J Clin Periodontol 2004; 31: 639–642 doi: 10.1111/j.1600-051X.2004.00550.x

Journal of Clinical Periodontology

The electric toothbrush: analysis of filaments under stereomicroscope

L. Checchi, E. Farina, P. Felice and M. Montevecchi

Department of Periodontology, School of Dentistry, University of Bologna, Bologna, Italy

Checchi L, Farina E, Felice P, Montevecchi M: The electric toothbrush: analysis of filaments under stereomicroscope. J Clin Periodontol 2004; 31: 639–642. doi: 10.1111/j.1600-051X.2004.00550.x. © Blackwell Munksgaard, 2004.

Abstract

Background: The use of manual and electric toothbrushes has a fundamental role in primary prevention in oral hygiene. However, aggressive use of the toothbrush, especially those with non-rounded filaments, can result in lesions in both soft and hard oral tissue. Without doubt, the electric toothbrush is a useful aid for the patient, and it is therefore interesting to evaluate not only its effectiveness in plaque removal, but also the relationship between morphology of filaments and incidence of muco-gingival pathologies.

Objective: The aim of this research was to evaluate various forms of bristles of electric toothbrushes under a stereomicroscope vision.

Data sources: Brushes tested included two samples of toothbrushes from six different types. Tufts from the same position on the toothbrush head were removed and examined under stereomicroscope. In this study the percentage of rounded filaments that is considered acceptable and non-traumatic was evaluated according to the Silverstone and Featherstone classification.

Conclusions: Morphological analysis of electric toothbrush filaments revealed a low percentage of rounded filaments. In only four of 12 electric toothbrushes tested there were more than 50% of the filaments rounded in appearance.

Key words: electric toothbrush; end-rounded filaments; gingival recession

Accepted for publication 26 October 2003

The mechanical removal of plaque from dental surfaces using a toothbrush is considered to be an essential prerequisite to oral health. The toothbrush removes food residue and bacterial plaque from surfaces, massages the gums and reduces tissue inflammation. The electric toothbrush is currently one of the most common hygienic tools. The first electric toothbrushes, which were introduced in the 1960s, worked by low level vibration with a ''side to side'' movement of the head (Grappiolo et al. 2002). These models were shown to be as good as manual toothbrushes in the removal of plaque. (Love et al. 1993, Taylor et al. 1995). Further research led to the production of electric toothbrushes with a rotary movement and a higher frequency of vibration and have been shown to be superior to earlier models (Quirynen et al. 1994, Van der Weijden et al. 1994, Walmsley 1997). The advantages of electric toothbrushes lay in the fact that they require a minimum of skill in handling by the patient and that the head has a constant and autonomous movement, independent of the brushing technique used (Driesen et al. 1998, Warren & Chater 1996). Also certain models come with extras such as pressure sensors and timers, which provide added safety of use. Moreover they can be extremely useful for older patients, those with manual difficulties, patients with dental appliances or dentinal hypersensitivity (Wilcoxon 1991, Blahut et al. 1993, Boyd & Rose 1994).

However, despite the obvious advantages of toothbrushing in plaque removal, an aggressive use of the brush (electric or manual) and incorrect cleaning habits can cause lesions to both hard tissue (abrasions in the area of the cemento-enamel junction) and to soft tissue, leading to the recession of the marginal tissue and the exposure of the cemento-enamel junction (Radentz et al. 1976, Sangnes 1976, Khocht et al. 1993, Danser et al. 1998). Various factors contribute to the incidence of dental abrasions and gingival recession: brushing technique; the pressure employed (Van der Weijden et al. 1996) and the number of strokes (Phaneuf et al. 1962); the duration of the brushing process and its frequency (Checchi et al. 1999); the material of the bristles (Massassati & Frank 1982); the quality of the toothpaste used and its abrasive power (Radentz et al. 1976, Dyer et al. 2000); the condition of hard and soft tissue (Khocht et al. 1993). Another important parameter in evaluation concerns the hardness or flexibility of the bristles and morphology of the filaments used (Phaneuf et al. 1962). Many studies have observed a relationship between the morphology of filaments and the appearance of gingival lesions (Khocht et al. 1993, Drisko et al. 1995, Danser et al. 1998, Dyer et al. 2000). According to Breitenmoser (1979) filaments with sharp cut ends cause more lesions compared to those with soft rounded ends. In a study of different makes of manual toothbrushes published in 2001, Checchi et al. evaluate the percentage of rounded filament ends that can be considered acceptable according to Silverstone and Featherstone's 1988 criteria. The results showed that only six brushes out of 62, of four brands out of 31 tested, showed a percentage of acceptable rounded ends greater than 50%.

The goal of this study was to examine and evaluate the form of filaments of electric toothbrushes under stereomicroscope vision.

Materials and Methods

The study was carried out on a sample of 12 electric toothbrushes (two samples for each of six different models: Braun Oral B 3D Excel (Braun, Kromberg, Germany), Mentadent Integral (Lever Fabergè Italia, Casalpustarlengo, Italy), Rotadent (ProDentec, Batesville, AR, USA), Broxo Klassic (Les Produits Associes, Geneva, Switzerland), Colgate Actibrush (Palmolive, New York, NY, USA) and Interplak (Bausch & Lomp, Tucker, GA, USA)). The toothbrushes were purchased in supermarkets and pharmacies and analyzed under the stereomicroscope. The design of the head (rectangular or circular), the number of tufts, their layout (the number of rows) and the number of single filaments that made up each tuft was noted for each model. Using a slow-speed diamond disc a tuft of filaments was removed from the same place on each brush. The top left-hand tuft was removed from rectangular electric toothbrushes, while the tuft opposite the handle was removed from circular toothbrushes. In the case of the Rotadent brushes, which have a large single tuft, a number of filaments (based on the average from the other brushes) were randomly removed using tweezers. To enable examination under the stereomicroscope the filaments of each tuft were removed using universal pincers or, in the case of the Interplak, a sharp cutter was used to cut the filaments from the base of the tuft. The filaments were then aligned and mounted on smooth Bristol paper with adhesive tape. Each card was numbered on the back so as not to influence the judgment of the examiner. The analysis of the filaments was carried out under the stereomicroscope magnified $\times 5$, with an optic fiber light source.

A total of 1091 filaments were examined. For each sample the percentage of end-rounded filaments (considered acceptable) and of non-end-rounded filaments (considered unacceptable) was revealed, using Silverstone and Featherstone's 1988 classification. Following this, the average percentage of end-rounded filaments for each brand of electric toothbrush was calculated, based on the results obtained from the individual samples.

Gini's heterogeneity index $\sum_{i=1}^{n-1} F_i(1 - F_i)$/maximum of heterogeneity, where F_i are the frequency of modalities and maximum of heterogeneity is number of modalities − 1/number of modalities, which was used to measure the heterogeneity among the samples of electric toothbrushes.

Results

Analysis of 12 electric toothbrushes reveals that the number of tufts varies greatly between models according to the morphology of the brush head. The four Broxo and Interplak toothbrushes had rectangular heads with four or two rows, respectively. The other samples all had circular heads with a number of concentrated rows ranging from one (Rotadent) to three (Braun Oral B). The total number of tufts also varied from a minimum of one (Rotadent) to a maximum of 28 arranged in four rows (Broxo). The number of filaments contained in a single tuft varied from 44 (Mentadent) to 196 (Interplak); moreover, there were also differences between samples of the same brand. (Table 1). Examination under the stereomicroscope revealed that some filaments have rounded ends whereas others are not rounded in all samples (Fig. 1). The results are shown in Table 2. Only four out of 12 electric toothbrushes from three brands out of the six (one, Braun Oral B; one, Colgate; two, Interplak) had more than 50% acceptably rounded filaments. The Interplak brushes and the Braun Oral B had the largest average percentages with, respectively, 58.1% and 49.1%. A group of 3 electric toothbrushes from 2 different brands (Mentadent and Rotadent) had a percentage of less than 10%. It should be noted that only the Interplak electric toothbrushes had more than 50% of acceptable filaments in both samples.

Gini's index of heterogeneity that is 0.75 confirms the extreme dis-homogeneity between the number of acceptable filaments in the different brands examined.

Discussion

One of the main objectives of oral hygiene is to retard the accumulation of bacterial plaque to maintain periodontal health. This is principally accomplished by the use of toothbrushes. At this point it is important to consider not only the efficiency of such devices but also the risk of causing damage to either soft or hard tissues. Incorrect toothbrushing habits can create lesions to both soft and hard tissues. These lesions

Table 1. Electric toothbrushes examined: for each toothbrush the number of rows, tufts and filaments is indicate

Brands of electric toothbrushes	Number of rows	Number of tufts	Number of filaments
Broxo	7 × 4	28	70
Broxo	7 × 4	28	66
Colgate	2 concentric rows	23	58
Colgate	2 concentric rows	23	62
Braun Oral B	3 concentric rows	26	58
Braun Oral B	3 concentric rows	26	52
Mentadent	2 concentric rows	23	50
Mentadent	2 concentric rows	23	44
Interplak	3 × 2	6	196
Interplak	3 × 2	6	195
Rotadent	1	1	120
Rotadent	1	1	120

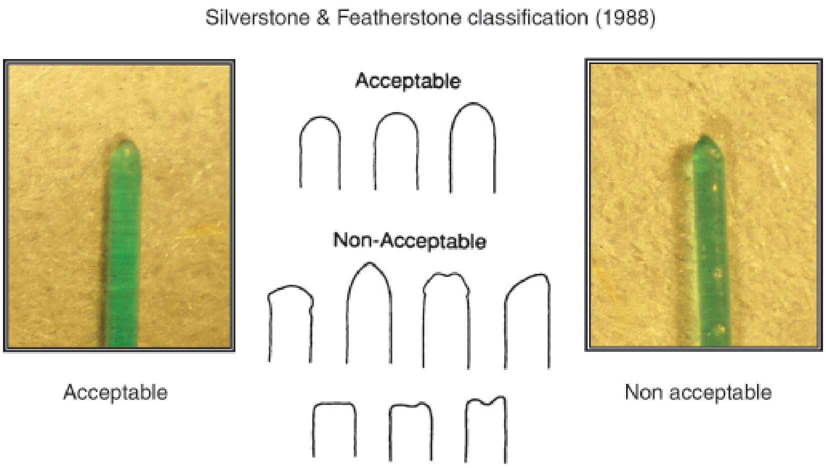

Fig. 1. Acceptable and non-acceptable samples as the Silverstone and Featherstone classification.

Table 2. Electric toothbrushes with number and percentage of acceptable and non-acceptable filaments in two samples

Brands of electric toothbrushes		Acceptable filaments			Non-acceptable filaments	
		N°	%	media%	*N*°	%
Broxo	1	14	20,0	20,6	56	80,0
	2	14	21,2		52	78,8
Colgate	1	16	27,6	40,8	42	72,4
	2	33	53,2		29	46,8
Braun Oral B	1	22	37,9	49,1	36	62,1
	2	32	61,5		20	38,5
Mentadent	1	9	18,0	10,6	41	82,0
	2	1	2,3		43	97,7
Interplak	1	99	50,5	58,1	97	49,5
	2	128	65,6		67	34,4
Rotadent	1	5	4,2	5,8	115	95,8
	2	9	7,5		111	92,5

can cause aesthetic problems or dentinal hypersensitivity, which can cause great discomfort for patients. Several factors involved in mechanical plaque removal have been considered as possible causes of lesions: brushing pressure, frequency, brushing techniques, stiffness and unfavorable shape of toothbrush bristles, use of toothpaste (Phaneuf et al. 1962; Breitenmoser et al. 1979; Massassati & Frank 1982; Van der Weijden et al. 1996, Checchi et al. 1999; Dyer et al. 2000). Without doubt the hardness of bristles and the morphology of the tip are a contributory factor. The necessity of using end-rounded filaments for both manual and electric toothbrushes is undeniable (Breitenmoser et al. 1979, Drisko et al. 1995). Several studies used SEM to view the tips of the filaments. It works by using a ray of electrons to project a two-dimensional image onto a screen so that it appears three-dimensional. Samples for SEM analysis need to be coated by gold-palladium sputter coating procedures. The heat generated by cathodes during this process can cause the morphology of the filament to alter. In 1995, Franchi & Checchi showed that the temperatures in the sputter coater varied at different distances from the cathode and at different lengths of golden-palladium coating. The temperature can alter the morphology of the filaments. At 59°C filaments in a vertical position appear rounder when compared to others, making the results unacceptable.

The stereomicroscope can also be used to observe the morphology of filaments and needs no high temperature preparation of the sample. (Drisko et al. 1995).

In fact in order to avoid altering their morphology in this study the stereomicroscope with optic fiber lighting was used to examine the tips of filaments in electric toothbrushes. The electric toothbrushes examined in this study were brand-new, infact it is interesting to consider that usage of a brush will change the original end-rounding due to wear: used toothbrushes show a different morphology of tip (Massassati & Frank, 1982).

Results showed an average percentage of acceptable filaments ranging from 5.8% to 58.1% and only one of the brands examined had more than 50% acceptable filaments for both samples.

The newer generation of electric toothbrushes can offer notable advantages for patients; however, considering their popularity on the market, manufacturers should carry out more quality controls to ensure that products are not only efficient but safe too.

Acknowledgment

The authors wish to thank Dr. Henry A. Sachs (New York, NY, USA) for editing the manuscript.

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Address:
Luigi Checchi
Ordinario di Parodontologia
University of Bologna
Italy
Fax: +051/305907
E-mail: lchecchi@alma.unibo.it