Research Journal of Medical Sciences 2 (3): 128-132, 2008
ISSN: 1815-9346

In vitro Evaluation of Toothbrushing Abrasion by 4 Standard Toothbrushes

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Abstract: Abrasion is an important possible side-effect of individually used mechanical oral hygiene products which encouraged researchers to investigate products with less potential complications. This study examined brushing abrasion of 4 standard toothbrushes (Soft Oral-B, Medium Oral-B, Soft Panbeh-Riz and Medium Panbeh-Riz) *in vitro*. A specific mold was used to make samples by setting composite on acrylic resin. The samples were subjected to a 200 g force applied by toothbrushes connected to V8 Cross Brushing Machine for 18000 cycles in the solution of toothpaste with fluoride and distilled water. The samples were scaled before and after experiment and their weight loss measured after 3000, 6000, 9000, 12000, 15000 and 18000 cycles. Two way ANOVA and Tukey tests were used for statistical analysis. The study showed Soft Oral-B (Advantage) to produce the least abrasion among the four toothbrushes. Soft Panbeh-Riz had the most abrasion. Medium Panbeh-Riz and Medium Oral-B (Indicator) showed similar abrasion rate. The results showed that abrasion effects existed in all toothbrushes while it was increased with the increase occurred in number of cycles showing linear pattern.

Key words: Abrasion, toothbrush, panbeh-riz, Oral_B, evaluation, *in vitro*

INTRODUCTION

Dental caries and periodontal diseases are the two most prevalent complications of dental plaque followed by tooth abrasion (Hooper *et al*., 2003). In spite of the advancements made in technology, the use of mechanical oral hygiene products such as toothbrush is the most effective way to overcome these complications. Considering this importance, toothbrushes were the subject of different studies from different aspects done for the purpose (Svinnseth *et al*., 1987).

Tooth abrasion has been considered as a physiologic outcome of chewing caused by age. Abrasion includes some other types like attrition; erosion and abfraction which all have pathologic origin and their etiology may be in relation with each other (Ronald, 1998; Addy *et al*., 2002). According to the published reports, the weight loss occurred in *in vivo* samples are less than *in vitro* specimens that stresses the protective role of saliva (Meurnman and Tengate, 1996). Tooth abrasion leads to enamel and dentine tooth surface loss, tooth sensitivity, esthetic complications involving masticatory system which all may to be restored (Clasen *et al*., 2000; Amaechi *et al*., 2000).

When toothbrush is considered to be the most frequently used device to keep good oral hygiene and as any contact between tooth and other mechanical devices can lead to tooth abrasion, the device must be studied from different aspects (Hooper *et al*., 2003; Theodor *et al*., 2002; Carranza *et al*., 2002). Improper use of toothbrush, however, can lead to soft and hard tissue traumas (Carranza *et al*., 2002; Sangnes 1976; Gillette and Van, 1980). Gingival recession is the most prevalent complications of toothbrush improper usage stressed repeatedly (Sangnes and Gjermo, 1976; Hansen and Johansen, 1997; Larsson, 1996; Bergstrom and Lavstedt, 1979). Hard tissue lesions are mainly due to abrasive ingredients of toothpaste while toothbrush abrasion leads to gingival tissue lesions (Sangnes, 1976).

Various factors such as brushing method, brushing force, toothbrush type, filament stiffness, brushing time and intervals, etc are important in toothbrush abrasion (Dyer *et al*., 2000, 2001). It has been reported that horizontal brushing method leads to most abrasion rate

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and tissue lesions (Bergstorm and Lavstedt, 1979) while this rate increases with the increase of brushing force and times (Sorensen and Nguyen, 2002). The complications of toothbrushing are also repeatedly observed in aged people (Sangnes, 1976). Brushing times and methods are mostly involved in toothbrush abrasion in comparison to toothpaste and bristles' stiffness (Sorensen and Nguyen, 2002).

Along with published studies, factories have improved the toothbrushes' quality to increase their cleaning efficiency and decrease relevant oral tissue lesions (Dyer *et al*., 2001). Toothbrushes with end-rounded bristles are the products in this process which has caused to 30-50% reduction in trauma and tissue lesions by itself. Some studies concluded hard toothbrush types to cause abrasion mostly (Carranza *et al*., 2002; Harte and Manly, 1976) while other indicated soft types to have high abrasion when exposed to toothpaste (Dyer *et al*., 2000; Phaneuf, 1962). At the same time, other clinical documents considered toothbrush type to have no effect on abrasion (Bergstorm and Lavstedt, 1979; Bjorn and Lindhe, 1966).

Different toothbrushes are available with different length, thickness, filament kind and stiffness (nylon, poly esther), order and compression and etc all of them are important when used with toothpaste and also in abrasion rate (Dyer *et al*., 2000). The necessity of studies for toothbrush selection is stressed here. Extra to these mentioned, the public interest towards the use of well known toothbrushes which are expensive, has caused a lot of money be spent without any clinical documentation about their superiority. So, this study investigated the abrasion caused by four toothbrushes [soft Panbeh-Riz (Boshehr Mesvak-Iran), medium Panbeh-Riz (Boshehr Mesvak-Iran), soft Oral-B (Advantage), medium Oral-B (Indicator)].

MATERIALS AND METHODS

The techniques used for this study were selected similarly to the studies found in literature or by pilot study. The study performed experimentally *in vitro*. Thirty two specimens prepared at the dimensions of 1×1×1.5 cm^3, there being eight specimens of each toothbrush group, in a mold of polycarbonate (Fig. 1). Self-cure poly methyl methacrylate (Acropars, Iran) acryls with the height of 1.3 cm were placed into the mold. After making pores at the finishing acryl areas, 2 mm of synergy dental composite (Coltene Co.) were applied on them and cured by Coltolux 75 (Colten Whaledent USA) for 40 se. The pieces' surfaces were polished by grinding with a 400-grit silicium carbide paper to remove the pores. Then, samples were stored in a closed-door glass dish at laboratory temperature.

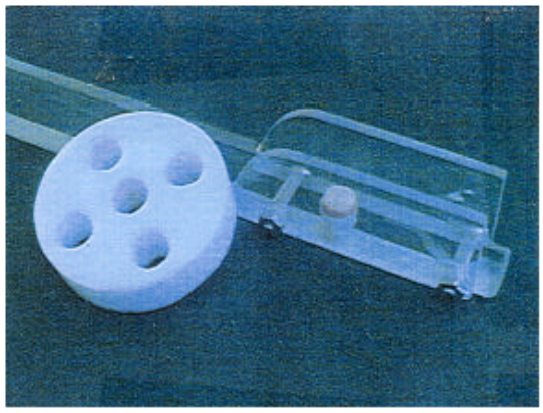

Fig. 1: Poly carbonate mold for sample fabrication with a clip

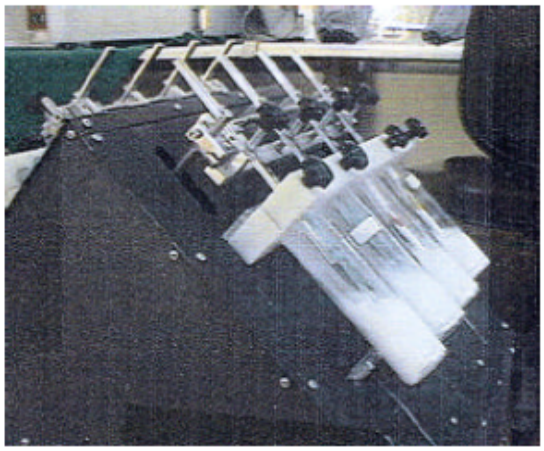

Fig. 2: V8 cross brushing machine

V8 Cross Brushing Machine with abrasivity standard of ISO 11906 was used to simulate typical movement of a toothbrush across the specimen under controlled load and fluid conditions. So, produced abrasion will be similar to that toothbrushing with toothpaste produce in the oral cavity (Fig. 2). The control of linear movement of the connected toothbrushes and also the vertical load applied by toothbrush tip point to the surface lets investigator to simulate different toothbrushing methods by the instrument. The toothbrush movement and contact with the specimen must be performed into a liquid environment.

The sample was placed into a transparent poly carbonate clip with a hole equivalent to the sample size after weighing. An ISO 9001 standard digital scales (Sartorius AG Gottingen, Germany) with 0.0001 accuracy. The transparent clip was fixed into the machine special glass cylinder. Four studied toothbrushes [soft Panbeh-Riz (Boshehr Mesvak-Iran), medium Panbeh-Riz

(Boshehr Mesvak-Iran), soft Oral-B (Advantage), medium Oral-B (Indicator)] were fixed in their specific positions in the machine after each other to produce determined toothbrushing procedure. The applied load by the toothbrush was controlled to 200 g by regulating the springs prepared for the purpose while glass cylinders with the sample and clip were fixed afterwards. The toothbrushes were connected to the machine so that the tootxhbrush's tip was placed oppositely to the samples when the glass and piece contained clip were positioned (Fig. 3).

A mixture of fluoride toothpaste (Paveh, Tolidaru Co. Iran) and distilled water with a ratio of 20 g 100 mL^{-1} was prepared to flow when the toothbrush moving on the sample and cover the entire surface. The weight of toothpaste was determined by a scale with 0.1 g accuracy. The linear movement of toothbrush was controlled to pass the sample entirely with all bristles producing abrasion like intraoral situations.

The number of cycles was kept on 3000 to stop after 3000 cycles automatically. The samples were got out of the clip and stored in a closed-door dish for 24 h after washing by water and drying by paper drier. Then, the same scale was used to measure the samples weight again while the numbers were recorded in a questionnaire prepared previously.

All these procedures were repeated for 6000, 9000, 12000, 15000 and 18000 cycles.

All operations were performed by the researcher in a similar laboratory situation using the same devices in order to overcome related bias. Other testing variables like toothpaste mixture concentration, abrasion times, abrasive machine speed, applied load by toothbrush, environment temperature, drying conditions and washing related circumstances were similar for all specimens. Two way ANOVA and Tukey multiple comparison tests were used for statistical analysis.

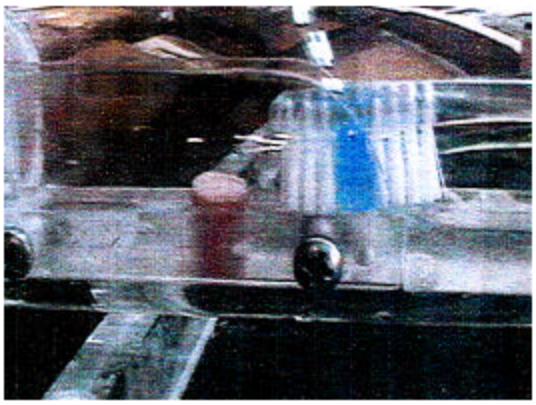

Fig. 3: Set of toothbrush, transparent clip and glass cylinder

RESULTS

The study showed Soft Oral-B (Advantage) to produce the least abrasion among the four toothbrushes as well as Soft Panbeh-Riz to have the most abrasion. Medium Panbeh-Riz and Medium Oral-B (Indicator) showed similar abrasion. The mean and standard deviation of changes occurred in samples' weight during the six stages with relation to their base weight is showed in Fig. 4. It shows the increase in weight loss and consequent abrasion rate with an increasing number of toothbrush abrasion cycles. The data were analyzed using a two-way Analysis of Variance (ANOVA) and the Tukey post-hoc test. Significant differences ($p<.0001$) in cycle number were found, while the effect of toothbrush type and simultaneous effect of toothbrush type and cycle number on weight loss were not statistically significant ($p<0.6$, $p<0.1$). The results performed Tukey test about pair groups are presented in Table 1.

The mean and standard deviation of weight loss of samples in every 3000 cycle of toothbrush abrasion are shown in Table 2 which make possible to compare the studied toothbrushes with each other in every 3000 cycle. In 0-3000 and 6000-9000 cycle, Soft Oral-B and Soft Panbeh-Riz caused to least and most weight loss, respectively while in 3000-6000 cycle, Soft Oral-B and Medium Oral-B, in 9000-12000 cycle, Soft Oral-B and

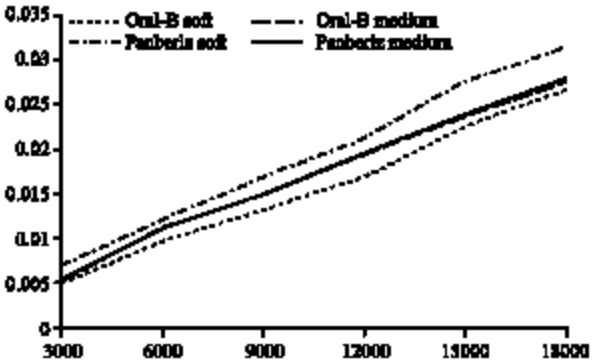

Fig. 4: Weight changes occurred after 3000, 6000, 9000, 12000, 15000 and 18000 cycles in samples according to base weight

Table 1: Comparisons of two pair groups

Toothbrush 1	Toothbrush 2	Mean difference (weight loss (g))	P value
Soft Panbeh-Riz	Ssoft Oral-B	0.0048	0.0001
	Medium Panbeh-Riz	0.0034	0.0001
Soft Oral-B	Medium Oral-B	0.0010	0.085
	Soft Panbeh-Riz	0.0048	0.0001
Medium Panbeh-Riz	Medium Oral-B	0.0004	0.772
	Soft Panbeh-Riz	0.0034	0.0001
Medium Oral-B	Soft Oral-B	0.0010	0.085
	Medium Panbeh-Riz	0.0004	0.772

Table 2: Weight loss (g) occurred in every 3000 cycle of toothbrush abrasion

	Cycles					
Toothbrushes	0-3000	3000-6000	6000-9000	9000-12000	12000-15000	15000-18000
Soft Panbeh-Riz	0.0070±0.0003	0.0051±0.0003	0.0048±0.0001	0.0042±0.0002	0.0065±0.0003	0.0038±0.0001
Soft Oral-B	0.0051±0.0001	0.0044±0.0001	0.0036±0.0001	0.0037±0.0001	0.0056±0.0001	0.0040±0.0001
Medium Panbeh-Riz	0.0056±0.0003	0.0054±0.0002	0.0039±0.0001	0.0045±0.0004	0.0044±0.0001	0.0040±0.0001
Medium-Oral-B	0.0053±0.0006	0.0057±0.0002	0.0038±0.0002	0.0044±0.0002	0.0043±0.0003	0.0039±0.0001

Medium Panbeh-Riz, in 12000-15000 cycle, Medium Oral-B and Soft Panbeh-Riz and in 15000-18000 cycle, Soft Panbeh-Riz and Soft Oral-B produced the least and most abrasion during the procedure.

DISCUSSION

There have been some researches using similar technique used in this study. For instance, use of V8 Cross Brushing Machine was indicated in Svinnseth (1987), Dyer *et al.* (2000, 2001) and Sorensen (2002), or the applied load of 200 g was almost the mean value used by investigators such as Svinneseth (1987) and Dyer *et al.* (2000, 2001). The use of synergy dental composite was considered after a pilot study performed on Fuji glass ionomer, synergy composite and Acropars self cure poly methyl methacrylate after 3000 cycles of abrasion when the result showed synergy composite to produce the most weight changes. As studies on toothbrush abrasion exposing to brush alone or water has not lead to valid results, different toothpastes with different concentrations were used by researchers like Dyer *et al.* (2000, 2001) and Sorensen (2002). In the present study, a fluoride toothpaste (Paveh, Tolidaru Co. Iran) fairly used by public was selected to be use.

Calculation on the clinical outcome of the data *in vitro* indicates that toothbrushing with Soft Oral-B (Advantage) brush and a mixture of toothpaste and water would produce minimal damage to tooth surface while Soft Panbeh-Riz brush to have the most abrasion. Medium brushes showed similar abrasion and with the increase in abrasion cycle number, the affected area was increased. Dyer *et al.* (2000) indicated hard toothbrushes to cause least abrasion while soft brushes the most which supports our findings about soft toothbrushes (Dyer *et al.*, 2000). They also considered brushes (filament stiffness) to be of little clinical significance. In the present study, the effect of toothbrush type (soft, medium) on the abrasion was not statistically significant too. Linear pattern of abrasion was concluded in both studies.

In another *in vitro* study on abrasion by different manual toothbrushes, abrasion was shown to be progressive with increasing strokes and the pattern of abrasion for each brush to a first approximation linear that coincide with the present study (Dyer *et al.*, 2001).

Filament diameter is considered by Dyer *et al.* (2000) and Phaneuf (1962) as the reason for higher abrasivity of soft brushes, so the same explanation may justify the results of the present study.

Filament configuration of toothbrush head is another factor makes the products of a same factory act differently in abrasion procedure. Further examinations performed on Soft Oral-B (Advantage) brush revealed the filaments not to have similar height. Consequently, simultaneous contacts would not meet with sample surface. It is obvious that lower toothbrush abrasion will be produced less contacts are made between the brush and tooth. Lack of clinical difference in abrasion by medium brushes may be explained in term of their structural similarity. All these suggest the need to establish criteria for brush filament characteristics in addition to plaque removal power for toothbrushes.

CONCLUSION

The results showed abrasion in all brushes while Soft Oral-B (Advantage) produced the least abrasion as well as Soft Panbeh-Riz the most. Abrasion by Medium Panbeh-Riz and Medium Oral-B (Indicator) was almost similar. Abrasion effects of toothbrush increased with the increase occurred in number of cycles showing a linear pattern.

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