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Influence of the Sonic Power Toothbrush on Reduction of Gingival inflammation and on the Amount of Interleukin-6, *Prevotella intermedia* and *Actinobacillus actinomycetemcomitans* in Periodontal Pocket

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I. INTRODUCTION

Bacterial plaque plays an important role in gingival inflammation and progression of periodontal breakdown to cause periodontitis. In the experimental gingivitis study of Löe et al.[1], reversible recovery of gingival health was achieved by the removal of accumulated plaque, which further emphasized daily plaque control in the maintenance of periodontal health[2,3].

Toothbrushing has been known as a basic method for mechanical plaque removal and the efficacy is governed by three main factors, namely, the design of the brush, the skill of the individual using the brush and the frequency and duration of use[4]. The latter two might be improved by the instructions of the oral hygienic care, however, majority of the people still do not fulfill the recommended time (2 minutes per session, 2 times per day) and appropriate methods of brushing[5]. Kleber et al.[6] found that subjects failed to brush nearly 40% of their tooth surfaces in the study of brushing time and pattern. Posterior regions rather than anterior or lingual and proximal than buccal sites are less cleansed and are more prone to development of periodontal disease.

Limited compliances with educational interventions of oral hygiene in general population led to the efforts to compensate for the human failings in the brushing skills and sonic power toothbrush is one of the challenges in designing the brush with best possible cleansing action regardless of the

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brushing technique. In this point of view, Sonicare Elite® has its effect on plaque removal by the mechanical cleansing from direct contact and by the dynamic fluid activity from acoustic energy[7,8]. Microelectronics within the brush handle utilizes solid-state electronics to produce magnetic field with a rapid oscillation movement which shows a frequency of 260Hz and 31,000 strokes per minute[9,10]. It has specialized designs such as angulated head from the shaft and curved shape of the brush with longer bristles at both ends which makes it easier and more efficient to cleanse hard-to-reach sites like interproximal, lingual, and posterior areas[11]. In addition to a direct scrubbing action to remove the plaque, it also causes turbulent fluid, streaming, bubble activity and shear force around the tooth brush under the air or fluid environment[12-14]. Cavitation activities and hydrodynamics of the surrounding fluids have been suggested to generate fluid forces that lift and disperse plaque bacteria from dental surfaces about 3~4mm beyond the reach of the brush tips[12,15].

The clinical features of chronic periodontitis are gingival inflammation with the alterations in color and texture, bleeding on probing from gingival pocket, periodontal pocketing, clinical attachment level and loss of alveolar bone. Although these clinical parameters provide information on the severity of the periodontitis and are used as the gold standards in the diagnosis of the disease, there are limitations in measuring the activity or the progression[16]. Several efforts have been arisen to seek for the methods in monitoring and identifying patients at increased risks of the disease progressions. Microbiological testing[17], analysis of the host response[18] and genetic analyses[19] have been proposed in regard to the multifactorial aspects of the periodontitis. In each test category, polymerase chain reaction (PCR) assay, especially when modified as "real-time" PCR, can be used not only for the detection of specific microorganisms in plaque but also its quantification[20] and the detection of components or the volume of the gingival crevicular fluid (GCF) can be a potential diagnostic marker related to the host response to the periodontal disease[21].

The purpose of this study was to evaluate the influence of sonic power toothbrush in reduction of gingival inflammation, interleukin-6 and periodontopathogens - *Prevotella intermedia, Actinobacillus actinomycetemcomitans* - in the periodontal pocket of chronic incipient to moderate periodontitis patients compared with the manual toothbrush group in 12-week follow-up period.

II. MATERIALS AND METHODS

1. Subjects

The subjects were drawn from the volunteers who visited the Department of Periodontology at the Yonsei University. Written, informed consents were obtained from all volunteers prior to the study which was granted by the Institution Review Board (IRB : Registration

No. 2005-1) of Clinical Research, Yonsei University Dental Hospital. All subjects had to fulfill inclusion criteria such as age between 25 and 55 years, having at least 20 permanent teeth, mean gingival index (Löe & Silness) and plaque index (Silness & Löe) at least 1.0, chronic incipient to moderate periodontitis with pocket probing depth 4~6mm and no probing depth deeper than 6mm, regular manual toothbrush user, no medical problems, no antibiotics or anti-inflammatory agents within the last 2 weeks, no previous periodontal therapy except for routine dental prophylaxis and no dental prophylaxis within the last 3 months. Among the initially selected 93 subjects, 59 were grouped into sonic power toothbrush (test group) and 34 into manual toothbrush (control group). During the 12-week follow-up, 11 subjects failed to appear (7 of the test, 4 of the control group) and the final data were collected from the 52 in test group and 30 in control group.

Table 1. Distributions of the subjects

Characteristics	Manual toothbrush	Sonic power toothbrush
Total subjects	30	52
Male	14	25
Female	16	27
Mean age	38.0	40.9
Age range	25-55	25-55
Smoking / Non-smoking	4 / 26	9 / 43

Table 2. Criteria for the plaque index and gingival index

* Plaque Index (PI ; Silness & Löe)	
0	No plaque in the gingival area
1	A film of plaque adhering to the free gingival margin and adjacent area of the tooth. The plaque may be recognized only by running a probe across the tooth surface
2	Moderate accumulation of soft deposits within the gingival pocket and on the gingival margin and/or adjacent tooth surface tooth surface that can be seen by the naked eye
3	Abundance of soft matter within the gingival pocket and/or on the gingival margin and adjacent tooth surface
* Gingival Index (GI ; Löe & Silness)	
0	Normal gingival
1	Mild inflammation, slight change in color, slight edema ; no bleeding on palpation
2	Moderate inflammation, redness, edema, and glazing ; bleeding on probing
3	Severe inflammation, marked redness and edema, ulcerations ; tendency to spontaneous bleeding

2. Clinical examination

One investigator who was blinded to each brush group performed the clinical examinations. Subjects were randomly assigned to each group and the distributions of the age, gender and smoking were similar between these groups (Table 1).

Clinical parameters include plaque index (PI; Silness & Löe), gingival index (GI; Löe & Silness) (Table 2), bleeding on probing (BOP), pocket probing depth (PPD) and clinical attachment level (CAL). When measuring PI and GI, each tooth were assessed at 4 sites (mesiobuccal, buccal, distobuccal, lingual) and other parameters at 6 sites (mesiobuccal, buccal, distobuccal, mesiolingual, lingual, distolingual) using UNC probe (PCVUNC 12PT, Hu-Friedy, USA).

1) Oral hygiene instructions (OHI)

Subjects were instructed to brush twice a day for 2 minutes each session. Both groups used the same toothpastes (2080®, Aekyung, Korea) and interdental cleaning or adjunctive aids were not allowed to use. The subjects in sonic power toothbrush group were given Sonicare Elite® (Philips Oral Healthcare Inc., Snoqualmie, Washington, USA)(Figure 1) and instructed to position the brush head toward the gumline to touch the teeth and gingiva with gentle and slight circular motions. For manual toothbrush group, each subject was taught to use modified Bass technique with Butler #311 multi-tufted manual toothbrush (J.O. Butler Co., Chicago, IL, USA).

Figure 1. Sonicare Elite® power toothbrush

2) Examination protocols

At the baseline visit, full mouth examination of PI and GI were done. Among the teeth examined, 3 teeth which had the deepest probing pocket depth were selected as specific sites for further sampling of laboratory workup and BOP, PPD and CAL were measured only at the 3 selected teeth. After the assessments, professional cleaning

Table 3. Study design

Visit / Parameters	Baseline	1 week	4 week	12 week
PI, GI, BOP	W	W	W	W
PPD, CAL	S	S	S	S
GCF sample	Sd	Sd	-	Sd
Pathogen sample	Sd	Sd	-	Sd

W : measuring whole dentition in both Sonicare and manual group
S : measuring 3 selected teeth in both Sonicare and manual group
Sd : measuring deepest pockets of 3 selected teeth in both Sonicare and manual group

of scaling and root planning were done. Subsequent visits at the week 1, 4 and 12, all the parameters were measured only at the 3 selected teeth except for the PI and GI which were additionally examined for the whole surfaces at 12-week (Table 3).

3. Laboratory assessment

1) Cytokine Interleukin-6 (IL-6) in Gingival Crevicular Fluid (GCF)

Cytokine IL-6 of the GCF at 3 selected teeth which had the deepest probing pocket depth was assessed. The site with the deepest PPD in each tooth was chosen and isolated with cotton rolls. After gentle drying with air syringe, 3 paper points (Meta Dental, USA) were inserted at the crevice of each site until mild resistance was felt. They were left for 30 seconds, removed and then stored in a labeled sterile 1.5mL conical tube (Ratiolab® GmbH, Germany) containing 0.3mL of Hank's buffered salt solution (HBSS 10×, Gibco BRL Invitrogen Co., USA) with 0.5% fetal bovine serum (FBS, Gibco Invitrogen Co., USA). The samples were collected at baseline, 1 and 12-week follow-up and frozen at -20℃ until required for the detection workups. IL-6 concentration in GCF was assayed by commercially available ELIZA kit (Quantikine® Human IL-6 immunoassay, R&D systems Inc., USA) following instructions supplied by the manufacturer and the cytokine concentration was measured in pg/mL with spectrophotometer at 450nm. Intensity of color developed in each microplate well related to the amount of cytokine and was measured by automated microplate reader (Microplate Manager®, BMS Co., Korea).

2) Detection of periodontal pathogens

To detect *Prevotella intermedia* (*P. intermedia*) and *Actinobacillus actinomy-cetemcomitans* (*A. actinomycetemcomitans*) subgingival plaque samples were taken by sterilized curettes at the deepest periodontal pockets of 3 selected teeth, placed in labeled sterile 1.5mL conical tubes containing 1mL of Reduced Transport Fluid (RTF)[22] and stored at -80℃ until detection. 200μ L of the sample was used for automated DNA isolation and purification from each tube with the QIAamp® DNA Mini Kit (QIAGEN Inc., USA) and isolated DNA was eluted in 200μ L elution buffer. For quantitative real-time polymerase chain reaction (PCR), TaqMan assay in 16s rRNA gene sequences which were selected from the taxonomy database of the National Center for Biotechnology Information was used. Specially designed PCR primers and probes were selected and checked through the web with the Basic Local Alignment Search Tool program (BLAST®, NCBI homepage http://ncbi.nlm.nih.gov/blast) for homology with unrelated sequences (Table 4). The total volume of PCR mixture used 45μ L which contained 25μ L of Platinum® Quantitative PCR SuperMix-UDG with ROX master mix (Invitrogen Co., USA), 1μ L of

Table 4. Designs of PCR primers and fluorogenic probes for specific detection of the pathogens

Bacteria	Sequence	(5'→3')
Pi	Forward	CGG TCT GTT AAG CGT GTT GTG
	Reverse	CAC CAT GAA TTC CGC ATA CG
	Probe	FAM-TGG CGG ACT TGA GTG CAC GC-TAMRA
Aa	Forward	GAA CCT TAC CTA CTC TTG ACA TCC GAA
	Reverse	TGC AGC ACC TGT CTC AAA GC
	Probe	FAM-AGA ACT CAG AGA TGG GTT TGT GCC TTA GGG-TAMRA

Pi : *Porphyromonas intermedia* , Aa : *Actinobacillus actinomycetemcomitans*

extracted DNA stored in Qiagen AE buffer (QIAGEN Inc., USA), forward and reverse primer and the probe of 1μ L each and sterile distilled water to adjust volume. Real time PCR was carried out in ABI Prism 7700 Sequence detection system with SDS (Ver. 1.91) software (ABI Prism 7700 Sequence detection system, Applied Biosystems, USA) using the following sequences : 2 minutes at 50℃, 2 minutes at 95℃, 45 cycles of 15 seconds at 95℃ and 65℃ for 45 seconds. The threshold cycle (CT) was obtained at which a significant increase in the reaction product is first detected.

4. Statistical Analyses

Within each group, mean and standard deviation (S.D.) was measured for each subject for clinical parameters and assessments. To assess the ability of plaque removal at anterior and posterior sites, PI, GI, and BOP were used as the parameters. For 3 selected teeth which had the deepest probing pockets at the baseline examination, PI, GI, BOP, PPD and CAL were used. To compare the difference between baseline and each following period (1, 4 and 12-week) in a group, Wilcoxon signed ranks test was introduced. For the comparison in the Sonicare and the manual group in each time interval, unpaired T-test was done and Repeated measures multivariate analyses of variance (ANOVA) were used to test for time- and device-dependent differences for the clinical assessments between 2 groups over 4 visits. In addition to the clinical data, cytokine IL-6 in GCF and the amount of subgingival pathogens - P. intermedia, A. actinomycetemcomitans - at baseline, 1 and 12-week of the 2 groups were analyzed by the same methods described above.

III. RESULTS

1. Clinical data

1) Comparisons between the sonic powered toothbrush and the manual toothbrush in anterior and posterior sites

Three kinds of parameters - PI, GI, BOP

Table 5. Plaque index of the 2 groups at each visit : mean score±standard deviation for anterior and posterior regions

Group / Each visit	Anterior		Posterior	
	Manual	Sonic	Manual	Sonic
Baseline	1.22±0.37	1.23±0.40	1.94±0.39	1.71±0.30
1 week	1.06±0.37	0.62±0.46†‡	1.56±0.36†	0.96±0.45†‡
4 week	1.03±0.26	0.65±0.39†‡	1.53±0.40†	0.98±0.43†‡
12 week	1.01±0.38	0.54±0.36†‡	1.44±0.47†	0.93±0.46†‡

†: statistically significant from baseline at $p<0.05$ (Wilcoxon signed ranks test)

‡: statistically significant from manual at $p<0.05$ (unpaired T-test)

Repeated measures ANOVA of both devices across all time intervals at both anterior and posterior sites : $p<0.05$

Table 6. Gingival index of the 2 groups at each visit : mean score±standard deviation for anterior and posterior regions

Group / Each visit	Anterior		Posterior	
	Manual	Sonic	Manual	Sonic
Baseline	1.28±0.37	1.18±0.38	1.84±0.28	1.64±0.26
1 week	1.08±0.37†	0.56±0.49†‡	1.50±0.31†	0.94±0.46†‡
4 week	1.05±0.25†	0.56±0.41†‡	1.50±0.32†	0.86±0.40†‡
12 week	1.04±0.42†	0.60±0.39†‡	1.44±0.56†	0.90±0.46†‡

†: statistically significant from baseline at $p<0.05$ (Wilcoxon signed ranks test)

‡: statistically significant from manual at $p<0.05$ (unpaired T-test)

Repeated measures ANOVA of both devices across all time intervals at both anterior and posterior sites : $p<0.05$

Table 7. Bleeding on probing of the 2 groups at each visit : mean score±standard deviation for anterior and posterior regions

Group / Each visit	Anterior		Posterior	
	Manual	Sonic	Manual	Sonic
Baseline	0.40±0.19	0.38±0.23	0.75±0.21	0.71±0.19
1 week	0.10±0.17†	0.02±0.06†‡	0.34±0.23†	0.19±0.14†‡
4 week	0.08±0.12†	0.03±0.09†	0.31±0.21†	0.20±0.14†‡
12 week	0.21±0.18†	0.06±0.11†‡	0.44±0.30†	0.23±0.20†‡

†: statistically significant from baseline at $p<0.05$ (Wilcoxon signed ranks test)

‡: statistically significant from manual at $p<0.05$ (unpaired T-test)

Repeated measures ANOVA of both devices across all time intervals at posterior sites : $p<0.05$

- were used to compare between 2 groups in anterior and posterior sites. In PI of anterior regions, there was a significant reduction ($p<0.05$) in 1, 4 and 12 week compared to baseline in Sonicare group, whereas the difference in manual group did not show any significance. It also showed that the significant reduction of plaque ($p<0.05$) was shown in the Sonicare group compared to the manual at every follow-up visit. In posterior regions, both of the groups showed statistical differences ($p<0.05$) in the follow-up period than the baseline and the Sonicare group showed significant reduction ($p<0.05$) than the manual group. Both in the anterior and posterior regions, statistical significances ($p<0.05$) were demonstrated for the device and time dependent differences (Table 5). In GI (Table 6) and BOP (Table 7), similar patterns of statistical results were shown. At anterior and posterior regions, both of the groups showed the significant reductions ($p<0.05$) in the follow-up visit than the baseline and more reduction ($p<0.05$) was found in the Sonicare group compared to the manual at every visit.

Table 8. Plaque index of the 2 groups at each visit : mean score±standard deviation for 3 selected teeth

Each visit \ Group	All surfaces of 3 selected teeth	
	Manual (n=30)	Sonic (n=52)
Baseline	1.46±0.31	1.38±0.33
1 week	1.19±0.32†	0.70±0.42†‡
4 week	1.16±0.26†	0.72±0.38†‡
12 week	1.12±0.36†	0.65±0.37†‡

†: statistically significant from baseline at $p<0.05$ (Wilcoxon signed ranks test)

‡: statistically significant from manual at $p<0.05$ (unpaired T-test)

Repeated measures ANOVA of both devices across all time intervals : $p<0.0001$

Table 9. Gingival index of the 2 groups at each visit : mean score±standard deviation for 3 selected teeth

Each visit \ Group	All surfaces of 3 selected teeth	
	Manual (n=30)	Sonic (n=52)
Baseline	1.46±0.27	1.33±0.29
1 week	1.21±0.32†	0.70±0.42†‡
4 week	1.18±0.24†	0.73±0.38†‡
12 week	1.14±0.40†	0.65±0.37†‡

†: statistically significant from baseline at $p<0.05$ (Wilcoxon signed ranks test)

‡: statistically significant from manual at $p<0.05$ (unpaired T-test)

Repeated measures ANOVA of both devices across all time intervals : $p<0.0001$

However, statistical significances ($p<0.05$) were demonstrated for the device and time dependent differences (ANOVA) in GI of both anterior and posterior region, whereas only posterior region showed significance ($p<0.05$) at BOP.

Table 10. Bleeding on probing of the 2 groups at each visit : mean score±standard deviation for 3 selected teeth

Group / Each visit	All surfaces of 3 selected teeth	
	Manual (n=30)	Sonic (n=52)
Baseline	2.38±0.49	2.39±0.49
1 week	1.82±0.69†	1.52±0.85†
4 week	1.60±0.85†	1.52±0.83†
12 week	1.49±0.96†	1.27±0.81†

† : statistically significant from baseline at $p<0.05$ (Wilcoxon signed ranks test)

Table 11. Probing pocket depth of the 2 groups at each visit : mean score±standard deviation for 3 selected teeth

Group / Each visit	3 selected teeth	
	Manual (n=30)	Sonic (n=52)
Baseline	3.51±0.44	3.72±0.69
1 week	3.21±0.38†	3.30±0.67†
4 week	3.11±0.46†	3.25±0.74†
12 week	2.99±3.71†	3.03±0.67†
% Change§	14.19±8.16%	18.47±10.05%

† : statistically significant from baseline at $p<0.05$ (Wilcoxon signed ranks test)
§Percentage change from baseline to 12 week evaluation

Table 12. Clinical attachment level of the 2 groups at each visit : mean score±standard deviation for 3 selected teeth

Group / Each visit	3 selected teeth	
	Manual (n=30)	Sonic (n=52)
Baseline	3.60±0.65	4.16±1.06
1 week	3.24±0.38†	3.54±0.90†
4 week	3.11±0.46†	3.30±0.82†
12 week	2.99±0.37†	3.11±0.83†
% Change§	15.65±9.92	24.26±12.51

† : statistically significant from baseline at $p<0.05$ (Wilcoxon signed ranks test)
§Percentage change from baseline to 12 week evaluation

2) Comparisons between the sonic powered toothbrush and the manual toothbrush in 3 selected teeth

All parameters - PI, GI, BOP, PPD, CAL - were measured for 3 selected teeth. In the mean values of PI (Table 8) and GI (Table 9), statistically significant reductions (P<0.05) in 12 week follow-up than baseline were shown at both devices. Sonicare group had more significant decrease (p<0.05) than manual at 1, 4 and 12 week and the changes in 2 groups over time also seemed to have significant differences (p<0.05).

For BOP (Table 10), PPD (Table 11) and CAL (Table 12), there were no significant differences between 2 groups though both had significant reductions (p<0.05) in 12 week follow-up period compared to baseline. In percent change of PPD, Sonicare group showed 18.47±10.05%, while manual group

Table 13. Cytokine IL-6 concentration (pg/ml) of the GCF of the 2 groups at each visit : mean score±standard deviation for 3 selected sites

Group* \ Each visit	baseline	1 week	12 week	% Change§
Manual	6.10±6.02	4.91±4.71	3.87±3.24†	37.0
Sonic	5.91±6.79	4.53±4.06	2.93±2.90†	51.0

*n : Manual=30, Sonic=53

† statistically significant difference from the baseline at p<0.05 (Wilcoxon signed ranks test)

§Percentage change from baseline to 12 week evaluation

Table 14. CT (threshold cycle) value of *Prevotella intermedia* in 2 groups at each visit : mean score±standard deviation for 3 selected sites

CT value \ Each visit	baseline	1 week	12 week
Manual	27.89±4.40	27.96±4.90	30.05±5.01
Sonic	27.13±3.64	27.56±4.26	27.62±4.05

No significant differences with baseline at p<0.05

No significant differences between 2 brush groups at p<0.05

Table 15. CT (threshold cycle) value of *Actinobacillus actinomycetemcomitans* in 2 groups at each visit : mean score±standard deviation for 3 selected sites

CT value \ Each visit	baseline	1 week	12 week
Manual	38.59±8.48	39.72±6.84	40.52±6.14
Sonic	40.94±6.76	41.14±6.25	40.96±6.57

No significant differences with baseline at p<0.05

No significant differences between 2 brush groups at p<0.05

was 14.19±8.16%. In CAL, the percent change of Sonicare group appeared to be 24.26± 12.51%, while manual group showed 15.65±9.92%.

2. Laboratory assessment data

1) Gingival crevicular fluid : cytokine IL-6 levels (pg/mL)

The mean cytokine IL-6 concentration values (pg/mL) of 3 selected sites in both groups were measured and during the 12 week period, both groups showed significant differences ($p<0.05$) from the baseline. There were no significant differences ($p<0.05$) between two groups, however, the percent change of the Sonicare group (51%) was greater than the manual group (37%) showing the stronger downward tendency in the concentration of IL-6 at the Sonicare group (Table 13).

2) Subgingival Plaque Pathogen Detection

The threshold cycles (CT value) of *P. intermedia* (Table 14) and *A. actinomycetemcomitans* (Table 15) in baseline, 1 and 12 week of both groups were measured and there were no statistical differences found in follow-up visit from baseline value or between two groups.

IV. DISCUSSION

There are several studies trying to Figure out the efficacy of electric toothbrushes on the plaque removal and gingivitis[23-25] using the clinical parameters like plaque (PI), gingival index (GI) and bleeding on probing (BOP) and more recently, investigators looked at the effects on the chronic periodontitis for which other parameters such as probing pocket depth (PPD) or clinical attachment level (CAL) are needed to be involved[9,26,27]. These parameters are classical gold standards to diagnose the periodontal disease in severity but have the limitations to show the disease activity or to monitor the sites and subjects at the risk of progression[28]. From this point of view, evaluations in the effects of the Sonicare Elite® on the chronic incipient to moderate periodontitis were prepared not only by the clinical parameters mentioned above but also by the laboratory tests detecting cytokine interleukine-6 in gingival crevicular fluid (GCF) and periodontopathogens in quantitative real-time polymerase chain reaction (PCR) assay in the present study.

For clinical effects in hard-to-reach sites, whole dentition of each subject was divided into anterior and posterior site. PI, GI and BOP of both devices (Sonicare and manual toothbrush) showed significant improvements in the 12 week interval except for the PI in anterior region which had the tendency but not significantly improved. In comparison of the BOP between anterior and posterior site, statistical decrease was found only at the posterior region during 12 week. When the parameters were measured for the selected sites PI and GI consistently showed better

results in Sonicare group in the following visits though no significant differences between the devices were shown for BOP, PPD and CAL. The measurements for 3 selected teeth merely represented the deepest pocketing sites and had the limitations to show the effect for whole dentition however, descriptive statistics in percent change reduction between baseline and 12 week indicated that there was a tendency for the Sonicare group to show greater improvement in CAL than the manual group. The clinical result of this study suggest the superiority in the electric toothbrush group and confirm the findings of Johnson and McInnes[29-31] who also compared the ability to remove plaque of Sonicare with the manual group. There are several other studies which are in agreement mentioned above using various kinds of action modes in electric brushes such as counter-rotary brush[23,25], reciprocating device[25] and circular brush with rotating and oscillating motion[24].

Biochemical inflammatory changes of cytokine IL-6 were detected in the Sonicare group during 12 week interval to measure the resolution of inflammation and significant reduction in the follow-up period. As the periodontal disease is initiated and progressed by presence of elevated levels of pathogenic bacteria within gingival crevice[32-34] and resulted from an imbalance in host protective and destructive mechanisms by an infectious process[21,35], methods using host response analysis or microbial tests might be considered. Gingival crevicular fluid (GCF), an inflammatory exudate composed of serum, tissue breakdown products, inflammatory mediators and antibodies against dental plaque bacteria that seeps into gingival crevices or periodontal pockets, is suggested as a potential diagnostic tool for quantitative evaluation of inflammatory status by detecting its volume and the components and also as possible markers for the progression of periodontitis[28]. Local imbalance of the inflammatory mediator cytokine in GCF and an increase in the concentration of interleukin-1 beta (IL-1β) and interleukin-6 (IL-6) can significantly indicate or predict disease activity at a site. In microbiologic tests, real-time polymerization chain reaction (PCR) is known as a highly sensitive method in detecting not only the specific microorganism but also its quantification[20]. Synthesized 16S rRNA probes that are highly specific to individual species make it possible to detect any organisms in the plaque sample and in this study *Prevotella intermedia (P. intermedia)* and *Actinobacillus actinomycetemcomitans (A. actinomycetemcomitans)* were used. They are putative periodontopathogenic microorganisms and the amount is assessed by the threshold cycle (CT). When dissociation curves for the amplicons were generated after each run in real-time PCR, increased fluorescent signal is associated with an exponential growth of PCR product during the linear-log phase and the cycle at which a significant increase in the reaction product is first detected appears as CT. The higher the initial amount of

DNA, the sooner accumulated product is detected in the PCR process and the lower the CT value[36]. There are some studies considering the ability of the electric toothbrush to remove subgingival bacterial plaque by indirect effect of hydrodynamics[15] suggested that the fluid forces lift and disperse subgingival bacteria which is 3~4mm beyond the mechanical reach of the bristles and in vitro study of McInnes et al.[30-32], there had been ideas that structural and metabolic effects on oral bacteria by the low-amplitude acoustic energy might retard the plaque formation. In this study reduction in the amount of the two microorganisms did not show the significant difference and this might be due to the plaque sampling technique which had the limitation in standardization and to associate with wide standard deviation. Furthermore, some of the errors in the sampling procedures that the study sites over 4mm which might have been away from the reach of the direct or indirect effect of the electric toothbrush were included. It is also important to be aware of the fact that each pocket has somewhat unique microbiological profile and the sample from a diseased site may not be a representative to whole dentition or even of other diseased sites. *Actinobacillus actinomycetemcomitans,* one that was involved in our study, is infrequently detected microorganism and its presence sometimes might not be shown even in the sampling of numerous diseased sites[33-34]. Unfortunately, usage of GCF and real-time PCR in order to add the more precise detection and information of gingival inflammation did not work well due to the limitations mentioned above and technical improvements in laboratory test is needed.

In spite of the limitations, the results in the present study still showed the conclusion that the Sonicare toothbrush had a significant effect in the improvement of plaque removal and gingival inflammation in chronic incipient to moderate periodontitis.

V. CONCLUSION

1. Both of the Sonicare and manual groups demonstrated significant reductions ($p<0.05$) in the clinical parameters of gingival inflammation (plaque index, gingival index, bleeding on probing) during 12 week period and the Sonicare showed more statistical significance ($p<0.05$) than the manual group.
2. In posterior region, bleeding on probing of the Sonicare group showed a statistically significant ($p<0.05$) reduction during 12 week period.
3. At 3 selected teeth which had the deepest pocket, probing pocket depth and clinical attachment level showed significant reductions ($p<0.05$) than baseline in both of the groups. In the percent change of each parameter, probing pocket depth appeared to be 18.47±10.05% for the Sonicare, 14.19±8.16% for the manual and clinical attachment level showed 24.26±

12.51% at the Sonicare compared to 15.65±9.92% at the manual group. There were no statistically significant differences between two groups.

4. IL-6 concentrations of GCF in both groups showed statistically significant reductions ($p<0.05$) at 12 week interval. The percent change of Sonicare appeared to be 51% and the manual to be 37%, but there were no significant differences between the groups.
5. In detection of *Prevotella intermedia and Actinobacillus actinomycetemcomitans*, there was no significant reduction of amount at either manual or Sonicare group.

In this study, the Sonicare toothbrush had a significant influence in the reduction of plaque removal, gingival inflammation and clinical parameters than the manual group and the interleukin-6 of the Sonicare group tended to reduce more in the periodontal pocket of chronic incipient to moderate periodontitis.

VI. REFERENCES

1. Löe H, Theilade E, Jensen JB. Experimental gingivitis in man. J Periodontol 1965;36:177-187.
2. Löe H, Silness J. Periodontal disease in pregnancy. I. Prevalence and severity. Acta Odontologica Scandinavica 1963;21: 533-551.
3. Theilade E. Dental plaque & dental calculus. In Lindhe J, Textbook of periodontology, 1983, Copenhagen, Munksgaard.
4. Yankell SL. Toothbrushing and toothbrushing techniques. Primary preventive dentistry, 3rd Edition, Norwalk, CT, Appleton and Lange 1991:79-106.
5. Axelsson P, Lindhe J. Effect of controlled oral hygiene procedures on caries and periodontal disease on adults. J Clin Periodontol 1978;5:133-151.
6. Kleber CJ, Putt MS, Muhler JC. Duration and pattern of toothbrushing in children using gel or paste dentifrice. J Am Dent Assoc 1981;103:723-726.
7. Engel D, Nessly M, Morton T, Martin R. Safety testing of a new electronic toothbrush. J of Periodontol 1993;64:941-946.
8. Johnson BD, McInnes C : Clinical evaluation of the efficacy and safety of a new sonic toothbrush. J of Periodontol 1994; 65:692-697.
9. O'Beirne G, Johnson RH, Persson GR, Spektor MD. Efficacy of a sonic toothbrush on inflammation and probing depth in adult periodontitis. J Periodontol 1996; 67:900-908.
10. Hope CK, Wilson M : Effects of dynamic fluid activity from an electric toothbrush on in vitro biofilms. J of Clin Periodontol 2003;30:624-629.
11. Versteeg PA, Timmerman MF, Rosema NAM, Warren PR, Van der Velden U, Van der Weijden GA. Sonic-powered toothbrushes and reversal of experimental gingivitis. J of Clin Periodontol 2005;32: 1236-1241.
12. 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;23:641-648.
13. Stanford CM, Srikantha R, Wu CD. Efficacy of the Sonicare toothbrush fluid dynamic action on removal of human su-

pragingival plaque. J of Clin Dent 1997; 8:10-14.
14. Hope CK, Petrie A, Wilson M. In vitro assessment of the plaque-removing ability of hydrodynamic shear forces produced beyond the bristles by 2 electric toothbrushes. J of Periodontol 2003;74: 1017-1022.
15. Wu-Yuan CD, Anderson RD, McInnes C : Ability of the Sonicare® electronic toothbrush to generate dynamic fluid activity that removes bacteria. 1994;5:89-93.
16. Sinem E, Cohen S, Cohen RE. Analysis of host responses and risk for disease progression. Periodonol 2000 2004;34:57-83.
17. Synder B, Ryerson CC, Corona H, Grogan EA, Reynolds HS, Contestable PB, Boyer BP, Mayer J, Mangan T, Norkus N, Zambon JJ, Genco RJ. Analytical performance of an immunologic-based periodontal bacterial test for simultaneous detection and differentiation of Actinobacillus actinomycetemcomitans, Porphyromonas gingivalis, and Prevotella intermedia. J Periodontol 1996;67:497-505.
18. Lamster IB. Evaluation of components of gingival crevicular fluid as diagnostic tests. Ann Periodontol 1997;2:123-137.
19. Kornman KS, Crane A, Wang HY, di Giovine FS, Newman MG, Pirk FW, Wilson TG, Jr. Higginbottom FL, Duff GW. The interleukine-1 genotype as a severity factor in adult periodontal disease. J Clin Periodontol 1997;24:72-77.
20. Asai Y, Jinno T, Igarashi H, Ohyama Y, Ogawa T. Detection and quantification of oral treponemes in subgingival plaque by real-time PCR. J Clin Microbiol 2002; 40:3334-3340.
21. Lamster IB, Grbic JT. Diagnosis of periodontal disease based on analysis of the host response. Periodontol 2000 1995;7:83-99.
22. Salam A, Loesche S and WJ. Survival of Human Dental Plaque Flora in Various Transport Media. Appl Microbiol 1972; 24(4):638-644.
23. Baab DA, Johnson RH. The effect of a new electric toothbrush on supragingival plaque and gingivitis. J Periodontol 1989; 60:336-341.
24. Van der Weijden GA, Danser MM, Nijboer A, Timmerman MF, Van der Velden U. The plaque removing efficacy of an oscillating/rotating toothbrush. A short-term study. J Clin Periodontol 1993;20:273-278.
25. Khocht A, Spindel L, Person PA. A comparative clinical study of the safety and efficacy of three toothbrushes. J Periodontol 1992;63:603-610.
26. Hellstadius K, Asman B, Gustafsson A. Improved maintenance of plaque control by electric toothbrushing in periodontitis patients with low compliance. J Clin Periodontol 1993;20:234-237.
27. Youngblood JJ, Killoy WJ, Love JW, Drisko C. Effectiveness of a new home-removal instrument in removing subgingival and interproximal plaque. A preliminary in vivo report. Compendium Cont Educ Dent Suppl.1985;6:S128-S141.
28. Eley BM, Cox SW. Advances in periodontal diagnosis. Part 1. Traditional clinical methods of diagnosis. Br Dent J 1998;184:10-16.
29. McInnes C, Engel D, Martin RW. Bacterial luminescence. A new tool for investigating the effects of acoustic energy and cavitation. J of the Acous Soc of Am 1990;88:2527-2532.
30. McInnes C, Engel D, Martin RW. Fimbria damage and removal of adherent bacterial after exposure to acoustic energy. Oral Microbiol and Immunol 1993; 8:277-282.

31. McInnes C, Engel D, Moncla BJ, Martin RW. Reduction in adherence of Actinomyces viscosus after exposure to low-frequency acoustic energy. Oral Microbiol and Immunol 1992;7:171-176.
32. Socransky SS, Haffajee AD. Microbial mechanisms in the pathogenesis of destructive periodontal diseases : a critical assessment. J Periodont Res 1991;26:195-209.
33. Socransky SS, Haffajee AD. The bacterial etiology of destructive periodontal disease : current concepts. J Periodontol 1992;63: 322-331.
34. Haffajee AD, Socransky SS. Effect of sampling strategy on the false-negative rate for detection of selected subgingival species. Oral Microbiol Immunol 1992;7: 57-59.
35. Lamster IB, Smith QT, Celenti RS, Singer RE, Grbic JT. Development of a risk profile for periodontal disease : Microbial and host response factors. J Periodontol 1994;65:511-520.
36. Bai RK, Wong L-JC. Detection and quantification of heteroplasmic mutant mitochondrial DNA by real time amplification refractory mutant system quantitative PCR analysis : a single-step approach. Clin Chem 2004;50(6):996-1001.

-국문초록-

치주낭 내의 치은 염증의 감소와 Interleukin-6, *Prevotella intermedia* 및 *Actinobacillus actinomycetemcomitans* 에 대한 전동 칫솔의 효과

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세균성 치태는 치은의 염증과 치주 조직 파괴를 동반하는 치주염의 주요한 인자로서 치주 조직 건강을 유지하기 위하여 적절한 치태 조절이 필요하다. 본 논문의 목적은 12주 동안 만성 초기 및 중등도 치주염 환자에서 치은염에 대한 임상 지수의 감소, interleukin-6 (IL-6) 농도와 치주질환 원인균인 *Prevotella intermedia* (*P. intermedia*), *Actinobacillus actinomycetemcomitans* (*A. actinomycetemcomitans*)에 대한 소니케어 전동 칫솔의 효과를 일반 칫솔과 비교해 보고자 하는 데 있다.

총 82명의 환자를 선택하였으며, 30명은 일반 칫솔, 52명은 소니케어 전동 칫솔 군으로 분류하여 칫솔질 교육을 실시하였다. 전악을 전치부와 구치부로 나누어 초진, 1, 4, 12주에서의 치태, 치은 지수 및 탐침 시 출혈 여부를 조사하였으며, 가장 깊은 치주낭 탐침을 보이는 치아 3개를 선택하여 탐침 깊이와 부착 정도를 측정하였고, 선택된 치아에서 초진, 1, 12주에 채취된 샘플을 통해 치은열구액 내의 IL-6 농도와 *P. intermedia, A. actinomycetemcomitans* 의 CT값을 추가적으로 조사하여 다음과 같은 결과를 얻었다.

1. 소니케어 전동 칫솔과 일반 칫솔군 모두 치은 염증을 나타내는 임상 지수 (치태지수, 치은지수, 탐침 시 출혈)는 12주 기간 동안 유의한 감소 ($p<0.05$)를 보였으나, 전동 칫솔 군에서 통계학적으로 더욱 유의하게 ($p<0.05$) 나타났다.
2. 전치부를 제외한 구치부 치아에서 소니케어 전동 칫솔군은 12주 기간 동안 탐침 시 출혈의 감소가 통계학적으로 유의하게 ($p<0.05$) 나타났다.
3. 가장 깊은 치주낭 탐침 깊이를 보이는 3개의 선택된 치아에서 치주낭 탐침 깊이와 부착 정도는 두 군 모두 초진에 비해 유의한 감소 ($p<0.05$)를 보였다. 퍼센트 변화 비교에서 치주낭 탐침 깊이는 소니케어 전동 칫솔군이 18.47±10.05%, 일반 칫솔군이 14.19±8.16%로, 부착 정도는 소니케어 전동 칫솔군이 24.26±12.51%, 일반 칫솔군이 15.65±9.92%로 각각 나타났으나, 군 간 통계적 유의차는 보이지 않았다.
4. 치은열구액의 IL-6 농도는 두 군 모두 12주 기간 동안 통계적으로 유의한 감소 ($p<0.05$)를 나타내었다. 퍼센트 변화 비교에서 전동 칫솔군은 51%, 일반 칫솔군은

37%로 각각 나타났으나, 군 간 통계적 유의차는 보이지 않았다.

5. *Prevotella intermedia, Actinobacillus actinomycetemcomitans* 의 관찰에서 두 군 모두 유의한 차이는 없었다.

위 결과를 통해 본 연구에서는 소니케어 전동 칫솔의 사용이 일반 칫솔에 비하여 만성 초기 및 중등도 치주염 환자에서 치태의 제거, 치은 염증 및 임상 지수의 감소에 유의한 효과가 있으며 IL-6 의 감소 경향에도 효과가 있음을 관찰하였다.

Key worlds: 소니케어 전동 칫솔, 임상 지수, Interleukin-6, 치은열구액, 만성 치주염