










ORIGINAL ARTICLE

# The effectiveness of apple, sugar-free chewing gum, Rolly Brush® and tooth brushing in the reduction of plaque index: Crossover randomized clinical trial.

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## OPEN ACCESS

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### ABSTRACT

**Background:** The implementation of the self-cleaning practice is of fundamental importance for the maintenance of oral health and to remove the human dental biofilm which is considered the main etiological factor for the development of caries and periodontal diseases.

**Objective:** This study aimed to evaluate the use of chewing gum, Rolly Brush® and apples as forms of mechanical control and removal of the dental biofilm in the absence of brushing.

**Materials and Methods:** Eighteen volunteers were submitted to plaque index evaluation after a period of 24 hours of no oral hygiene. Then, they would use one of the methods: chewing gum, Rolly Brush®, apple or tooth brushing, chosen by a draw, for one minute, and then, plaque index was evaluated again. This stage was repeated until all participants were submitted to all selected methods, in periods of 24 hours each.

**Results:** Dental brushing was more effective when compared to each of the other methods applied and there was a statistically significant reduction of dental plaque index after applying all methods of cleaning in all groups.

**Conclusion:** Chewing gum, Rolly Brush® and apple may be used as auxiliary to dental brushing or when such method is impossible to be performed.

**Clinicaltrials.gov:** number of protocol NCT 03.601.585.

### KEY WORDS

Oral Hygiene; Tooth Brushing; Dietary Fiber; Chewing Gum; Dental Plaque Index.

### RESUMO

**Fundamento:** A implementação da prática de autolimpeza é de fundamental importância para a manutenção da saúde bucal e remoção do biofilme dental humano que é considerado o principal fator etiológico para o desenvolvimento de cáries e doenças periodontais.

**Objetivo:** Este estudo teve como objetivo avaliar a utilização de goma de mascar, Rolly Brush® e maçã como formas de controle mecânico e remoção do biofilme dental na ausência de escovação.

**Materiais e Métodos:** Dezoito voluntários foram submetidos à avaliação do índice de placa após um período de 24 horas sem higiene bucal. Em seguida, utilizariam um dos métodos: goma de mascar, Rolly Brush®, ingerir uma maçã e escovar os dentes, escolhida por sorteio, por um minuto, e então, o índice de placa era novamente avaliado. Essa etapa foi repetida até que todos os participantes fossem submetidos a todos os métodos selecionados, em períodos de 24 horas cada.

**Resultados:** A escovação dentária foi mais eficaz quando comparada a cada um dos outros métodos aplicados e houve redução estatisticamente significativa do índice de placa dentária após a aplicação do método de limpeza em todos os grupos.

**Conclusão:** Goma de mascar, Rolly Brush® e maçã podem ser utilizados como auxiliares da escovação dentária ou quando tal método for impossível de ser realizado.

**Clinicaltrials.gov:** Número do protocolo NCT 03.601.585.

### PALAVRAS CHAVE

Higiene Oral; Escovação Dentária; Fibra Dietética; Goma de Mascar; Índice de Placa Dentária.

## Clinical relevance

Brushing is still the most effective method for oral hygiene, but in the impossibility to do so, the ideal would be to recommend the patient to eat an apple, in this case, the healthiest.

## INTRODUCTION

The implementation of the self-cleaning practice through health education is of fundamental importance for the maintenance of oral health and considered a relevant public health measure.<sup>1</sup> Its function is to remove the human dental biofilm (HDB) which is considered the main etiological factor for the development of caries and periodontal diseases.<sup>2</sup> Currently, despite advances in preventive dentistry, dental caries still remains a public health problem in several countries, being the most common disease around the world.<sup>3,4</sup>

Biofilms are organized in communities of microbial cells formed in a 3D structure which are covered by an extracellular matrix of polymeric substances such as exopolysaccharides.<sup>5</sup> One of the main acid-producing pathogen that causes dental caries found in biofilms is *Streptococcus mutans* along with opportunistic fungal pathogen *Candida albicans*.<sup>6,7</sup>

Preventive treatments, especially for children and teenagers, include better eating habits limiting the ingestion of sugar and promotion of oral hygiene. The most effective method for HDB control is mechanical cleaning through tooth brushing with fluoride with fluoride toothpaste and auxiliary methods of oral hygiene.<sup>8,9</sup> However, many individuals, whether by disability, lack of effort, lack of time or by the impossibility of the medium, do not remove the dental biofilm adequately from all dental surfaces. Thus, there is a need for alternative and complementary methods for the reduction of plaque index.

Studies have shown that chewing gum can act as a mechanism of oral hygiene when normal tooth brushing is not possible.<sup>10,11</sup> Besides the mechanical effect on plaque index, chewing gum also stimulates salivary flow boosting tooth enamel remineralization.<sup>12</sup> The increase in saliva production is very important as it is capable of promoting protection against abrasive lesions, such as dental caries, by lubricating the oral mucosa and also removing bacteria.<sup>13,14</sup>

Chewing gums, also have a caries-reducing effect, since bacteria are unable to metabolize the polyols present in the composition of sugar-free chewing gums in acids.<sup>15</sup>

The consumption of natural fibrous foods may be capable of promoting a mechanical action during chewing and assisting the control of HDB, once they promote the cleaning of dental surfaces.<sup>14,16</sup>

In fibrous foods such as apples, there is the presence of condensed tannins, which have anti-adhesion properties capable of inhibiting the binding between some bacteria and thereby impair the formation of HDB.<sup>17</sup> Rajaram et al.<sup>18</sup>, showed that the increase of fiber intake in the diet has positive results in bleeding on probing and gingivitis.

Chewable toothbrushes have recently been developed as a convenient, travel and child friendly alternative elevating motivation during oral hygiene, improving plaque removal, and facilitating oral hygiene in areas where of difficult access such as lingual surfaces.

Chewable toothbrushes have xylitol and are built with medium soft bristles which, together prevent caries and facilitate plaque removal.<sup>19,20</sup> Rolly Brush® (Headquarter - Via Tito ed Ettore Manzini 5, 43126 Parma, Italia) disposable brushes have been shown to be able to significantly reduce plaque index and debris level, thus contributing to maintenance of good oral hygiene.<sup>21</sup>

Alternative methods, such as chewing gum, when used as an adjunct to tooth brushing provided significant reductions in plaque index scores. However, there are few studies in the literature that evaluate these and other forms of mechanical control and removal of the human dental biofilm in the absence of brushing, that is, used alone.<sup>22,23</sup>

No study was found in the literature comparing the four methods described here for the power to reduce plaque index. Thus, the objective of the present study is to comparatively analyze the consumption of apple, mastication of sugar-free chewing gum and use of Rolly Brush® brushes in the removal of human dental biofilm.

The hypothesis is that all three methods evaluated can have a positive effect on the plaque removal in the impossibility of normal tooth brushing.

## MATERIALS AND METHODS

### Trial design

The present study is a randomized crossover controlled single blind trial. It was conducted according to the Consolidated Standards of Reporting Trials (CONSORT).<sup>24</sup>

The study was approved by the Research Ethics Committee of Universidade Federal dos Vales do Jequitinhonha e Mucuri (UFVJM) under protocol 2.403.458 and is in accordance with the legislation in force in the country and in accordance with the principles and ethical values for research contained in the Declaration of Helsinki of 1975, revised in 2013.

### Registration

It was registered on Clinical Trials under the number of protocol NCT 03.601.585. The same was developed in the period from March 15 to June 19, 2018 in the Periodontics Clinic of the Department of Dentistry FCBS / UFVJM.

### Participants

Individuals with good general systemic health, who did not have gingivitis or periodontal disease were included. For the periodontal evaluation each patient was evaluated at the clinic by a trained evaluator considering the following parameters: bags larger than 3 mm, with at least eight occlusal surfaces of healthy premolars and / or molars, not considering healthy teeth with restorations and sealants of pits and fissures. Individuals who used orthodontic appliances, removable prostheses or who underwent periodontal scaling in the last 6 months were excluded.

The study population consisted, initially, of 20 participants, graduate students and employees of UFVJM, fourteen females and six males, ages between 18 and 26 years, mean of 22.72 years and standard deviation of 1.78.

### Randomization

In the first stage, the volunteers were attended by the randomizer (EMGB) at the Periodontics Clinic / UFVJM and were informed of the risks of their participation, in addition to the clarifications about the study, listed in a script and, if they agreed, they would sign an Informed Consent Form. The volunteers then underwent a clinical examination (to assess need for supragingival scaling or

definitive restorations) and received prophylaxis in order to clear the plaque index. From that moment, the volunteers were instructed to suspend all methods of oral hygiene and not to consume apples and chewing gums for twenty-four hours.<sup>25</sup> All participants were submitted to the four methods tested on different days and following the same criteria, placing the four methods in an envelope.

Before each visit, the randomizer opened the envelope with the patient's name and selected one of the methods to be performed on that day of intervention. After the draw, the card with the method was removed, and this procedure was performed until the volunteer had been submitted to all 4 tested procedures.

Randomization of interventions was done before each round of testing. The participants would take an envelope containing four numbered test cards: 1 = Rolly Brush<sup>®</sup>, 2 = sugarless chewing gum, 3 = brushing; and 4 = apple consumption of the same type and size. So the volunteers only became aware of the test at the time of doing so.

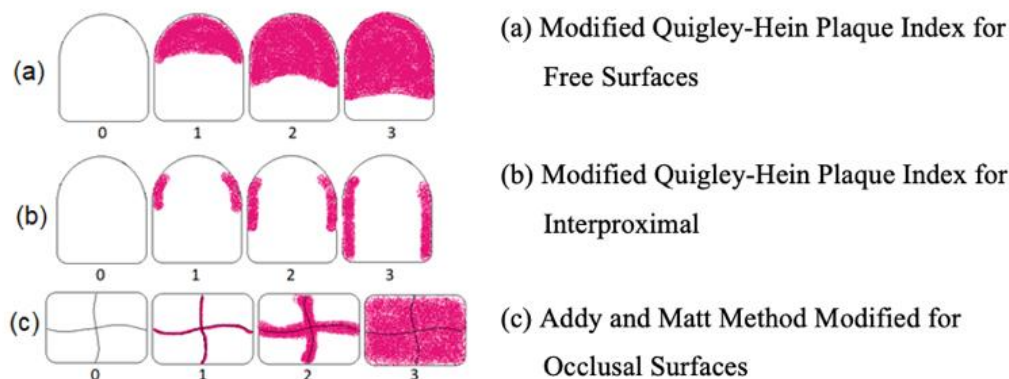
In the second stage, at least twenty-four hours after the first, the volunteer received from the researcher (LVM) a disposable glass with 10 ml of basic fuchsin for mouthwash. This method was chosen, so that there was no removal of HDB, as it could happen with the use of cotton.

The researcher performed the dental exam to measure the plaque index on each dental surface and recorded it in the medical record. After completing the examination of all dental surfaces, the researcher withdrew from the clinical environment so that the method was randomly selected.

The volunteer used the method drawn for one minute and received a disposable cup with 50 ml of water in order to remove residues from the fibrous food and / or mask the aroma of the applied test. Researcher returned to the clinical setting, re-examined all surfaces and recorded them in a new clinical record.

The clinical records were stored in a named and dated envelope, identified by the alternatives "before the application of the method" and "after the application of the method".

After the procedure the volunteer received prophylaxis and topical application of fluoride. On the third, fourth and fifth stages, the volunteers went through the protocol of proce-



**Figure 1.** Representation of the scores of the surfaces.

dures already mentioned in the second stage. The randomizer removed the cards from the methods already applied in the previous steps. Again, they received prophylaxis and topical application of fluoride. Each stage was evaluated within a period of 24 hours of each other.

The HDB measurement was done through the modified Quigley-Hein Board Index<sup>26</sup> for all teeth (Figure 1). For the vestibular, lingual and palatine surfaces, score 0 represented the free surface of HDB; score 1 the dental surface that had less than 1/3 of its area covered; score 2, dental surface with recoating between 1/3 and 2/3; and score 3 surfaces with more than 2/3 of their total area covered (a).

On the interproximal (mesial and distal) sides, the same scores had the following counts: 0 for total absence of HDB; 1 when 1/3 of the proximal region was covered; 2 when 2/3 of the proximal region was covered; and 3 when the entire proximal region was coated with HDB (b).

For the occlusal surfaces of molars and premolars, the method used by Addy et al (1998) was adapted,<sup>23</sup> reducing the score 0 referred to the total absence of BDH; score 1 when the occlusal fissures were delineated by the HDB; score 2 when the BDH extended out of the set of fissures, however did not cover the entire occlusal surface; and score 3 the occlusal surface fully stained by the HDB marker (c).

The evaluations were done before (baseline) and soon after the interventions. The evaluator was unaware of the tests used. Participants were instructed not to talk to the evaluator about the method used. The reliability of the evaluator's evaluation was tested using the Kappa test of 0.92, after calibration and compliance in the two evaluations carried out on a pilot test.

### Sample size

The sample calculation was performed considering the stan-

dard deviation of the plaque index of 0.37%<sup>28</sup> and the difference to be detected between groups stipulated in 0.40%, with a significance level of 5% and power of 95%. 10% were added to the value found to prevent losses, thus the total number of patients for investigation was 20 patients.

### Statistical methods

The data collected were analyzed by SPSS software (Statistical Package for Social Sciences, IBM Inc., USA) version 25. Descriptive statistics analyzes were performed to obtain mean, standard deviation, absolute and relative frequencies of the data. The normality of the data was verified by the Shapiro-Wilk test.

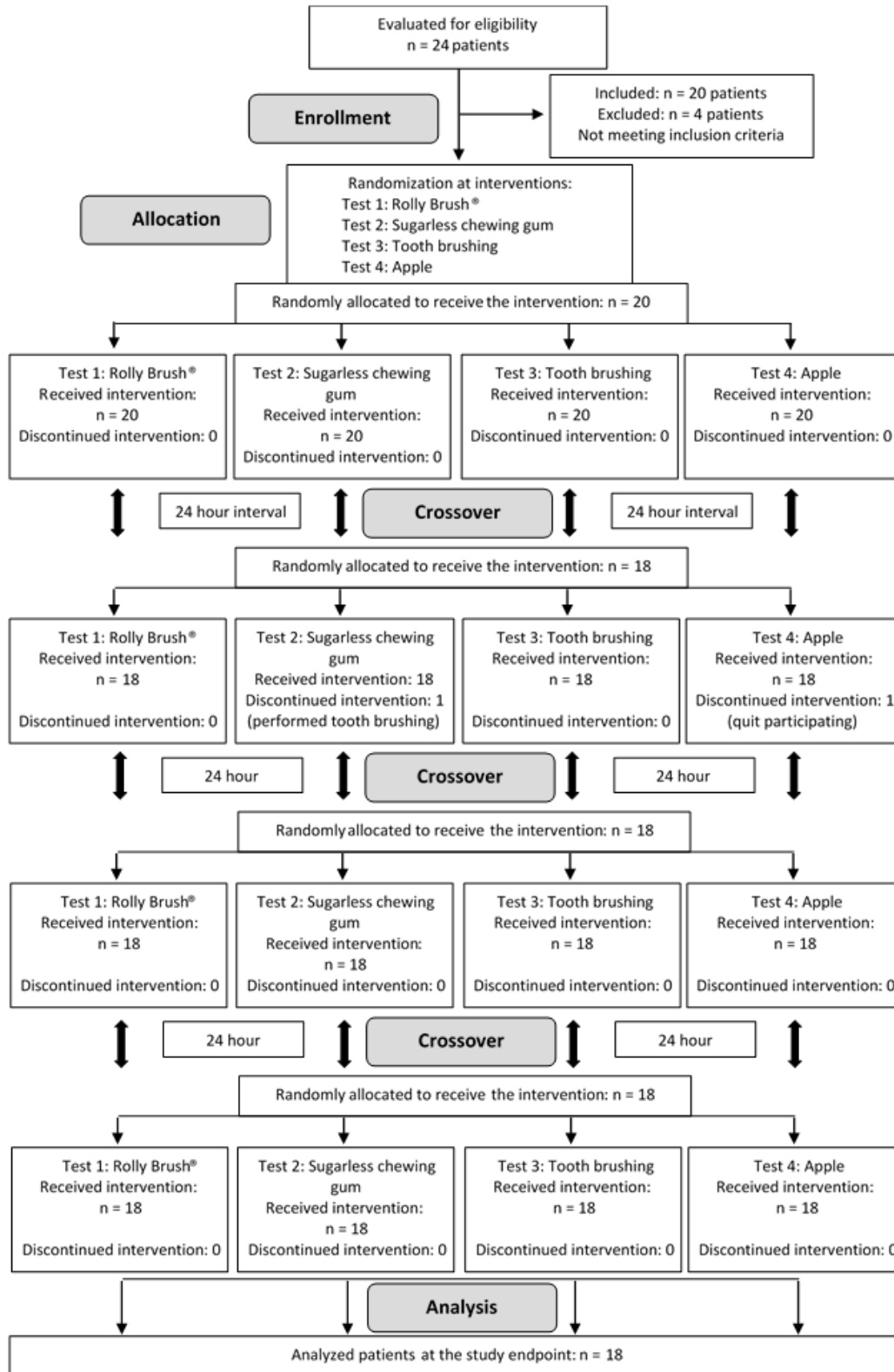
To verify if there was a significant difference before and after treatment, the data were submitted to paired t-test. To verify if there was a significant difference between the groups, the results were submitted to the ANOVA test of repeated measures, with Bonferroni post-hoc. The significance level of 95% was adopted ( $p < 0.05$ ).

## RESULTS

### Recruitment

The 20 volunteers recruited were allocated for randomization in the four groups (tests 1 to 4). However, two of these volunteers were excluded from the final analysis, one for giving up participating and the other for not suspending the sanitation to use the methods.

Each of them used only one method (test 2, which was equivalent to sugarless chewing gum and test 4, which was equivalent to fibrous food), abandoning the study after this first application of the intervention. The other 18 volunteers received the four research tests, having completed the entire protocol (Figure 2).



**Figure 2.** Flow chart indicating steps and number of participants.

**Table 1.** Comparison before and after application of cleaning method.

Group	Average of dental plaque index (SD)	p*
Brushing before	2.07 (0.24)	<b>&lt;0.001</b>
Brushing after	1.31 (0.32)	
Rolly Brush® before	2.02 (0.23)	<b>0.032</b>
Rolly Brush® after	1.75 (0.49)	
Apple before	2.01 (0.18)	<b>&lt;0.001</b>
Apple after	1.68 (0.24)	
Sugar-free chewing gum before	2.01 (0.16)	<b>&lt;0.001</b>
Sugar-free chewing gum after	1.76 (0.30)	

\*Paired t test

**Table 2.** Comparison of treatment effectiveness between groups.

Group	p*	Group	p*	Post-hoc**
Brushing before		Brushing after (G1)		G1xG2: 0.001
Apple before	0.529	Apple after (G2)	<b>&lt;0.001</b>	G1xG3: 0.014
Rolly Brush® before		Rolly Brush® after (G3)		G1xG4: 0.002
				G2xG3: 0.999
				G2xG4: 0.999
Sugar-free chewing gum before		Sugar-free chewing gum after (G4)		G3xG4: 0.999

\*Repeated measures ANOVA \*\*Bonferroni test

### Outcome and estimation

It was found that there was a statistically significant difference before and after the application of the cleaning method in all groups (Table 1).

There was no statistically significant difference in plaque index between the baseline groups, indicating that all volunteers had a very similar plaque index at the time prior to the application of any of the tests. There was a statistically significant difference between groups after hygiene. Although all methods reduced HDB scores, dental brushing was more effective when compared to each of the other methods applied (Table 2), obtaining mean and standard deviation before the method equal to 2.07 (0.24) and after the method equal to 1.31 (0.32).

### DISCUSSION

Among the methods of oral hygiene, mechanical toothbrushing is the world's most widely adopted<sup>29</sup> and is the most effective method for promoting tooth cleaning. Limiting sugar intake and brushing with fluoride toothpaste removes plaque and avoids the development of caries and improves gingival health.<sup>4</sup> However, it can be suggested that despite the good results obtained by other methods, on the present study, they should not replace in a prolonged or definitive way dental brushing done through the conventional method, thus suggesting, their use as complementary methods.

Researches<sup>11,25</sup> confirm the results found in this study, since it could be demonstrated that sugar-free chewing gums and fibrous foods such as apples can be used as oral hygiene devices in the absence of dental brushing, since both were able to statistically significantly reduce the plaque index.

Sugar-free chewing gums have an important role in the control of BDH since they are capable of inhibiting the metabolism of *Streptococcus mutans* and suppressing the increase in the number of total bacteria present in the saliva.<sup>30,31</sup> Hashiba et al.<sup>23</sup> also point out that the use of sugarless chewing gum may temporarily replace conventional oral hygiene in special situations, such as in the absence of clean water supply.

The apple also plays an important role in inhibiting the formation of HDB because the tannins present in its composition act as inhibitory substances for the action of the enzyme glycosyltransferase and thus contribute to the reduction of the formation of human dental biofilm.<sup>21</sup> In addition to the chemical performances for inhibition and / or reduction of HDB formation, it is very important to note that chewing gum and apples are capable of promoting a mechanical action during mastication, and as a consequence, contribute to the cleaning of dental surfaces.<sup>14</sup>

The use of the Rolly Brush® mini disposable brush was statistically significant, in agreement with a study that highlights its potential to maintain good oral hygiene, significantly reducing plaque, debris level, and reducing the amount of *Streptococcus mutans* in the saliva, when used in the long term, preventing the development of caries.<sup>21</sup> In a recent study, Kayalvizhi et al.<sup>19</sup> successfully demonstrated reduction of plaque in children aged between 8-10 years, in a period of 7 days, improving oral hygiene and gingival health.

It can be observed from this study that the twenty-four hour period without the use of oral hygiene methods was sufficient to obtain the formation of HDB<sup>25</sup> stained by fuchsin on dental surfaces. Another important observation is the fact that there was no statistically significant difference in the plaque index between the groups in the baseline, since this fact confers greater safety and reliability in the results found after applying the different tests.

### Limitations

One limitation found for the development of this study was the impossibility to blind the patients and the tester, in addition to the sample being composed of university students. The possible sources of bias include the reduced time to use the methods, the influence of self-cleaning by masticatory movements,<sup>32</sup> the use of non-standard toothbrushes, since all volunteers used their own brushes and the non-use of dental floss. We chose not to use floss to simply compare the mechanical action of the brush with the other methods and the volunteers were also instructed to use the usual brushing method. The difficulty of the patients staying more than twenty-four hours without brushing was observed. The embarrassment and discomfort in the social life<sup>33</sup> caused by bad breath, due to the microbial degradation of the organic substrates present in the oral cavity,<sup>34</sup> were minimized through prophylaxis at the end of each stage

which may be a source of bias since participants tend to behave differently than usual when under observation.<sup>35</sup>

The study presented here was conducted in accordance with the CONSORT recommendations,<sup>24</sup> with the intention of producing a good level of evidence in the area.

The methodological quality of the study was carefully observed for high internal validity. Randomization at each round was a precaution so that neither participants nor raters could predict the test that would be done at that time. This study can be easily replicated, taking into account that the scores of the same values (0, 1, 2, 3) for all faces (free, occlusal and interproximal) in the plaque indexes used facilitate interpretation and decrease errors and biases. This method was chosen instead of the dichotomous one due to the fact that there could be reductions in plaque index not represented in it, since it considers only absence or presence of plaque.

### Generalizability

Brushing is still the most effective method for oral hygiene, but in the impossibility to do so, as the other three methods had an equal performance among them, the ideal would be to recommend the patient to eat an apple, in this case, the healthiest, universally accepted and more affordable, taking into consideration the self-cost of the mini disposable brush. This also gives the study extensive external validity. It is suggested that the other methods tested may be used as auxiliary to dental brushing or when such method is impossible to be performed.

### CONCLUSIONS

Within the limits of this study it is concluded that all three methods studied were able to reduce the HDB present in dental surfaces. It can be observed that, in the absence of proper conditions to use a toothbrush, eating an apple, chewing sugarless gum or using a chewable toothbrush can reduce the level of debris.

Thus, it is suggested that more randomized clinical trials with rigorous methodologies be performed in order to provide better scientific evidence regarding plaque removal alternatives in case of inability to use a conventional toothbrush.

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### CONFLICT OF INTEREST STATEMENT

The authors declare that there is no conflict of interests related to this study.

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