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Is a new sonic toothbrush more effective in plaque removal than a manual toothbrush?

ABSTRACT

Aim Powered or manual toothbrushes are daily-used instrument in the Western area for the control and removal of bacterial biofilm. Among powered-toothbrushes, sonic technology has shown to produce fluid turbulent activity that might assist in plaque removal; however, limited knowledge is available in-vivo. The objectives of this study were to compare the plaque removal efficacy of two different toothbrushes in a population not familiar with sonic technology, and to collect and analyse data regarding oral hygiene habits. The null-hypothesis was that a sonic toothbrush is able to remove a superior amount of plaque compared to the manual type.

Materials and methods Forty young adult patients were enrolled in the study. A single-cohort crossover clinical trial was designed. For each patient, three appointments were scheduled: the first (T0) was used for oral care education and explanations of toothbrushes techniques, for a preliminary professional hygiene session, and for delivery of a questionnaire; at one week (T1), plaque evaluation was performed (Turesky modification of the Quigley and Hein index) at baseline and after asking patients to brush with the randomly selected manual or sonic device. At the last appointment (week 3, T2), the same plaque evaluations of T1 were repeated asking patients to brush with the other toothbrush. Entire mouth indexes were calculated and mean reductions in whole mouth plaque scores

were obtained (pre-brushing minus post-brushing values) for the two tested toothbrushes. Multiple ANOVA tests ($p=0.05$) were used 1) to compare plaque levels between male and female subjects at baseline and post-brushing, regardless the type of toothbrush, and 2) to differentiate between mean reductions in whole mouth plaque scores according to the type of toothbrush (manual versus sonic). The study population was subjected to descriptive statistical analysis; potential relationships between socio-demographic variables and obtained plaque scores were evaluated (Mann-Whitney and Kruskal-Wallis tests).

Results Full-mouth plaque levels were reduced at post-brushing sessions, regardless the device, by approximately 62% ($p<0.0001$). Mean plaque index reductions for manual and sonic toothbrush were of 1.05 ± 0.22 and 1.19 ± 0.37 , respectively. A statistically significant difference was found between the two devices ($p=0.0342$). The powered sonic toothbrush removed about 10% more plaque than the manual type. From the collected questionnaire financial data, willingness to pay (WTP) values expressing economic efforts of patients for the purchase of toothbrushes were of $\text{€ } 4.83 \pm 3.86$ and of $\text{€ } 54.75 \pm 36$, for the manual and sonic devices, respectively.

Conclusion Within the limitations of the study, in subjects without any previous experience of a similar technology, the single use of the sonic toothbrush showed a significantly greater plaque reduction compared to the manual traditional toothbrush (null-hypothesis accepted).

Keywords Efficacy, In-vivo clinical trial, Oral habits, Plaque removal, Sonic toothbrush.

Introduction

Mechanical removal of bacterial plaque is the most efficient method to control conditions such as dental caries, gingivitis, and for prevention of progressive periodontal disease [Mandel, 1966; Theilade et al., 1966]. However, it has been reported that daily brushing only partially removes plaque deposits [Warren et al., 1998]. Regular plaque removal with a manual toothbrush represents the most frequently used method of oral hygiene in Western society. When used correctly and for a sufficient period of time, the manual toothbrush efficiently removes supragingival plaque [Pizzo et al., 2010; Saxer and Yankell, 1997].

Dental caries, an oral health problem strictly related to inefficient plaque removal, is influenced by several variables: social status, geographical area, and age [Campus et al., 2007]. In most individuals plaque scores

are reduced approximately by 50% during manual toothbrushing [Pizzo et al., 2010]. Current data suggests that a simplification of home dental hygiene procedures might be useful.

To improve plaque removal different designs of manual and powered toothbrushes were introduced over the past 40 years [Kiche et al., 2002; McInnes et al., 1992]. According to Terezhalmay et al. [2005], the powered toothbrushes were found to deliver greater plaque removal by 42.4% and 28.2% compared to the control manual toothbrushes; Lazarescu et al. [2003] have shown that, after 3 weeks of use, the powered brush was significantly more efficient than the manual brush in the group of subjects unfamiliar with electric devices.

In recent literature, four main types of powered toothbrushes are available, based on their mechanism of action: side to side, counter-oscillation, rotation-oscillation, circular [Heanue et al., 2003; Robinson et al., 2005]. Deacon et al. [2010] reported in an extended systematic review that no definitive conclusions can be drawn regarding the superiority of one type of powered toothbrush over another. The safety of power toothbrushes has been clearly established, and daily use of a power toothbrush is at least as safe as a manual toothbrush. The use of a powered toothbrush, which employs a mechanical action instead of a manual one, reduces brushing force and the incidence of gingival bleeding because of gum damage [He et al., 2001; Boyd, 1997]. In addition, power toothbrushes have been shown to be well received and improve compliance in orthodontic patients [Silvestrini Biavati et al., 2010].

A particular type of electric toothbrush is based on sonic energy; McInnes et al. [1992] showed that plaque bacteria can be removed using this technology. Sonicare toothbrush operates at a frequency of 260 Hz: the brush head oscillation produces a bristle tip velocity that, when inserted in a fluid/air environment, creates turbulent fluid and bubble activity and associated shear forces. There is evidence, in vitro, that fluid activity assists in removal of both plaque and stain [Khambay and Walmsley, 1995].

The aim of this study was to compare the plaque removing efficacy of two different toothbrushes in a population unfamiliar with sonic toothbrushes and to collect and analyse data regarding oral hygiene habits. The null hypothesis tested was that sonic toothbrush is able to remove a superior amount of plaque compared to the manual conventional toothbrush.

Materials and methods

Study population

A total of 40 healthy young adults males and females (18 men and 22 woman; mean age, 24±3.5; range 18-32 years) volunteered to participate to this study. Screening and selection of subjects were performed randomly out

INCLUSION CRITERIA	EXCLUSION CRITERIA
Good general health	Bad oral health: caries, periodontal diseases or oral lesions.
Minimum of 24 natural teeth.	A history of rheumatic fever, AIDS, leukemia, cirrhosis, sarcoidosis, diabetes mellitus, hepatitis, or any medical condition requiring consultation or drug therapy.
Subjects that reported brushing at least once daily.	Any physical condition that limits manual dexterity required for toothbrushing.
Never used a sonic power toothbrush before.	A present history of medications that are likely to affect oral health.
	Antibiotic usage during the two months preceding the study
	Fixed orthodontic appliances
	Removable dentures or extended fixed prosthesis

TABLE 1 Inclusion and exclusion criteria applied for the selection of participants.

of the patients of the Department of Oral Rehabilitation from the Istituto Stomatologico Italiano, University of Milan, Italy. A single investigator explained the objectives of the research; inclusion and exclusion criteria applied for all participants are reported in Table 1.

Study design

A single-cohort, crossover clinical trial [McCracken et al., 2005], single blind, 2 treatments, 3-week total observation time was conducted. The study was approved by the local ethics committee and complied with the requirements of the Declaration of Helsinki.

Materials

The Philips Sonicare DiamondClean 300 Series (Philips Oral Healthcare Inc., USA) toothbrush and the Butler Gum 409 Compact Soft (Sunstar America Inc., USA) manual brush were used.

The BioRepair Plus (Coswell Farma, Italy) fluoride toothpaste was provided to all subjects during the whole test period.

Plaque was disclosed using a Ivoclar Plaque Test indicator liquid (Fluorescein disodium salt < 1 wt.%, glycerine, distilled water) (Ivoclar Vivadent AG, Liechtenstein) in association with a LED light curing unit (Valo Cordeless, Ultradent products Inc., USA).

Procedure

For each patient enrolled in the study, 3 appointments were scheduled one week apart, using the following scheme: Baseline (T0); Week 1 (T1); Week 2 (T2).

Baseline (T0)

After a study description refresh, all subjects provided informed consent to participation. Two educational

movies were shown individually to all participants; the first one illustrated the modified Bass technique for the manual toothbrush while the second explained the proper mode of use for the sonic toothbrush (manufacturer's usage instructions). No specific interdental cleaning aids were used.

Patients were invited to replicate demonstrated movements on an oral model. Then a questionnaire was given to collect demographic data (gender, age), oral health and economical information, habits regarding oral hygiene (use of mouthwashes, floss, checkups, toothbrush knowledge and preferences). The form is reproduced in Figure 1. In the questionnaire, the strength or magnitude of preference for manual and sonic toothbrushes was recorded by means of a Willingness to Pay (WTP) analysis: this was performed by asking patients the maximum amount of money they would spend for a specific oral care device. The measurement of patient preferences by WTP index is frequently used in medicine since it might be helpful when dealing with decisions in health economics [Augusti et al., 2013]; this type of analysis is also considered important for an evaluation of patients' perspectives regarding dental preventive measures (like hygiene procedures) or treatments. WTP was also elicited for an in-office professional hygiene session.

The intraoral examination was followed by professional prophylaxis [Turesky et al., 1970]. The following appointment was planned at one week. Volunteers were asked to refrain from all oral hygiene measures 23–25

h prior to the appointment and to refrain from eating, drinking or smoking in the preceding 4 h.

Week 1 (T1)

At T1 and T2, participants received an oral examination of hard and soft tissues and Ivoclar Vivadent Plaque Test was used for disclosing plaque [Pizzo et al., 2010]. Using a micro-brush the fluid was applied to 3 teeth at a time in the upper and lower arches, both for buccal and lingual surfaces. Under a polymerisation light, plaque appears fluorescent yellow. Plaque's scoring was performed and recorded using the Turesky modification of the original index of Quigley and Hein [Biesbrock et al., 2007; Quigley and Hein, 1962] (Fig. 2). Plaque examinations were performed by a single trained, experienced dentist who had previously demonstrated the ability to differentiate between score levels [Creeth et al., 2009]. After this assessment, a manual toothbrush or a Sonicare device was randomly delivered to the patient. Subjects were addressed to the brushing session; brushing time was divided evenly between the 4 dental quadrants and set to 2 minutes (total time). The brushing was supervised by a single investigator who did not make the plaque assessment: to avoid impartiality, subjects brushed out of the examiner's view; the toothbrushes were collected immediately after brushing. Dental plaque remaining on the subject's teeth was disclosed again and the level evaluated and recorded as before.

The last control at one week was scheduled. The patient was asked not to brush teeth for 23–25 hours prior to the appointment and to refrain from eating, drinking or smoking in the preceding 4 hours, as previously instructed [Pizzo et al., 2010].

Week 2 (T2)

For the third session once again, an initial assessment of the plaque was carried out. The second toothbrush was provided and tested. A new plaque score was recorded following the same procedures as above.

Data analysis

For each completed plaque evaluation an entire mouth index was calculated using the following formula: index = total score / number of examined surfaces. For each

Demographic data		
Name:	Surname:	
Age:	Gender (M/F):	
Habits		
How often do you have a dental check-up? (select times/year) 0 times/year 1 times/year 2 times/year 3 times/year		
Which kind of toothbrush do you use? Manual toothbrush rotary electric toothbrush Oscillating electric toothbrush Sonic toothbrush	Do you also use dental floss? Yes No Only on anterior teeth	Do you also use any mouthwash? Yes No
Have you ever done any dental hygiene session? Yes No	How many times do you subject to oral hygiene session? 1 times/year 2 times/year 3 times/year Once every two years	
Financial		
In your opinion which is the right price for a professional hygiene session?		
Which is the price you are willing to pay for a manual toothbrush?€	Which is the price you are willing to pay for a sonic toothbrush?€	Where do you prefer to buy your next toothbrush: Dentist Chemist Supermarket Online

FIG. 1 The questionnaire.

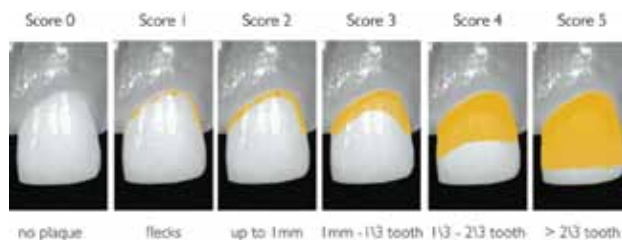


FIG. 2 Plaque's scoring according to Quigley-Hein index, Turesky modification. Total Index = Total score/Number surfaces examined.

Demographic data (N=40)				
Gender (n)	Male: 18	Female: 22		
Age (mean)	Male: 23.78	Female: 24.23		
Age (range)	< 20 yrs: 3	20-25 yrs: 27	>25 yrs: 10	
Habits				
Mouthwash (n)	Yes: 21	No: 19		
Dental Floss (n)	Yes: 18	No: 22		
Current toothbrush (n)	Manual: 37	Power Rotating: 3		
Shopping (n)	Store: 15	Dentist: 10	Pharmacy: 13	Internet: 2
Dental Checkup (range)	<1/year: 6	1/year: 20	2/year or more: 14	
In-office Hygiene (range)	<1/year: 21	1/year: 15	2/year or more: 4	
Financial				
WTP* for toothbrush (€)	Manual (Mean ± SD): 4,83 ± 3,86		Sonic (Mean ± SD): 54,75 ± 36	
WTP* for professional hygiene session (€)	Male (Mean ± SD): 76,39 ± 30		Female (Mean ± SD): 78,64 ± 22	
* Willingness To Pay				

TABLE 2 Descriptive statistics for the studied population.

patient, reductions in whole mouth plaque scores were obtained (pre-brushing minus post-brushing values) for the two tested toothbrushes. Analysis of variance (ANOVA) was used to:

- 1) detect differences in baseline pre-brushing mean plaque levels between T1 and T2 appointments;
- 2) compare plaque levels between male and female subjects at baseline and post-brushing, regardless the type of toothbrush;
- 3) compare mean reductions in whole mouth plaque scores according to the type of toothbrush (manual versus sonic). The level of significance was set at $p=0.05$ for all statistical tests.

The study population was subjected to descriptive statistical analysis using a professional software (SPSS Statistics 19, IBM Corp.). The potential relationships between specific categorical socio-demographic variables and obtained plaque scores were analysed using the Mann-Whitney U test (dummy variables) and

Kruskal-Wallis (multiple variables).

Results

All 40 enrolled patients completed the scheduled appointments and were included in the final data analysis; no subject dropped the study because of adverse effects related to treatment.

Table 2 shows demographic characteristics, habits and collected financial information of the investigated population. Results are presented diagrammatically as box plots (Fig. 3, 4).

The efficacy of brushing action, regardless the tested device (manual or sonic), was confirmed: in fact, mean full mouth plaque levels were lower at post-brushing than at baseline sessions (by approximately 62%; $p<0.0001$).

Average baseline plaque scores ranged from 0.5

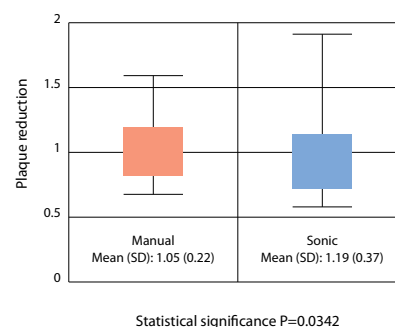
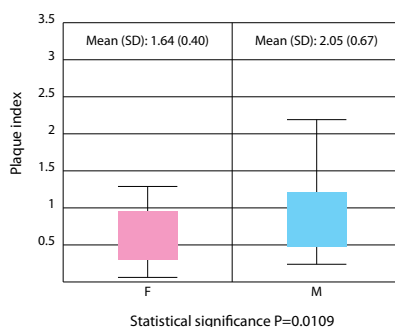
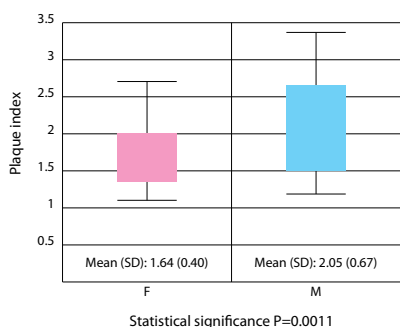


FIG. 3A Baseline (A) and post-brushing (B) recordings of plaque index by gender (F: Female; M: Male).

FIG. 4 Plaque index reductions for the tested manual and sonic toothbrushes.

to 3.35 (mean: 1.82 ± 0.57); a statistically significant difference was found between male and female subjects ($p=0.0011$). At post brushing sessions the difference among gender was confirmed with average plaque scores from 0.1 to 2.23 (mean: 0.7 ± 0.46 ; $p=0.0109$).

The calculated mean plaque index reductions for manual and sonic toothbrush were of 1.05 ± 0.22 and 1.19 ± 0.37 , respectively. A statistically significant difference was found between the two devices ($p=0.0342$) (Fig. 4). The powered sonic toothbrush removed 10% more plaque than the manual one.

The population showed an overall positive attitude towards regular dental check-ups (85% of patients reported to attend a clinical examination at least once per year, or even more frequently: 2 or more visits/year). The most common tool used for daily home dental cleaning was the conventional manual toothbrush, while a restricted number of subjects (3/40) reported to use an electric (rotating-oscillating) device; additional aids (like mouthwashes or dental floss) for optimisation of home oral hygiene procedures were also moderately adopted by approximately 50% of patients.

Despite the studied population (young adults with a mean age of 24 years) being supposedly familiar with current internet technologies, very low consideration for online shopping in order to buy a toothbrush was recorded, stores and pharmacies, followed by direct purchase from the family dentist, were preferred.

Assigned mean WTP values for manual and sonic tested toothbrushes were of € 4.83 ± 3.86 and of € 54.75 ± 36 , respectively. For a professional hygiene session the mean economic effort declared by patients was € 77.6 ± 25 , with no significant difference ($p>0.05$) detected between male (76.39 ± 30) and female (78.64 ± 22) subjects.

Discussion

The process of maintaining good oral hygiene depends on the ability and motivation of individual patients [Ferrazzano et al., 2008]; it is helped by the use of an efficient modern toothbrush [Claydon and Addy, 1996]. Both manual and power toothbrushes have increased the ability to remove plaque, although the effectiveness of manual toothbrush is still limited by manual dexterity and skill of the user [Heasman, 2001]. Power toothbrushes have partially overcome this limitation with the added advantage of simplifying the brushing technique and increasing the motivation to brush regularly.

The aim of our study was to investigate data collection within a cross-over design of clinical trial using efficacy of plaque removal as the primary outcome measure. There are a number of advantages in using crossover design clinical trials: the subjects act as their own

controls; moreover, an increase in efficiency and precision is obtained and the sample size is usually lower than for comparable parallel group design [McCracken et al., 2004; McCracken et al., 2005; Piantadosi, 1997].

Reports in the literature have consistently demonstrated that powered toothbrushes with rotation-oscillation mechanisms deliver superior plaque removal compared to manual toothbrushes. The efficacy of sonic toothbrushes has been demonstrated in several clinical and *in vitro* studies [Stanford et al., 1997; Zimmer et al., 2000] and may be explained by the fluid dynamic activity. The authors showed in their *in vitro* study that the Sonicare could remove 56-78% of plaque from enamel specimens at a distance of 3 mm between the dental surface and bristles [Stanford et al., 1997].

This clinical trial was clinically designed to assess the efficacy of brushing alone, in the absence of additional cleaning tools such as flossing. Results from the present study showed that the tested sonic device was safe and effective in removing plaque from whole mouth compared to the manual toothbrush: a significant additional 10% reduction was found for subjects without any previous use or familiarisation with the sonic technology. Based on our results, the correct use of an electric brush do not seem to be more difficult at first trial compared to a manual toothbrush; as demonstrated by Lazarescu et al. [2003], after providing proper instructions, subjects rapidly developed an effective brushing technique with a short learning curve.

Our study model did not consider a minimum plaque index score as an inclusion criterion and we reported a mean baseline PI value of 1.82. This is in accordance with the demographic analysis: regular dental checkups and in-office professional hygiene sessions were reported by the majority of patients. Our data showed an overall extremely positive attitude of the population towards oral care and prevention. For these reasons, it would be inappropriate to extrapolate the results of this study to make any assumptions regarding tooth brushing efficacy in the general population (that may show different/higher plaque levels) [McCracken et al., 2005].

The obtained financial information revealed that patients established higher mean WTP values for the sonic brush compared with the traditional brush (54.75 vs. 4.83); however, the estimated price for the power device was lower than its current commercial value.

This study did not compare long-term use or clinical outcomes such as bleeding and gingivitis. Power toothbrush studies showing significant reduction in plaque have also shown significant reduction in periodontal indexes [Zimmer et al., 2000]. Considering the present research, we did not evaluate residual plaque levels at proximal surfaces after brushing: however, other studies have found the ability of power

brushes to reduce plaque levels also in difficult-to-reach tooth areas [Sharma et al., 2006].

Additional studies measuring long-term use and clinical outcomes are needed for this new sonic toothbrush; claimed advantages beyond plaque removal efficacy, like abrasion features or the effects on dentin sensitivity, should be further investigated.

Conclusion

The tested null-hypothesis has been accepted. In subjects without any previous experience of a similar technology, the single use of the sonic toothbrush showed significant greater reduction in plaque compared to the manual traditional toothbrush.

References

- › Augusti D, Augusti G, Re D. Prosthetic restoration in the single-tooth gap: patient preferences and analysis of the WTP index. *Clinical Oral Implants Research* 2014; 25:1257-1264.
- › Boyd RL. Clinical and laboratory evaluation of powered electric toothbrushes: review of the literature. *J Clinical Dentistry* 1997;8:67-71.
- › Campus G, Solinas G, Cagetti MG, Senna A, Minelli L, Majori S et al. National Pathfinder survey of 12-year-old Children's Oral Health in Italy. *Caries research* 2007;41:512-517.
- › Claydon N, Addy M. Comparative single-use plaque removal by toothbrushes of different designs. *J Clinical Periodontology* 1996;23:1112-1116.
- › Creeth JE, Gallagher A, Sowinski J, Bowman J, Barrett K, Lowe S et al. The effect of brushing time and dentifrice on dental plaque removal in vivo. *J Dental Hygiene (American Dental Hygienists' Association)* 2009;83:111-116.
- › Cronin MJ, Dembling WZ, Cugini M, Thompson MC, Warren PR. A 30-day clinical comparison of a novel interdental cleaning device and dental floss in the reduction of plaque and gingivitis. *J Clinical Dentistry* 2005;16:33-37.
- › Deacon SA, Glennly AM, Deery C, Robinson PG, Heanue M, Walmsley AD et al. Different powered toothbrushes for plaque control and gingival health. *The Cochrane database of systematic reviews* 2010:CD004971.
- › Dorfer CE, Berbig B, von Bethlenfalvy ER, Staehle HJ, Pioch T. A clinical study to compare the efficacy of 2 electric toothbrushes in plaque removal. *J Clinical Periodontology* 2001;28:987-994.
- › Ferrazzano GF, Cantile T, Sangianantoni G, Ingenito A. Effectiveness of a motivation method on the oral hygiene of children. *Eur J Paediatr Dent* 2008;9:183-187.
- › He T, Carpinello L, Baker R, Knippenberg S, Das A, Winston L et al. Safety of three toothbrushes. *American J Dentistry* 2001;14:123-126.
- › Heanue M, Deacon SA, Deery C, Robinson PG, Walmsley AD, Worthington HV et al. Manual versus powered tooth-brushing for oral health. *The Cochrane database of systematic reviews* 2003:CD002281.
- › Heasman P. Power toothbrushes. Efficacy of a unique gum protection system with an interproximal tip. Introduction. *J Clinical Dentistry* 2001;12:1.
- › Khambay BS, Walmsley AD. An in vitro evaluation of electric toothbrushes. *Quintessence international* 1995;26:841-848.
- › Kiche MS, Fayle SA, Curzon ME. A clinical trial comparing the effectiveness of a three-headed versus a conventional toothbrush for oral hygiene in children. *Eur J Paediatr Dent* 2002;3:33-38.
- › Lazarescu D, Boccaneala S, Illiescu A, De Boever JA. Efficacy of plaque removal and learning effect of a powered and a manual toothbrush. *J Clinical Periodontology* 2003;30:726-731.
- › Mandel ID. Dental plaque: nature, formation and effects. *J Periodontology* 1966;37:537-567.
- › McCracken GI, Preshaw PM, Heasman L, Stacey F, Steen N, Heasman PA. Efficacy of plaque removal of the Sonicare Elite versus the Sonicare Advance from hard-to-reach sites. *J Clinical Periodontology* 2004;31:1007-1011.
- › McCracken GI, Steen N, Preshaw PM, Heasman L, Stacey F, Heasman PA. The crossover design to evaluate the efficacy of plaque removal in tooth-brushing studies. *J Clinical Periodontology* 2005;32:1157-1162.
- › McInnes C, Engel D, Moncla BJ, Martin RW. Reduction in adherence of *Actinomyces viscosus* after exposure to low-frequency acoustic energy. *Oral Microbiology Immunology* 1992;7:171-176.
- › Piantadosi S. *Clinical Trials. A Methodologic Perspective*. 1st edition ed. New York: John Wiley & Sons; 1997.
- › Pizzo G, Licata ME, Pizzo I, D'Angelo M. Plaque removal efficacy of power and manual toothbrushes: a comparative study. *Clinical Oral Investigations* 2010;14:375-381.
- › Quigley GA, Hein JW. Comparative cleansing efficiency of manual and power brushing. *JADA* 1962;65:26-29.
- › Robinson PG, Deacon SA, Deery C, Heanue M, Walmsley AD, Worthington HV et al. Manual versus powered tooth-brushing for oral health. *The Cochrane database of systematic reviews* 2005:CD002281.
- › Saxer UP, Yankell SL. Impact of improved toothbrushes on dental diseases. I. *Quintessence International* 1997;28:513-525.
- › Sharma NC, Lyle DM, Qaqish JG, Galustians J. Evaluation of the plaque removal efficacy of three power toothbrushes. *J International Academy Periodontology* 2006;8:83-88.
- › Silvestrini Biavati A, Gastaldo L, Dessi M, Silvestrini Biavati F, Migliorati M. Manual orthodontic vs. oscillating-rotating electric toothbrush in orthodontic patients: a randomised clinical trial. *Eur J Paediatr Dent* 2010;11:200-202.
- › Stanford CM, Srikantha R, Wu CD. Efficacy of the Sonicare toothbrush fluid dynamic action on removal of human supragingival plaque. *J Clinical Dentistry* 1997;8:10-14.
- › Terezhalmay GT, Bartizek RD, Biesbrock AR. Relative plaque removal of three toothbrushes in a nine-period crossover study. *J Periodontology* 2005;76:2230-2235.
- › Theilade E, Wright WH, Jensen SB, Loe H. Experimental gingivitis in man. II. A longitudinal clinical and bacteriological investigation. *J Periodontal Research* 1966;1:1-13.
- › Turesky S, Gilmore ND, Glickman I. Reduced plaque formation by the chloromethyl analogue of vitamin C. *J Periodontology* 1970;41:41-43.
- › Warren PR, Landmann H, Chater BV. Electric toothbrush use. Attitudes and experience among dental practitioners in Germany. *American J Dentistry* 1998;11:S3-6.
- › Zimmer S, Fosca M, Roulet JF. Clinical study of the effectiveness of two sonic toothbrushes. *J Clinical Dentistry* 2000;11:24-27.