CLINICAL STUDY ON THE PLAQUE REMOVING ABILITY OF THREE NEW TOOTHBRUSHES

NAHID Y. M. ASHRI

ABSTRACT

The aim of the study was to compare the plaque removal efficacy of three relatively recent designs of manual toothbrushes. Fifteen healthy dental students, aged 21-25 years, participated in this blind three-way crossover study. The students were randomly assigned to three groups (A, B, C) with 15 participants in each group. The Rustogi Modified Navy Plaque Index was used to assess the presence of plaque. The participants were asked to refrain from oral hygiene measures for 48 hours (two days). On day three, the participants returned to clinic and the plaque was measured. After instructions on how to use the toothbrushes, each group started the experiment with a different type of toothbrush. After one week of application, the plaque index was used again to assess the oral hygiene status of each participant. This was followed by one week of recess before each group switched to the next type of toothbrush. The duration of the study was five weeks. All examinations were performed by one examiner who was blind to the identity of the test products. A mixed model analysis of covariance (ANCOVA) for a crossover design, with baseline plaque score as the covariate, was applied to the baseline minus one-minute post-brushing differences in average whole mouth plaque scores. Supplemental analysis were also performed using ANCOVA model separately for average gingival margin scores and for average interproximal scores, using the appropriate baseline score as the covariate. All comparisons were two sided at the 0.05 level of significance. The Dentoclinic toothbrush delivered an adjusted (via ANCOVA) mean difference between baseline and post brushing scores of 0.245, while Aquafresh delivered an adjusted mean difference of 0.207 versus 0.196 for the Sensodyne tooth brush. The Dentoclinic demonstrated a statistically significantly greater reduction in plaque than the Aquafresh ($p<0.001$), which in turn had a statistically significantly greater reduction in plaque than the Sensodyne toothbrush ($p<0.001$). The Dentoclinic toothbrush group had, on average, 25.2% and 18.3% greater plaque removal scores than the Sensodyne toothbrush group and the Aquafresh toothbrush group, respectively. Results for the interproximal and gingival margin regions also demonstrated statistically significantly ($p<0.001$) greater plaque removal for the Dentoclinic group relative to the other groups. It can be concluded that the Dentoclinic toothbrush delivers greater plaque removal as compared to the Sensodyne toothbrush and the Aquafresh toothbrush.

Key words: *Dentoclinic toothbrush, Aquafresh toothbrush, Sensodyne toothbrush, plaque removal, Rustogi Modified Navy Plaque Index.*

INTRODUCTION

It is well established that dental plaque is an essential etiological factor of caries and gingivitis[1,2] and the strong association of plaque with chronic gingivitis has been revealed in epidemiological surveys.[3] These findings resulted in the supposition that the mechanical control of plaque could prevent gingivitis and thereby periodontal disease.

The prevalence of gingival inflammation, particularly in young adults[4], suggests that most of the population practices inadequate oral hygiene particularly in certain areas of the dentition.[5,6] Indeed, toothbrush studies established that only modest (40-60%) quantities of plaque are removed even after 2 minutes' brushing[7] and, that most people allocate a maximum of 10% of their total brushing time to lingual surfaces.[5,6]

Correspondence: Dr. N. Y. Ashri, Associate Professor, Department of Preventive Dental Sciences, Division of Periodontics, College of Dentistry, King Saud University, P.O. Box 60169, Riyadh 11545, Saudi Arabia. Telephone numbers: Home: 966-1-233-2720, Mobile: 966-5058-008-80, Fax: 966-1-476-5357, E-mail: nashri00@yahoo.com

Of the many factors, notably compliance and manual dexterity that influence oral hygiene[8], the design of toothbrush has to-date been one of the least influential. This, however, has not reduced the commercial drive to improve brush design to produce a toothbrush that optimizes often poor, individual performance. Unfortunately, to-date, there has been insufficient evidence to conclude that any one design of manual toothbrushes is superior to others; the conclusion of reviews being that the user is the major variable.[8, 9, 10, 11]

Recently, there has been an array of new manual toothbrushes released into market. For some products, comparative plaque removal properties have been published [12, 13, 14, 15, 16, 17, 18]. Methods to study plaque removal efficacy have commonly employed single brushing crossover designs using the subject or a professional to perform the brushing. Such crossover designs have the theoretical advantage of standardizing the brushing, to leave the toothbrush as the only variable. The studies have also; by large allowed a 2 minute brushing time as this has evolved as the professionally recommended period, though why a two minute period is considered optimum remains unclear. Pervious studies suggest that many individuals use brushing times of less than 1 minute[7]. The primary aim of the present single-use study was to compare three manual toothbrushes for plaque removal using a typical brushing period.

MATERIALS AND METHODS

This was a three treatments, randomized, examiner-blind, five period cross-over study conducted at the University of King Saud, Riyadh, Saudi Arabia. Both the research protocol and written informed consent were reviewed and approved by an institutional review board prior to study initiation. The three treatment groups were Dentoclinic (Schiffer), Aquafresh Flex Compact (GlaxoSmithKline), and Sensodyne Softex (GlaxoSmithKline) toothbrushes. Randomization and treatment assignment were performed by a trained demonstrator.

The plaque index used was the Rustogi Modified Navy Plaque Index (RMNPI) which permits improved assessment of gingival margin and proximal plaque compared to the original Modified Navy Plaque Index[19]. The RMNPI divides each of the buccal and lingual surfaces into nine areas which are scored for the presence or absence of plaque. When all 18 areas are included in the calculation for each tooth, a whole mouth plaque score can be determined (Fig I). A gingival margin plaque score can also be calculated by using only the areas along the gingival margin, and an interproximal plaque scores can be calculated using only the areas incorporating the proximal surfaces from line angles to contact area.

Rustogi Modified Plaque Index (Figure I): Plaque was assessed for each tooth area (A to I) using the scale 1=Present and 0=Absent. Facial and lingual surfaces of all gradable teeth were scored and a mean plaque index (MPI) was calculated for each subject by dividing Total number of tooth areas with plaque present with total number of tooth areas scored. Subjects MPI scores were calculated for the whole mouth (areas A-I), for interproximal areas (areas D and F), Mesial (area F), Distal (D), and along the gingival margin (areas A, B, C).

Subjects included in the study had no physical limitations that would preclude normal brushing. A total of 15 dental students with a minimum of 20 gradable teeth, between the ages 21-25 years enrolled in the study based on study criteria. Prospective subjects were excluded from the study for the following reasons: obvious periodontal disease, orthodontic appliances or removable prosthesis, carious lesions requiring treatment, pregnancy, or inability to comply with the study protocol.

All subjects were randomly assigned to one of three sequence groups according to a computer-generated, randomization plan prepared in advance of study execution. Subjects received either one of the study brushes Dentoclinic, Aquafresh and Sensodyne at visit one. A minimum of 1-week washout period have been taken between the different visits. Subjects were provided with a commercially available fluoride dentifrice (Colgate Fresh Confidence) for use.

All subjects were appointed between 8 am and 1 pm to facilitate compliance with the study requirements. As subjects reported to clinic facility, they received a professional prophylaxis and were asked to refrain from brushing, flossing and gum chewing for 48 hrs prior to visit 1.

At visit 1 subject received a complete oral hard and soft tissue examination, and had plaque disclosed and assessed using RMNPI for their baseline plaque index. Subjects were then assigned their test brush and were asked not to use mouthwashes, gels or interdental cleaning aids during the study period and should do 1 min of brushing with their assigned toothbrush in their usual manner for 1 week. After 1 week subjects came for visit 2 and after disclosing, the RMNPI was scored again. A wash out period of one week was given for each

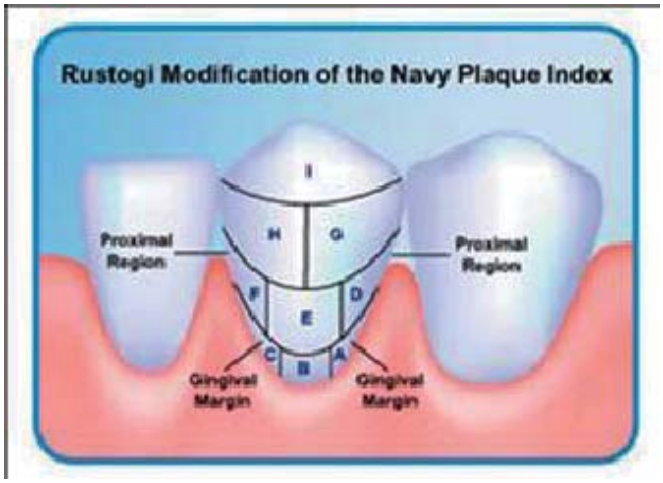

Fig. 1: Rustogi Modification of the Navy Plaque Index

Fig. 2: Left to right: Sensodyne, Aquafresh Flex and Dentoclinic

group. Subjects then returned after again refraining from oral hygiene for 48 hrs prior to the visit, and repeated the test procedures using the alternately assigned toothbrush. A 1-min brushing time was selected as being broadly representative of average oral hygiene care. It has been reported that average person brushes slightly less than 1 min [20, 21].

A trained examiner (NYA), who remained blind to the identity of all study products and treatment sequence assignments, performed the evaluations for all groups. Toothbrushes were provided in plain white packaging, and distributed by trained demonstrator immediately prior to subject departure. The toothbrushes were collected immediately when subjects arrives to clinic in order to maintain blinding of the examiner. All comparison toothbrushes are presented in Fig 2. All toothbrushes were similar in head size and bristle texture.

For statistical comparison, individual plaque score for each tooth at each examination were averaged on a per-subject basis. Each subjects had a single whole mouth average score for pre-baseline, baseline and for the exam following their assigned toothbrush for the study visit. The difference (Baseline minus post-brushing) in average scores was calculated and analyzed using a mixed model analysis of covariance (ANCOVA) for crossover design[21], with baseline whole-mouth average score as the covariate and terms in the model for subjects and treatment groups. Subjects were considered a random effect in the model. In addition to the analysis of whole mouth scores, supplemental analysis were performed using ANCOVA model separately for average gingival margin scores and for average interproximal scores, using the appropriate baseline scores as the covariate. All statistical tests of hypotheses were two sided and employed a level of significance of a= 0.05.

RESULTS

A total of 15 subjects were randomized and enrolled into 5-period crossover study. All subjects provided complete data for the three study periods. The age range of the study population was from 21-25 years. Baseline whole-mouth plaque index scores averaged between 0.357 and 0.364 prior to using the three toothbrushes. Adjusted mean whole mouth plaque removal (baseline minus post-brushing) scores were 0.245 for Sensodyne toothbrush, 0.207 for the Aquafresh toothbrush, and 0.196 for the Dentoclinic toothbrush.

Each of the pair wise differences among the three treatment groups were statistically significant ($p \leq 0.001$). For the whole mouth scores, the Dentoclinic toothbrush had an adjusted mean reduction in plaque score that was 18.3% higher than Aquafresh and 25.2% higher than the Sensodyne toothbrush. The adjusted mean for the Aquafresh toothbrush was 5.8% higher than that for the Sensodyne toothbrush (Table 1).

Similar results were found for the analysis of plaque in specific anatomic areas. Adjusted mean gingival margin plaque removal scores were 0.660 for Dentoclinic toothbrush, 0.555 for Aquafresh tooth-

brush, and 0.528 for Sensodyne toothbrush. Each of the pair wise differences among the three treatment groups was statistically significant (pd"0.001). For the gingival margin scores, the Dentoclinic had an adjusted mean reduction in plaque scores that was 18.9% higher than the Aquafresh toothbrush and 25.0% higher than the Sensodyne toothbrush. The adjusted mean for the Aquafresh was 5.2% higher than that for the Sensodyne toothbrush (Table 2).

Adjusted mean interproximal plaque removal scores were 0.065 for the Dentoclinic toothbrush, 0.056 for the Aquafresh toothbrush, and 0.052 for the Sensodyne toothbrush. The differences between the Dentoclinic toothbrush and the other two brushes were statistically significant (pd"0.002). There was no statistically significant difference (p=0.146) between the Aquafresh and the Sensodyne toothbrushes. For interproximal scores, the Dentoclinic toothbrush had an adjusted mean reduction in plaque scores that was 16.0% higher than the Aquafresh toothbrush and 25.5% higher than the Sensodyne toothbrush. The adjusted mean for the Aquafresh toothbrush was 8.2% higher than that for the Sensodyne toothbrush (Table 3).

Versus baseline, the Dentoclinic toothbrush reduced whole-mouth plaque scores by 68%, gingival margin plaque scores by 66%, and interproximal plaque scores by 86.1% following a single one-minute brushing. On the other hand, the Aquafresh toothbrush reduced the whole-mouth plaque scores by 57.5%, gingival margin plaque scores by 55.6%, and interproximal plaque scores by 75.2% following a single one-minute brushing. These results and those for the Sensodyne toothbrush are summarized in Table 4. There were no adverse events reported during the study. All three treatment regimens were well tolerated.

TABLE 1: RESULTS OF PLAQUE ON ALL REGIONS OF MOUTH

Treatment group	N	Baseline score (Mean±S.D)	Baseline minus post-brushing (adjusted Mean±S.D)	%Greater plaque Removal Score
Dentoclinic Toothbrush	30	0.364±0.038	0.245±0.004	25.2%
Aquafresh Toothbrush	30	0.360±0.032	0.207±0.004	5.8%
Sensodyne Toothbrush	30	0.357±0.025	0.196±0.004	——

The between group difference in adjusted means are statistically significant ($p\geq$0.001)

TABLE 2: RESULTS OF PLAQUE ON GINGIVAL MARGIN

Treatment group	N	Baseline score (Mean±S.D)	Baseline minus post-brushing (adjusted Mean±S.D)	%Greater plaque Removal Score
Dentoclinic Toothbrush	30	1.000±0.000	0.660±0.013	25.0%
Aquafresh Toothbrush	30	1.000±0.001	0.660±0.013	5.2%
Sensodyne Toothbrush	30	1.000±0.000	0.528±0.013	——

The between group difference in adjusted means are statistically significant ($p\geq$0.001)

TABLE 3: RESULTS OF PLAQUE ON INTERPROXIMAL REGIONS

Treatment group	N	Baseline score (Mean±S.D)	Baseline minus post-brushing (adjusted Mean±S.D)	%Greater plaque Removal Score
Dentoclinic Toothbrush	30	0.083±0.099	0.065±0.002	25.5%
Aquafresh Toothbrush	30	0.075±0.080	0.056±0.002	5.8%
Sensodyne Toothbrush	30	0.064±0.059	0.052±0.002	——

The p-values were calculated for differences between adjusted means; (p=0.002) for Dentoclinic toothbrush vs. Aquafresh toothbrush. (p<0.001) for Dentoclinic toothbrush vs. Sensodyne Toothbrush. (p=0.146) for Aquafresh Toothbrush vs. Sensodyne toothbrush.

TABLE 4: RESULTS OF PLAQUE ON INTERPROXIMAL REGIONS

Treatment group	N	Tooth area	Baseline score (Mean±S.D)	Baseline minus post-brushing differences (Mean±S.D)	% Plaque removal vs. Baseline
Dentoclinic Toothbrush	30	Whole mouth	0.364±0.038	0.247±0.034	68.0%
		Gingival margin	1.000±0.000	0.660±0.113	66.0%
		Interproximal	0.083±0.099	0.072±0.079	86.1%
Aquafresh Toothbrush	30	Whole mouth	0.360±0.032	0.207±0.040	57.5%
		Gingival margin	1.000±0.001	0.556±0.108	55.6%
		Interproximal	0.075±0.080	0.057±0.069	76.2%
Sensodyne Toothbrush	3	Whole mouth	0.357±0.025	0.194±0.036	54.4%
		Gingival margin	1.000±0.000	0.527±0.107	52.7%
		Interproximal	0.064±0.059	0.044±0.049	68.3%

The differences from baseline are all statistically significant ($p<0.001$)

DISCUSSION

In this randomized, examiner blind, cross-over, single-center study, a Dentoclinic toothbrush was found to deliver significant plaque removal with 25.2% and 18.3% greater plaque removal scores compared to the Sensodyne toothbrush and Aquafresh Toothbrush, respectively. Similar results were also found for the analysis of plaque in specific anatomical areas including gingival margin and interproximal sites.

Although there is general agreement among dental professionals that efficient plaque removal is the key for preventing and controlling periodontal diseases[8, 9, 10, 11], many people still have difficulty in maintaining this task with conventional oral hygiene aids [5, 6]. Controlled clinical research, such as the trial reported here, provides the dental professional with data to understand the potential plaque removal benefits of a toothbrush when used in a controlled environment.

When making recommendations to patients, the dental professional must also consider factors related to patient compliance and hygiene efficiency, as they also play an important role in treatment outcomes. For example, tooth brushing duration has been found to play an important role in plaque removal efficacy. Clinical research has shown individuals typically brush for only one minute or less.[20, 21] Further, toothbrush design also plays an important role in plaque removal efficacy as does tooth brushing duration.[12, 22, 23, 24] Under these circumstances, effective plaque removal does not seem to be realistic for most people who overestimate tooth brushing duration. Studies have shown that it is very difficult to change individual's habits.[25] Given the fact most people brush for only one minute or less and the difficult task of changing individual's habits, manufacturers should adapt advanced toothbrush designs to the most common tooth brushing habits of the general public.[26,27] These advanced design toothbrushes including improvements in handles, bristle trim arrangement, and brush head design allow penetration into dental embrasures and gingival margins that result in more effective plaque removal. These new designs have been shown to remove plaque at the lingual, interproximal, and posterior areas. These new features have been demonstrated in the new Dentoclinic toothbrush.

Reports in the literature have consistently demonstrated that the use of floss is just as important and necessary as the toothbrush.[28, 29, 30, 31] However, inadequate flossing by most people or inexperienced individuals with the use of dental floss [32] can lead to an accumulation of plaque, and ultimately gingivitis, particularly in areas that are inaccessible to a regular toothbrush. [24] For that reason, an individual may be wise to choose a toothbrush that would help in removing plaque in areas from between the teeth and along the gum line-areas a regular toothbrush does not reach well. The results of this study demonstrated the new Dentoclinic toothbrush was found to deliver significant plaque removal when compared to either the Sensodyne toothbrush or the Aquafresh toothbrush. This benefit was manifested on both whole-mouth, interproximal, and gingival regions with statistically significant plaque reductions favoring the Dentoclinic toothbrush observed for all regions.This result should not be over-interpreted relative to the effectiveness of floss between teeth at removing plaque or reducing gingivitis. Dental floss has the unique ability to remove plaque under the interproximal contacts where a toothbrush

cannot reach. [33] The Navy Plaque Index used in this study reflects the plaque control status of the patient and emphasizes plaque in the cervical portion of the tooth, which is in contact with the gingiva and at the line angles (1 to 2 mm interproximal). The relationship of the observed results to gingival and periodontal health is unknown, but it does not reflect plaque under interproximal contact or subgingival. It is also important to note these results are from a controlled clinical trial evaluating plaque levels following single brushings. As with any controlled research, results cannot automatically be extrapolated to non-clinical settings.

CONCLUSION

The Dentoclinic toothbrush group had significant mean plaque removal scores that were 25.2% and 18.3% greater than those observed in the Sensodyne toothbrush group and Aquafresh group.

DISCLAIMER: The author has no commercial interest in any of the products used in this research

REFERENCES

1 Fehr, Von der, F.R., Löe, H. & Theilade, E. Experimental caries in man. Caries Research 1970;4:131-148

2 Löe, H. Theilade, E. & Jensen, S. B. experimental gingivitis in man. Journal of Periodontology 1965; 36: 177-187

3. Ash, M. M. A review of the problems and results of studies on manual and power toothbrushes Journal of Periodontology 1964; 35: 202-213

4 Addy, M. Dummer PM., Griffiths G., Hicks R., Kingdon A., Shaw WC. Prevalence of plaque, gingivitis and caries in 11-12 years old school children. Journal of clinical Periodontology 1986; 14:115-118

5 Rugg-Gunn, A. J.,& Macgregor, I. D., M. A survey of tooth brushing behavior in children and young adults. Journal of Periodontal Research 1978; 13: 382-388

6 Macgregor, I. D., M., & Rugg-Gunn, A. J. A survey of tooth brushing sequence in children and young adults. Journal of Periodontal Research 1979; 14: 225-230

7 De La Rosa, M. R., Guerra J. Z., Johnson, D., A. & Radik A. W. Plaque growth and removal with daily tooth brushing Journal of Periodontology 1979; 50: 661-664

8 Frandsen, A. Mechanical oral hygiene practice. In: Dental plaque control measures and oral hygiene practices, ed. Löe H. & Kleinman, D. V. IRL Press, Oxford 1986; 93-116

9 Hancock, E., Prevention World Work Shop in Periodontics. Annals of Periodontology 1996; 1: 223-249

10 Claydon, N. & Addy, M. The use of planimetry to record and score the modified navy index and other area based indices. A comparative toothbrush study. Journal of clinical Periodontology 1995; 22:670-673

11 Ashri, N., Al-Kattan, R., Waffa, SH. The effect of toothbrush design and brushing proficiency on plaque removal , a clinical and scanning electron microscope study. J Pak Dent Assoc Jun 2003; 12(2):83-9.

12 Sharma, N. Galustians, J. Rustogi, K. McCool, J. Petrone, M. Volpe, A. Korn, L. Petrone, D. Comparative plaque removal efficacy of three tooth brushes in two independent clinical studies 1992; 3: C13-C20

13 Singh, S., Rustogi, K., McCool, J., Petrone, M. Volpe, A. Korn, L. Petrone, D. Clinical studies regarding the plaque removal efficacy of manual toothbrushes. Journal of Clinical Dentistry 1992; 3: C21-C29

14 Singh, S., & Deasy M., Clinical plaque removal performance of two manual toothbrushes. Journal of Clinical Dentistry 1993; 4: D13-Q16

15 Deasy M., Singh, S., Kemp, J., Curtis, J., Rustogi, K., Fung, K. A clinical comparison of plaque removal performance of three manual toothbrushes. Journal ofClinical Dentistry 1993; 4: D17-D21

16 Claydon, N., Leach, K., Newcombe, R., Ley, F., Scratcher, C., Addy, M. The use of professional brushing to compare 3 toothbrushes for plaque removal from individuals with gingival recession. 2000b; 27: 749-752

17 Sharma, N. Galustians, J. Qaqish, J. King, D. Low, M. Jacobs, D. Weber, D. An advanced toothbrush with improved plaque removal efficacy. American Journal of Dentistry 2000; 13; 15A-20A.

18 Wolff, D., Joerss, D. Dorfer CE. In vitro cleaning efficacy of interdental brushes with different stiffness and different diameter Oral Health Prev Dent 2006; 4 (4):279-85

19 Elliott, J., Bowers, G., Clemmer, B., Rovelstad, G. II. A comparison of selected oral hygiene devices in dental plaque removal. Journal Periodontology 1972;43:217

20 Emling RC, Flickinger KC, Cohen DW, et al. A comparison of estimated versus actual brushing time. Pharmacol Ther Dent. 1981;6(3-4):93-8.

21 Saxer UP, Barbakow J, Yankell SL. New studies on estimated and actual toothbrushing times and dentifrice use. J Clin Dent. 1998;9(2):49-51.

22 Sharma NC, Qaqish JG, Galustians HJ, et al. Plaque removal efficacy and safety of the next generation of manual toothbrush with angled bristle technology: results from three comparative clinical studies. Am J Dent. 2005 Feb;18(1):3-7.

23 Dorfer CE, von Bethlenfalvy ER, Kugel B, et al. Cleaning efficacy of a manual toothbrush with tapered filaments. Oral Health Prev Dent. 2003;1(2):111-8.

24 Claydon N., Addy, M., Scratcher C., Ley, F., Newcombe R. Comparative professional plaque removal study using 8 branded toothbrushes. Journal of clinical Periodontology 2002;29:310-316

25 Brown H, Prescott R. Applied Mixed Models in Medicine. John Wiley & Sons, Ltd., New York, 1999; 261-294

26 Weinstein P, Getz T, Milgrom P. Oral Self Care: Strategies for Preventive Dentistry. Virginia, Reston Press, pp. 1-3. 1985.

27 Saxer UP, Yankell SL. Impact of improved toothbrushes on dental diseases. I. Quintessence Int.1997 Aug;28(8):513-25.

28 Saxer UP, Yankell SL. Impact of improved toothbrushes on dental diseases. II. Quintessence Int.1997 Sep;28(9):573-93.

29 Bellamy P, Barlow A, Puri G, et al. A new in vivo interdental sampling method comparing a daily flossing regime versus a manual brush control. J Clin Dent. 2004;15(3):59-65.

30 Lang WP, Ronis DL, Farghaly MM. Preventive behaviors as correlates of periodontal health status. J Public Health Dent. 1995 Winter;55(1):10-7.

31 Spolsky VW, Perry DA, Meng Z, et al. Evaluating the efficacy of a new flossing aid. J Clin Periodontol. 1993 Aug;20(7):490-7.

32 Sjogren K, Lundberg AB, Birkhed D, et al. Interproximal plaque mass and fluoride retention after brushing and flossing—a comparative study of powered toothbrushing, manual toothbrushing and flossing. Oral Health Prev Dent. 2004;2(2):119-24.

33 Segelnick SL. A survey of floss frequency, habit and technique in a hospital dental clinic & private periodontal practice. N Y State Dent J. 2004 May-Jun;70(5):28-33.