ORIGINAL ARTICLE

Effect of a dental water jet with orthodontic tip on plaque and bleeding in adolescent patients with fixed orthodontic appliances

Naresh C. Sharma,[a] Deborah M. Lyle,[b] Jimmy G. Qaqish,[c] Jack Galustians,[d] and Reinhard Schuller[e]
Mississauga, Ontario, Canada, and Fort Collins, Colo

Introduction: Effective self-care is difficult for people with orthodontic appliances because of the inherent design of brackets and archwires. It is not uncommon to have increases in plaque and gingivitis after placement of fixed appliances. The purpose of this study was to evaluate the effect of using a dental water jet (DWJ) with a specialized tip (orthodontic) on plaque and bleeding in adolescent orthodontic patients with fixed appliances. **Methods:** One hundred six subjects were enrolled in this single blind, parallel clinical study. They were randomly assigned to 1 of 3 treatment groups: group 1, once daily irrigation with a DWJ and orthodontic jet tip plus a manual toothbrush; group 2, once daily flossing (FL) plus a manual toothbrush; group 3, manual toothbrush (MT) only. Plaque index (PI) and bleeding index (BI) scores were recorded at baseline, and at 2 and 4 weeks. **Results:** All groups showed statistically significant reductions in PI (whole mouth and interproximal) at 2 and 4 weeks ($P < .001$). In group 1, the DWJ was statistically more effective at reducing whole-mouth and interproximal plaque than the methods in the other groups ($P > .001$) at both 2 and 4 weeks, whereas the FL protocol in group 2 was significantly more effective than the MT protocol in group 3 at 4 weeks ($P = .025$) for whole-mouth plaque and at 2 and 4 weeks ($P = .011$ and $P = .028$, respectively) for interproximal plaque. All groups showed statistically significant reductions in BI (whole mouth and interproximal) at 2 and 4 weeks ($P < .001$). The DWJ in group 1 was statistically more effective at reducing whole-mouth bleeding than the protocols of the other groups at 2 and 4 weeks ($P < .001$), and the FL was statistically more effective than the MT at both times ($P < .001$). Both the DWJ and the FL were significantly more effective than the MT at 2 weeks ($P < .001$ and $P < .016$, respectively) for interproximal bleeding, but there were no differences between the groups at 4 weeks. **Conclusions:** A DWJ with a specialized orthodontic jet tip is effective for adolescents in fixed orthodontic appliances; it demonstrated beneficial results for the reduction of plaque and bleeding. (Am J Orthod Dentofacial Orthop 2008;133: 565-71)

In patients with fixed orthodontic appliances, effective daily plaque removal is a key component in preventing dental caries and periodontal infections. Studies have shown increases in plaque accumulation around bands and brackets and changes in bacterial composition.[1-3] Oral hygiene is difficult, and, if not performed effectively, gingival inflammation or enamel decalcification can result. Based on an average length of 2 years for orthodontic treatment, a simple, easy, and effective self-care routine is important. Limited short-term studies evaluating the efficacy of power toothbrushes compared with manual toothbrushes used by orthodontic patients show largely equivocal outcomes.[4-8] The literature is also limited on the efficacy of a dental water jet (DWJ) or dental floss with these patients. It is widely accepted that floss is effective at reducing interproximal bleeding, gingivitis, and plaque. The compliance rate of daily flossing is low among people without orthodontic appliances.[9,10] Although there is no evidence, it is easy to assume that this would be similar in orthodontic patients because flossing becomes more difficult. The DWJ has been extensively studied, and research has demonstrated significant reductions in gingivitis,[11-15] bleeding,[16-19] and pathogenic bacteria[16,20,21] in various patients including those at higher risk for gingival infection such as patients

[a]President and dental director, BioSci Research Canada Ltd., Mississauga, Ontario, Canada.
[b]Director, Professional and Clinical Affairs, Water Pik, Inc., Fort Collins, Colo.
[c]Manager, Clinical Trials, BioSci Research Canada Ltd., Mississauga, Ontario, Canada.
[d]Vice president, Operations, BioSci Research Canada Ltd., Mississauga, Ontario, Canada.
[e]Statistical consultant, BioSci Research Canada Ltd., Mississauga, Ontario, Canada.
Supported by a research grant from Water Pik, Inc. Employees or consultants of BioSci Research Canada collected the data and analyzed the statistics; an employee of Water Pik helped write the report.
Reprint requests to: Deborah M. Lyle, 1730 E Prospect Rd, Fort Collins, CO 80553; e-mail, dlyle@waterpik.com.
Submitted, August 2007; revised and accepted, December 2007.
0889-5406/$34.00

doi:10.1016/j.ajodo.2007.12.008

with diabetes[19] or patients in a supportive periodontal maintenance program.[17,22] The reduction of inflammation has also been seen in those with implants,[23] crowns and bridges,[24] and intermaxillary fixation.[25] Some studies used an antimicrobial as the irrigant in a DWJ and showed enhanced reductions in supragingival plaque, bleeding, and gingivitis compared with water.[13,14,16] Conversely, in some studies, there was no difference between the antimicrobial and water.[17,18]

This study was designed to evaluate the effect of a DWJ with an orthodontic jet tip on plaque and bleeding scores in adolescent orthodontic patients with fixed appliances.

MATERIAL AND METHODS

This randomized, single-center, single-blind, parallel clinical study included 106 adolescents, ages 11 through 17, currently in orthodontic treatment with full-mouth brackets (bands or bonds) and archwires. The subjects, recruited from Mississauga, Ontario, Canada, and the surrounding area, included 59 boys (55.7%) and 47 girls (44.3%) with a mean age of 13.6 years (SD $\pm$ 1.16). Only 1 subject stated that he or she smoked on the medial history. Data were not collected regarding treating orthodontist or length of treatment. No restrictions were based on race or ethnic origin.

Subjects were enrolled if they had a medical history showing good general health, at least 24 natural teeth in the mouth excluding the third molars, and full-mouth fixed orthodontic appliances. At the screening examination, each subject needed to have at least 50% bleeding sites and a plaque index (PI) score of 3.0. Oral and written information was given to each subject. Both parent and subject signed the consent form. Study protocol, consent form, and instructions were approved by the BioSci Research Canada, Ltd., Institutional Review Board.

Subjects were excluded from the study if they had any of the following: (1) medical history of rheumatic fever, AIDS, leukemia, cirrhosis, sarcoidosis, diabetes mellitus, hepatitis, current pregnancy, or any physical condition that limited manual dexterity; (2) current history of medications likely to affect gingival health (eg, acute hormonal therapy for such conditions as breast or prostate cancer), antisialagogues, and steroids; (3) use of prophylactic antibiotics or antibiotic usage 2 months before the start of the study; (4) advanced periodontitis or rampant dental caries based on a noninvasive examination; (5) removable oral prostheses or removable orthodontic appliances; and (6) requirement of premedication with antibiotics for dental appointments.

The subjects were randomly assigned to 1 of 3 groups: group 1, DWJ with orthodontic jet tip (model WP-100W; Water Pik, Fort Collins, Colo) and a manual toothbrush (MT) (Oral-B Soft Compact 35; Proctor & Gamble, Cincinnati, Ohio); group 2, unflavored waxed dental floss (FL) (Johnson & Johnson, Skillman, NJ) used with a floss threader (GUM Eez-Thru; Sunstar Americas, Chicago, Ill) plus a MT (Oral-B Compact 35); and group 3, MT (Oral-B Compact 35) only. All subjects received fluoridated toothpaste (Crest, Proctor & Gamble) and were instructed to use only the assigned products and not to use any other devices or aids such as mouthrinses, toothpicks, or interdental brushes. Written and verbal instructions were provided for the DWJ and the FL with the floss threader at the baseline visit and again on day 14. Subjects had to demonstrate proficiency with the products at each visit. All subjects were instructed to brush with the assigned MT for 2 minutes (timed) in the morning and the evening as they normally did. Subjects in the FL and DWJ groups used their assigned products once daily in the evening.

All subjects were examined by 1 clinician (N.C.S.) at baseline, and on days 14 and 28, and were instructed to refrain from any oral hygiene for 12 to 14 hours before each visit. Bleeding was evaluated by using the gingival bleeding index (BI).[26] A periodontal probe was inserted into the gingival crevice and swept from the distal to the mesial areas around each tooth. Four gingival areas (distobuccal, midbuccal, midlingual, and mesiolingual) around each tooth were assessed for bleeding and assigned a number from 0 to 2. Plaque was evaluated by using the Turesky modification of the Quigley and Hein plaque index (PI).[27] Before scoring, the subjects rinsed with a disclosing solution (Erythrosin FS & C Red #3 [Chromo-O-Red]; Germiphene, Brantford, Ontario, Canada).

Statistical analysis

Baseline scores were assessed by using a 1-way analysis of variance (ANOVA) and the *t* test along with the *P* value. This was done for the whole mouth and the interproximal area for the PI and BI. Each index was measured at specific sites and reported within and between groups. Differences within groups were measured by using a paired *t* test, separately for the data at 2 and 4 weeks. Between-treatment comparisons were measured by using 1-way ANOVA. This was used separately for the whole mouth and the interproximal area for plaque and bleeding. The ANOVA F score and the *P* value were reported. For within or between group comparisons, data transformation was applied to normalize the data, or analysis of covariance (ANCOVA) was used with baseline data as the covariate along with the change score if needed.

Table I. Whole mouth: 2-week PI results

Full mouth (n = 105)	*Baseline mean (SD)*	*2-weeks mean (SD)*	*Change score mean (SD) (t test*)*	*Change (%)*
DWJ (n = 36)	3.72 (0.181)	2.65 (0.213)	1.07 (0.262)	28.8
FL (n = 34)	3.75 (0.185)	3.29 (0.305)	0.46 (0.256)	12.2
MT (n = 35)	3.73 (0.170)	3.37 (0.310)	0.36 (0.276)	9.6
ANOVA (baseline score)		F (2, 102) = 0.21; P = .813		
ANOVA (2-week change score)		F (2, 102) = 76.1; P <.001		
		Pair-wise comparisons†		
		t test (*P* value)		
	FL		MT	
DWJ	9.7 (<.001)		11.4 (<.001)	
FL			1.6 (.119)	

*P values for paired t test for within-group plaque change score from baseline; P <.001.
†P <.05 indicates significant differences between the 2 treatments compared.

Table II. Whole mouth: 4-week PI results

Full mouth (n = 105)	*Baseline mean (SD)*	*4-weeks mean (SD)*	*Change score mean (SD) (t test*)*	*Change (%)*
DWJ (n = 36)	3.72 (0.181)	2.28 (0.265)	1.45 (0.298)	38.9
FL (n = 34)	3.75 (0.185)	3.37 (0.322)	0.38 (0.255)	10.3
MT (n = 35)	3.73 (0.170)	3.48 (0.219)	0.25 (0.179)	6.7
ANOVA (4-week change score)		F (2, 102) = 247.1; P <.001		
		Pair-wise comparisons†		
		t test (*P* value)		
	FL		MT	
DWJ	17.8 (<.001)		20.3 (<.001)	
FL			2.3 (.025)	

*P values for paired t test for within-group plaque change score from baseline; P <.001.
†P <.05 indicates significant differences between the 2 treatments compared.

RESULTS

The 3 groups did not differ at baseline in either the PI or the BI. One hundred five subjects finished the study. One subject withdrew from the FL group because he or she did not want to comply with daily flossing. No adverse events were experienced by any subjects during the study.

All 3 treatment groups showed statistically significant whole-mouth plaque reduction from baseline at the 2- and 4-week visits (P <.001). Pairwise comparisons between the DWJ group and the other 2 groups indicated that the DWJ group was statistically significantly better than the other groups (P <.001) at 2 and 4 weeks. There was no difference between the FL and the MT groups in whole-mouth plaque reduction at the 2-week visit (P = .119). At 4 weeks, the FL group was significantly better than the MT group (P = .25). The reductions at the 4-week visit were slightly lower than at the 2-week visit for both the FL and the MT groups. The improvement in whole-mouth plaque reduction at 2 weeks for the DWJ group was 2.34 times the reduction achieved by the FL group and 3.0 times the reduction observed in the MT group. These reductions were greater at the 4-week visit, with the DWJ group exhibiting 3.76 times the reduction of the FL group and 5.83 times the reduction of the MT group (Tables I and II).

All 3 treatment groups showed statistically significant interproximal area reduction from baseline at the 2- and 4-week visits (P <.001). Pairwise comparisons between the DWJ group and the other 2 groups indicated that the DWJ group was statistically significantly better at 2 and 4 weeks (P <.001). The FL group was significantly better than the MT group in interproximal area plaque reduction at the 2-week visit (P = .011) and the 4-week visit (P = .028). The reductions at the 4-week visit were slightly lower than at the 2-week visit for both the FL and the MT groups (Tables III and IV).

All 3 treatment groups showed statistically significant BI reduction from baseline at the 2- and 4-week visits (P <.001). Pairwise comparisons between the DWJ group and the other 2 groups indicated that the DWJ group differed statistically from the others at the 2- and 4-week visits (P <.001). The FL group differed from the MT group at the 2- and 4-week visits (P <0.001) (Tables V and VI).

All 3 groups showed statistically significant BI reduction for interproximal area from baseline to the 2- and 4-week visits (P <.001) (Tables VII and VIII). The DWJ

Table III. Interproximal area: 2-week PI results

Interproximal area (n = 105)	*Baseline mean (SD)*	*2-weeks mean (SD)*	*Change score mean (SD) (t test*)*	*Change (%)*
DWJ (n = 36)	3.73 (0.178)	2.69 (0.201)	1.04 (0.258)	27.8
FL (n = 34)	3.76 (0.181)	3.31 (0.291)	0.45 (0.247)	11.9
MT (n = 35)	3.74 (0.162)	3.39 (0.304)	0.35 (0.274)	9.3
ANOVA (baseline score)		F (2, 102) = 0.26; P = .774		
ANOVA (4-week change score)		F (2, 102) = 72.9; P <.001		
		Pairwise comparisons†		
		t test (*P* value)		
	FL		MT	
DWJ	9.5 (<.001)		11.2 (<.001)	
FL			1.6 (<.011)	

**P* values for paired *t* test for within-group plaque change score from baseline; P <.001.
†P <.05 indicates significant differences between the 2 treatments compared.

Table IV. Interproximal area: 4-week PI results

Interproximal area (n = 105)	*Baseline mean (SD)*	*4-weeks mean (SD)*	*Change score mean (SD) (t test*)*	*Change (%)*
DWJ (n = 36)	3.73 (0.178)	2.38 (0.231)	1.35 (0.283)	36.2
FL (n = 34)	3.76 (0.181)	3.39 (0.313)	0.37 (0.250)	9.9
MT (n = 35)	3.74 (0.162)	3.50 (0.212)	0.24 (0.168)	6.5
ANOVA (4-week change score)		F (2, 102) = 227.7; P <.001		
		Pair-wise comparisons†		
		t test (*P* value)		
	FL		MT	
DWJ	17.1 (<.001)		19.5 (<.001)	
FL			2.2 (.028)	

**P* values for paired *t* test for within-group plaque change score from baseline; P <.001.
†P <.05 indicates significant differences between the 2 treatments compared.

Table V. Whole mouth: 2-week BI results

Full mouth (n = 105)	*Baseline mean (SD)*	*2-weeks mean (SD)*	*Change score mean (SD) (t test*)*	*Change (%)*
DWJ (n = 36)	0.69 (0.059)	0.22 (0.053)	0.48 (0.063)	69.0
FL (n = 34)	0.70 (0.058)	0.32 (0.057)	0.38 (0.059)	54.8
MT (n = 35)	0.68 (0.042)	0.40 (0.086)	0.28 (0.093)	41.3
ANOVA (baseline score)		F (2, 102) = 0.92; P = .400		
ANOVA (2-week change score)		F (2, 102) = 63.8; P <.001		
		Pair-wise comparisons†		
		t test (*P* value)		
	FL		MT	
DWJ	5.4 (<.001)		11.3 (<.001)	
FL			5.7 (<.001)	

**P* values for paired *t* test for within-group plaque change score from baseline; P <.001.
†P <.05 indicates significant differences between the 2 treatments compared.

group and the FL group did not differ at the 2-week visit (P = .430). However, the DWJ group and the FL group were significantly better than the MT group (P <.001 and P <.016, respectively). The reductions for the DWJ group at the 2-week visit for whole-mouth BI was 1.07 times the reduction for the FL group and 1.39 times the reduction for the MT group. There were no differences between groups at the 4-week visit for interproximal area bleeding.

DISCUSSION

An effective home-care program geared to the unique challenges of those with fixed or other orthodontic appliances is an important consideration in orthodontic therapy. Traditional methods might not be appropriate or sufficient because of increased plaque retention and limitations in access. Some manual toothbrushes are designed to improve plaque removal around

Table VI. Whole mouth: 4-week BI results

Full mouth (n = 105)	*Baseline mean (SD)*	*4-weeks mean (SD)*	*Change score mean (SD) (t test*)*	*Change (%)*
DWJ (n = 36)	0.69 (0.059)	0.11 (0.044)	0.59 (0.069)	84.5
FL (n = 34)	0.70 (0.058)	0.24 (0.073)	0.46 (0.070)	66.4
MT (n = 35)	0.68 (0.042)	0.30 (0.058)	0.38 (0.068)	56.1
ANOVA (4-week change score)		F (2, 102) = 78.1; P <.001		
		Pair-wise comparisons†		
		t test (*P* value)		
		FL	MT	
DWJ		7.4 (<.001)	12.4 (<.001)	
FL			4.9 (<.001)	

**P* values for paired *t* test for within-group plaque change score from baseline; P <.001.
†P <.05 indicates significant differences between the 2 treatments compared.

Table VII. Interproximal area: 2-week BI results

Interproximal area (n =105)	*Baseline mean (SD)*	*2-weeks mean (SD)*	*Change score mean (SD) (t test*)*	*Change (%)*
DWJ (n = 36)	0.62 (0.174)	0.13 (0.064)	0.49 (0.169)	78.9
FL (n = 34)	0.61 (0.205)	0.16 (0.108)	0.46 (0.165)	74.7
MT (n = 35)	0.62 (0.182)	0.27 (0.127)	0.35 (0.193)	57.0
ANOVA (baseline score)		F (2, 102) = 0.03; P = .975		
ANOVA (2-week change score)		F (2, 102) = 5.87; P <.004		
		Pair-wise comparisons†		
		t test (*P* value)		
		FL	MT	
DWJ		0.8 (.430)	3.3 (.001)	
FL			2.5 (.016)	

**P* values for paired *t* test for within-group plaque change score from baseline; P <.001.
†P <.05 indicates significant differences between the 2 treatments compared.

Table VIII. Interproximal area: 4-week BI results

Interproximal area (n = 105)	*Baseline mean (SD)*	*4-weeks mean (SD)*	*Change score mean (SD) (t test*)*	*Change (%)*
DWJ (n = 36)	0.62 (0.174)	0.08 (0.045)	0.55 (0.161)	87.6
FL (n = 34)	0.61 (0.205)	0.09 (0.063)	0.53 (0.208)	85.9
MT (n = 35)	0.62 (0.182)	0.14 (0.071)	0.48 (0.174)	76.8
ANOVA (4-week change score)		F (2, 102) = 1.40; P = .252		
		Pair-wise comparisons†		
		t test (*P* value)		
		FL	MT	
DWJ		0.4 (0.662)	1.6 (0.108)	
FL			1.2 (0.248)	

**P* values for paired *t* test for within-group plaque change score from baseline; P <.001.
†P <.05 indicates significant differences between the 2 treatments compared.

brackets and archwires, but they still rely on the user to implement them effectively. Power toothbrushes have been studied extensively in nonorthodontic patients and have demonstrated beneficial outcomes in supragingival plaque removal and gingival health when compared with manual toothbrushes.[28-32] Some power toothbrushes have also been studied with orthodontic subjects but rarely were superior to manual brushes.[4-8] It is documented that flossing can reduce bleeding and inflammation when used daily.[33-35] The use of a DWJ has consistently shown significant improvements in bleeding and gingivitis in addition to proinflammatory mediators IL-1β and PGE_2.[11-19,22-25] Unlike brushing and flossing, a DWJ was shown to remove subgingival pathogenic bacteria.[20,21] We evaluated the addition of a DWJ to traditional brushing and compared the outcomes with the standard of care—brushing and flossing.

Table IX. Comparisons of reductions among treatments*

	PI, whole mouth		*PI, interproximal area*		*BI, whole mouth*		*BI, interproximal area*	
Change from baseline	*2 week*	*4 week*	*2 week*	*4 week*	*2 week*	*4 week*	*2 week*	*4 week*
DWJ compared with FL	2.34	3.76	2.31	3.63	1.25	1.26	1.07	1.04
DWJ compared with MT	3.00	5.83	2.98	5.54	1.70	1.53	1.39	1.15
FL compared with MT	1.28	1.55	1.29	1.53	1.36	1.21	1.30	1.11

*Entries indicated magnitude of the reduction (eg, the DWJ group compared with the FL group had 3.8 times as large a reduction in the PI at the 4-week visit.

The results of this 28-day investigation demonstrate that the DWJ with the MT provide significant benefits to oral health through the reduction of plaque and bleeding in subjects with fixed orthodontic appliances. The DWJ removed significantly more whole-mouth and interproximal plaque and reduced bleeding 26% better than brushing and flossing (Table IX). The reduction of bleeding in this study is consistent with other DWJ studies, but plaque reduction was much higher. This is most likely attributable to the tapered brush at the end of the jet tip that was used to clean around the brackets and archwires while irrigating. A previous study by Barnes et al[11] with nonorthodontic adults comparing a DWJ with floss demonstrated similar results in bleeding in addition to significant reductions in gingivitis over the same time period. The plaque reduction in the DWJ group was significantly greater than in the FL and MT groups, but the reduction of interproximal bleeding did not reach significance at 28 days. This might be attributed to the subjects' response to the reduction of plaque or the quality of their plaque, the required twice daily brushing for 2 minutes, and the possible improved technique for brushing and flossing because of being subjects in a clinical study (Hawthorne effect).

The use of a DWJ with orthodontic patients dates back to the 1960s. A 1967 study compared normal oral hygiene with normal oral hygiene plus a DWJ in a 6-month split-mouth design.[36] The study showed improvements in clinical parameters for the DWJ side in spite of decreased compliance toward the end of the study. Jackson and Orthod[37] reported no significant differences in a crossover study with 20 subjects. Each subject used a MT, a power toothbrush, a MT plus a DWJ, and a power toothbrush plus a DWJ. The results for plaque and gingivitis were inconsistent with most DWJ studies and can be attributed to sample size or study design. A 1994 study by Burch et al[38] demonstrated superior results for the DWJ group regardless of toothbrush used (power or manual) compared with a MT over a 2-month period. Our study provides more current data for a DWJ with orthodontic subjects.

These results are based on a 28-day period. Several studies demonstrated significant reductions of inflammation with the DWJ in 3 to 6 months with nonorthodontic subjects[13,14,16-19] but did not compare the DWJ with brushing and flossing or use the orthodontic tip.

CONCLUSIONS

This 28-day randomized, single-blind study demonstrated that brushing and flossing or brushing and a DWJ are effective oral hygiene regimens for adolescents with fixed orthodontic appliances. The DWJ was significantly better than flossing for the reduction of whole-mouth and interproximal plaque and whole-mouth bleeding. Additional studies of longer duration with this population are recommended to evaluate the efficacy and compliance of the 2 oral hygiene regimens. Table 3.

REFERENCES

1. Naranjo AA, Trivino ML, Jaramillo A, Betancourth M, Botero JE. Changes in the subgingival microbiota and periodontal parameters before and 3 months after bracket placement. Am J Orthod Dentofacial Orthop 2006;130:275e17-e22.
2. Perinetti G, Paolantonio M, Serra E, D'Archivio D, D'Ercole S, Festa F, et al. Longitudinal monitoring of subgingival colonization by actinobacillus actinomycetemcomitans, and crevicular alkaline phosphatase and aspartate aminotransferase activities around orthodontically treated teeth. J Clin Periodontol 2004;31:60-7.
3. Lee SM, Yoo SY, Kim HS, Kim KW, Yoon YJ, Lim SH, et al. Prevalence of putative periodontopathogens in subgingival dental plaques from gingivitis lesions in Korean orthodontic patients. J Microbiol 2005;43:260-5.
4. Heasman P, Wilson Z, Macgregor I, Kelly P. Comparative study of electric and manual toothbrushes in patients with fixed orthodontic appliances. Am J Orthod Dentofacial Orthop 1998;114:45-9.
5. Costa MR, Silva VC, Miqui MN, Sakima T, Spolidorio DM, Cirelli JA. Efficacy of ultrasonic, electric and manual toothbrushes in patients with fixed orthodontic appliances. Angle Orthod 2007;77:361-6.
6. Hickman J, Millett DT, Sander L, Brown E, Love J. Powered vs. manual tooth brushing in fixed appliance patients: a short term randomized clinical trial. Angle Orthod 2002;72:135-40.
7. Thienpont V, Dermaut LR, Van Maele G. Comparative study of 2 electric and 2 manual toothbrushes in patients with fixed

orthodontic appliances. Am J Orthod Dentofacial Orthop 2001;120:353-60.
8. Trimpeneers LM, Wijgaerts IA, Grognard NA, Dermaut LR, Adriaens PA. Effect of electric toothbrushes versus manual toothbrushes on removal of plaque and periodontal status during orthodontic treatment. Am J Orthod Dentofacial Orthop 1997; 111:492-7.
9. Lang WP, Ronis DL, Farghaly MM. Preventive behaviors as correlates of periodontal health status. J Public Health Dent 1995;55:10-7.
10. Ronis DL, Lang WP, Farghaly MM, Ekdahl SM. Preventive oral health behaviors among Detroit-area residents. J Dent Hyg 1994;68:123-30.
11. Barnes CM, Russell CM, Reinhardt RA, Payne JB, Lyle DM. Comparison of irrigation to floss as an adjunct to tooth brushing: effect on bleeding, gingivitis, and supragingival plaque. J Clin Dent 2005;16:71-7.
12. Cutler CW, Stanford TW, Abraham C, Cederberg RA, Boardman TJ, Ross C. Clinical benefits of oral irrigation for periodontitis are related to reduction of pro-inflammatory cytokine levels and plaque. J Clin Periodontol 2000;27:134-43.
13. Flemmig TF, Newman MG, Doherty FM, Grossman E, Meckel AH, Bakdash MB. Supragingival irrigation with 0.06% chlorhexidine in naturally occurring gingivitis I. 6 month clinical observations. J Periodontol 1990;61:112-7.
14. Jolkovsky DL, Waki MY, Newman MG. Clinical and microbiological effects of subgingival and gingival marginal irrigation with chlorhexidine gluconate. J Periodontol 1990;61:663-9.
15. Lobene RR. The effect of a pulsed water pressure cleaning device on oral health. J Periodontol 1969;40:51-4.
16. Chaves ES, Kornman KS, Manwell MA, Jones AA, Newbold DA, Wood RC. Mechanism of irrigation effects on gingivitis. J Periodontol 1994;65:1016-21.
17. Newman MG, Cattabriga M, Etienne D, Flemmig T, Sanz M, Kornman KS, et al. Effectiveness of adjunctive irrigation in early periodontitis: multi-center evaluation. J Periodontol 1994;65: 224-9.
18. Flemmig TF, Epp B, Funkenhauser Z, Newman MG, Kornman KS, Haubitz I, et al. Adjunctive supragingival irrigation with acetylsalicylic acid in periodontal supportive therapy. J Clin Periodontol 1995;22:427-33.
19. Al-Mubarak S, Ciancio S, Aljada A, Mohantz P, Ross C, Dandona P. Comparative evaluation of adjunctive oral irrigation in diabetics. J Clin Periodontol 2002;29:295-300.
20. Cobb CM, Rodgers RL, Killoy WJ. Ultrastructural examination of human periodontal pockets following the use of an oral irrigation device in vivo. J Periodontol 1988;59:155-63.
21. Drisko CL, White CL, Killoy WJ, Mayberry WE. Comparison of dark-field microscopy and a flagella stain for monitoring the effect of a Water Pik on bacterial motility. J Periodontol 1987;58:381-6.
22. Fine JB, Harper DS, Gordon JM, Hovliaras CA, Charles CH. Short-term microbiological and clinical effects of subgingival irrigation with an antimicrobial mouthrinse. J Periodontol 1994;65:30-6.
23. Felo A, Shibly O, Ciancio SG, Lauciello FR, Ho A. Effects of subgingival chlorhexidine irrigation on peri-implant maintenance. Am J Dent 1997;10:107-10.
24. Krajewski JJ, Giblin J, Gargiulo AW. Evaluation of a water pressure cleansing device as an adjunct to periodontal treatment. Periodontics 1964;2:76-8.
25. Phelps-Sandall BA, Oxford SJ. Effectiveness of oral hygiene techniques on plaque and gingivitis in patients placed in intermaxillary fixation. Oral Surg Oral Med Oral Pathol 1983;56:487-90.
26. Saxton CA, Huntington E, Cummins D. The effect of dentifrices containing Triclosan on the development of gingivitis in a 21-day experimental gingivitis study. Int Dent J 1993;43:423-9.
27. Turesky S, Gilmore ND, Glickman I. Reduced plaque formation by the chloromethyl analogue of victamine C. J Periodontol 1970;41:41-3.
28. Johnson JD, McInnes C. Clinical evaluation of the efficacy and safety of a new sonic toothbrush. J Periodontol 1994;65:692-7.
29. Tritten CB, Armitage GC. Comparison of a sonic and a manual toothbrush for efficacy in supragingival plaque removal and reduction of gingivitis. J Clin Periodontol 1996;23:641-8.
30. van der Weijden GA, Timmerman MF, Reijerse E, Danser MM, Mantel MS, Nijboer A, et al. The long-term effect of an oscillating/rotating electric toothbrush on gingivitis. An 8-month clinical study. J Clin Periodontol 1994;21:139-45.
31. Ainamo J, Xie Q, Ainamo A, Kallio P. Assessment of the effect of an oscillating/rotating electric toothbrush on oral health. J Clin Periodontol 1997;24:28-33.
32. Warren PR, Cugini M, Marks P, King DW. Safety, efficacy and acceptability of a new power toothbrush: a 3-month comparative clinical investigation. Am J Dent 2001;14:3-7.
33. Shibly O, Ciancio SG, Shostad S, Mather M, Boardman TJ. Clinical evaluation of an automatic flossing device vs. manual flossing. J Clin Dent 2001;12:63-6.
34. Sharma NC, Charles CH, Qaqish JG, Galustians HJ, Zhao Q, Kumar LD. Comparative effectiveness of an essential oil mouthrinse and dental floss in controlling interproximal gingivitis and plaque. Am J Dent 2002;15:351-5.
35. 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 Clin Dent 2005:16:33-7.
36. York TA, Dunkin RT. Control of periodontal problems in orthodontics by use of water irrigation. Am J Orthod 1967;9: 639-50.
37. Jackson CL, Orthod C. Comparison between electric toothbrushing and manual toothbrushing, with and without oral irrigation, for oral hygiene of orthodontic patients. Am J Orthod Dentofacial Orthop 1991;99:15-20.
38. Burch JG, Lanese R, Ngan P. A two-month study of the effects of oral irrigation and automatic toothbrush use in an adult orthodontic population with fixed appliances. Am J Orthod Dentofacial Orthop 1994;106:121-6.