 0.05$), sustained after 6 months ($p > 0.05$). At 3 months (T1), PI was significantly lower for the sonic toothbrush group ($p < 0.05$).

Table 3 presents the results excluding the volunteers with zero scores at baseline (T0). Each index presents a different volunteer number, as the calculation excluded the volunteers with zero scores for that index. As for GI, there was a significant reduction after 3 months, for both toothbrush groups ($p < 0.05$), sustained after 6 months ($p > 0.05$). At baseline, the manual toothbrush group

presented GI greater than the sonic toothbrush ($p < 0.05$), but after 3 months no significant difference was observed ($p > 0.05$). There were no volunteers with a PI zero score at baseline.

Table 2. Median (minimum value; maximum value) for GI and PI according to the toothbrush used at all study time points.

Time	Groups			
	Manual Toothbrush		Sonic Toothbrush	
	GI	PI	GI	PI
T ₀	0.07 (0.00; 1.23) ^a	1.50 (0.25; 2.61) ^a	0.00 (0.00; 0.32) ^a	1.30 (0.50; 2.41) ^a
T ₁	0.00 (0.00; 1.36) ^a	*0.68 (0.11; 1.86) ^b	0.00 (0.00; 0.25) ^a	0.34 (0.00; 2.27) ^b
T ₂	0.00 (0.00; 1.43) ^a	0.38 (0.00; 2.59) ^b	0.00 (0.00; 0.14) ^a	0.57 (0.00; 1.52) ^b

*Differs from sonic toothbrush at the same study time point ($p \leq 0.05$). Medians in a column followed by different letters are significantly different ($p \leq 0.05$).

Table 3. Median (minimum value; maximum value) for GI and PI according to toothbrush used at all study time points, excluding volunteers with zero scores at baseline for each index.

Time	Groups			
	Manual Toothbrush		Sonic Toothbrush	
	GI (N=12)	PI (N=23)	GI (N=11)	PI (N=23)
T ₀	0.36 (0.07; 1.23) ^a	1.50 (0.25; 2.61) ^a	0.18 (0.02; 0.32) ^a	1.30 (0.50; 2.41) ^a
T ₁	0.06 (0.00; 1.36) ^b	*0.68 (0.11; 1.86) ^b	0.00 (0.00; 0.25) ^b	0.34 (0.00; 2.27) ^b
T ₂	0.05 (0.00; 1.43) ^b	0.38 (0.00; 2.59) ^b	0.04 (0.00; 0.14) ^a	0.57 (0.00; 1.52) ^b

*Differs from sonic toothbrush at the same study time point ($p \leq 0.05$). Medians in a column followed by different letters are significantly different ($p \leq 0.05$).

Discussion

Literature shows controversy about the efficacy of toothbrushes in plaque control. Some researches proved power toothbrushes are superior relative to manual toothbrushes [15,18,19,29-31]. Others reported that there is no significant difference between them [20,22,32-34]. In the present study, even PI reduced over time for both study groups, there was no significant difference between toothbrushes concerning plaque removal.

Some authors have evaluated the reduction of plaque index and gingival index for only a few weeks [18-20,35] or a few months [21]. And in some cases, even in a single-session [36], making difficult the comparison of results, as the methodologies differ. In this study, the interval between visits followed evaluation parameters previously defined [24], allowing no direct interference of the oral hygiene instructions and motivation performed in T₀ in the PI reduction seen at the following visits [23].

Regarding the assessment of the effect of supragingival plaque control on inflammatory status, even with the PI reduction (visible plaque) between visits, there has been no GI reduction, as also observed in previous studies [34,37]. Some studies showed the association between gingivitis and PI [17,20,21,35,36,38-40]. As for the studies in which the volunteers did not present gingivitis reduction after using the toothbrushes [37], possibly this effect was due to lack of the oral hygiene instructions and motivation at T₁, what would cause more false-positive results in PI reduction [23].

Low GI at baseline can result from the volunteers belonging to a differentiated group, receiving dietary follow up (from a nutritionist), behavioral coaching and professional psychological support from the institution as part of their educational activities. This situation illustrates how the multidisciplinary care focused on oral health became a supporting factor for the plaque reduction in those studies [41,42].

Although an association between PI and GI exists [22], the present study demonstrated that the significant reduction in PI observed for both groups did not repeat in GI. This shows that when dental plaque, as a single sub and supragingival film, is not properly removed from sulcus according to the recommended brushing technique (Bass), mild or moderate gingival inflammation may occur, even if the visible plaque around the crown of the tooth is low.

Toothbrush utilization time and inadequate removal of plaque seems to influence plaque control, interfering with its amount after toothbrushing. This represents an observation from the present study, which demonstrated a reduction in PI (visible plaque) after oral hygiene instructions and toothbrushing motivation [23,38,43]. However, it cannot be said that the non-visible plaque [subgingival] was reduced, what may have kept the gingival inflammation levels. According to the findings in this study, there has been no significant reduction in GI for both groups after 3 and 6 months, as previously observed [34].

However, more than the device used (manual or sonic), the toothbrushing technique, the dental material used and the dexterity with which the individual cleans his teeth and oral soft tissues (clearly linked to his ability and to the level of oral hygiene instructions received) are the determinant factors for plaque removal and consequently for health promotion. In addition, plaque control to prevent gingivitis and/or periodontitis is influenced by several individual and material factors [14].

There are few limitations associated with the present study. One of the potential limitations is that the investigation was carried out on two small and highly selected sample groups. The same study, conducted on larger and less favored sample groups would perhaps show conflicting results. The behavioral modifications of the volunteers caused by the participation in the study and the institution's discipline are other possible limitations and may have positively influenced the outcomes (Hawthorne effect).

The results of the present study were consistent with the literature, although the importance of the prevention and continuous oral hygiene instructions, independently from the results observed in the sample evaluated and from the device used, have to be considered. Reference studies highlight that these resources effectively stimulate the individuals for the daily plaque control and reduction practices, hence preventing early onset of oral diseases as caries and periodontal disease.

Conclusion

This study did not observe differences between manual and sonic toothbrushes for plaque control and the effects of plaque reduction on periodontal health were achieved mainly by oral hygiene instructions and motivation.

Financial Support: None.

Conflict of Interest: The authors declare no conflicts of interest.

Acknowledgments: We would like to thank the students from CAMP SBC who took part in this study.

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