

The effects of flossing with a chlorhexidine solution on interproximal gingivitis: a randomized controlled trial

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ABSTRACT

Background: Gingivitis is an inflammatory response of the gingival tissues to bacterial plaque that can be treated by brushing and flossing or rinsing with chlorhexidine. This study examined whether floss presoaked in chlorhexidine improved oral health relative to flossing alone. **Methods:** A 3-month, parallel, randomized control trial was conducted on 27 adults with a minimum of 10 bleeding sites, who were randomly assigned to a floss soaked in 0.12 per cent chlorhexidine or floss soaked in a placebo, quinine sulfate. Debridement and flossing instructions were performed at Week - 1. Probing depth, bleeding on probing, gingival plaque, and stain indices were assessed at Weeks 0, 6, and 12. Flossing compliance was monitored by self-reports and length of floss used. **Results:** Flossing compliance was high for both groups. All subjects had statistically significant reductions in gingival indices scores ($p < 0.0001$). The chlorhexidine group had statistically significant reductions for probing depth at Week 6 ($p = 0.03$); the effect was more pronounced in shallow sites (probing depth < 4 mm) Week 6 ($p = 0.01$) and Week 12 ($p = 0.01$). The chlorhexidine group also had statistically significant reductions for bleeding on probing in subjects with moderate gingivitis ($p = 0.01$) and in all areas of the mouth ($p = 0.01$ anterior; $p = 0.04$ posterior). The two groups did not differ significantly for stain and plaque indices. **Conclusion:** Flossing with chlorhexidine reduces probing depths and bleeding on probing in subjects with moderate gingivitis compared to flossing alone.

RÉSUMÉ

Contexte : La gingivite est une réaction inflammatoire des tissus gingivaux à la plaque bactérienne qu'on peut traiter avec la brosse à dents et la soie dentaire ou une solution de chlorexidine. Cette étude a donc pour objet d'établir si la soie dentaire préalablement trempée dans la chlorexidine améliore à elle seule la santé buccale. **Méthodes :** Des essais parallèles randomisés ont été menés pendant trois mois chez 27 adultes qui avaient au moins 10 sites de saignement et à qui on avait demandé au hasard d'utiliser de la soie dentaire trempée dans une solution de 0,12% de chlorexidine ou un placebo de sulfate de quinine. Les instructions touchant le débridement et la soie dentaire ont été exécutés la première semaine. On a ensuite évalué la profondeur de sondage, le saignement lors du sondage, la plaque gingivale et les indices de coloration aux semaines 0, 6 et 12. La fidélité d'utilisation de la soie dentaire a été surveillée par le biais des comptes-rendus personnels et la longueur de la soie dentaire utilisée. **Résultats :** Les deux groupes ont utilisé très fidèlement la soie dentaire. Tous les sujets ont présenté une diminution statistiquement significative de l'indice gingival ($p = 0,0001$). Le groupe soumis à la chlorexidine a eu une réduction statistiquement significative de la profondeur de sondage à la 6^e semaine ($p = 0,03$); le résultat a été plus prononcé dans les sites de faible profondeur (< 4 mm au sondage), ($p = 0,01$) à la 6^e semaine et ($p = 0,01$) à la 12^e semaine. Le groupe soumis à la chlorexidine a aussi montré une diminution statistiquement significative du saignement au sondage chez ceux qui avaient une gingivite modérée ($p = 0,01$) et dans toutes les autres parties de la bouche (antérieures, $p = 0,01$; postérieures, $p = 0,04$). Les deux groupes n'ont pas souffert de façon significative des indices de la coloration et de la plaque. **Conclusion :** L'utilisation de la soie dentaire trempée dans la chlorexidine réduit la profondeur et le saignement au sondage chez les sujets qui ont une gingivite modérée, comparativement à la soie dentaire seule.

Key words: chlorhexidine, dental floss, bleeding on probing

INTRODUCTION

Gingivitis is an inflammatory response of the gingiva to bacteria in dental plaque.¹⁻³ Although gingivitis can occur on all gingival surfaces, it is more prevalent in the interproximal areas.⁴ Gingivitis can be treated by mechanically removing the dental plaque by brushing teeth and dental flossing⁴⁻⁶ or by chemically inhibiting plaque formation via chlorhexidine (CHX).⁷⁻⁹

Kinane et al. (1992) investigated a novel flossing device that combined the beneficial aspects of dental floss and CHX to reduce gingival bleeding in gingivitis subjects.¹⁰ No significant differences were found between the CHX and placebo flossing devices.¹⁰ Although the dose of CHX may have been too low,¹⁰ another explanation is that the dental floss in the flossing device blocked the CHX from reaching the interproximal areas.

The purpose of this three-month, double-blinded, parallel randomized controlled trial (RCT) was to determine whether dental floss immersed in CHX would reduce the clinical signs of interproximal gingivitis better than a floss in placebo solution. Since rinsing with CHX is known to

cause extrinsic brown tooth stain,¹¹ a secondary aim was to determine whether flossing with CHX would result in tooth staining.

MATERIALS AND METHODS

The study received approval from the University of British Columbia's Clinical Research Ethics Board (#C05-0513 & H05-70513) and met the requirements of the Tri-Council Policy Statement for Ethical Conduct for Research Involving Humans 1998.

Twenty-seven adults with gingivitis or localized, mild periodontitis were recruited from Vancouver, British Columbia through newspaper advertisements, community advertisements, postings on Craig's List, and referrals. The American Academy of Periodontology (1999) definitions

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of plaque-associated gingivitis and localized, mild chronic periodontitis were used in the study.¹² Plaque-associated gingivitis is defined as gingival inflammation, which is confined to the gingivae with no clinical attachment loss or on stable, but reduced periodontium and is only associated with dental plaque and no other local contributing factors.¹² Chronic periodontitis is defined as a slow progressive disease that results in clinical attachment loss.¹² Chronic periodontitis can be further classified by extent, which is the number of sites that are involved, and severity of clinical attachment loss.¹² For example, localized, mild periodontitis is defined as 1-2 mm of clinical attachment loss in less than 30 per cent of the total sites.¹²

Subjects were enrolled if they were non-smoking adults with gingivitis or localized, mild periodontitis. A minimum of 10 bleeding on probing (BOP) sites was required. Subjects who were accepted into the study were required to floss daily, attend all instructional sessions, and sign a consent form.

Subjects were excluded from the study if they were pregnant or planned to become pregnant within the next three months, were allergic to CHX or quinine sulfate (QS), or were required to take antibiotic premedication for dental treatment. Subjects were also excluded if they had full or partial dentures, extensive crown and bridge coverage, full orthodontic bands and brackets, or generalized, severe periodontitis (i.e., more than 30 per cent of the sites having clinical attachment loss of 5 mm or more).¹² Subjects were excluded or removed from the study if they took antibiotics, Dilantin, Cyclosporin A, Nifedipine or other calcium channel blockers, daily aspirin or anti-coagulants, CHX or whitening products.

The enrolled subjects were randomly assigned to treatment group (CHX), dental floss (Johnson & Johnson Reach® unflavoured waxed dental floss, Montreal, Canada) with 0.12 per cent CHX (Peridex®, Zila Pharmaceuticals, Inc., Phoenix, Arizona), or placebo group (QS), dental floss (Johnson & Johnson Reach® unflavoured waxed dental floss, Montreal, Canada) with 0.1 per cent quinine sulfate solution. The placebo solution was prepared by a pharmacist to taste, smell, and to appear similar to the CHX solution. Subjects were randomized using a block design determined by a person who was not involved with the study in any other capacity. Subjects were enrolled on an ongoing basis between March 2006 and mid-September 2006, at which time the study was closed to accrual to allow the subjects to complete the 3-month study.

The study consisted of four visits over a 3-month period. All potential subjects underwent a screening visit at which medical and dental histories were recorded, periodontal condition and numbers of bleeding points were assessed, and the subject was informed about the nature of the study. If the subject met the inclusion and exclusion criteria, informed consent was obtained and the subject was scheduled for the debridement appointment.

During the debridement appointment (Week - 1) calculus and plaque were removed with a combination of ultrasonic and hand instrumentation. Superficial tooth stains were removed with rubber cup prophylaxis and pumice. Flossing technique was reviewed until the subject

was adept at using dental floss. Additional flossing instructions were available on a video clip on the study website and in the flossing diary. Subjects were requested to brush as usual, but refrain from using electric toothbrushes. Mouthwashes and additional professional dental hygiene services such as scaling, root planing, and rubber cup polishing were also prohibited during the study period.

Approximately one week after the debridement visit, subjects returned for baseline data collection (Week 0), which was collected in the following order: modified Löe and Silness gingival index (GI),¹³ modified Lobene stain index (SI),¹⁴ modified Silness and Löe plaque index (PI),¹⁵ probing depths in millimeters (PD) and modified Ainamo and Bay bleeding on probing (BOP).¹⁶

At the end of the baseline visit, subjects received a randomly-assigned floss and flossing diary to record their flossing activity. Subjects were instructed to brush as usual then floss once a day with approximately 18" (46 cm) of dental floss. They were also requested not to rinse their mouth with water after flossing to prevent the "medicine" from being washed away.

The solution-filled floss container was placed in a heavy glass candleholder to prevent accidental spillage. Subjects were requested to ensure that the dental floss was wet at all times and were given a small bottle with extra solution to refill the floss container as needed. If the subjects thought the floss was getting dry while flossing, they were encouraged to use two pieces of dental floss, i.e., one piece for each row of teeth. All subjects received an Oral-B soft Indicator® toothbrush #40 (Gillette Co., Boston, Massachusetts) and Colgate® regular anti cavity mint toothpaste (Colgate-Palmolive Canada Inc., New York, New York) with instructions to only use these products with their assigned dental floss and not to share the study materials with family members.

At Weeks 6 and 12, measurements were retaken on the same teeth in the same order as Week 0. The dental floss, floss diary, toothbrush, and toothpaste were replenished with a new supply at Week 6. Subjects were questioned about any changes in their medical histories and whether they had experienced any side effects at each of the follow-up visits. To assess flossing compliance, the length of remaining dental floss in the container was measured and compared with the self-reported usage recorded in the flossing diary. If at the end of the study a subject presented with any one or all of these - calculus, stain, and BOP, an exit debridement was performed. All subjects were dismissed at Week 12 and requested to return to their usual oral health care professional for continuing care.

One examiner, who was blinded to the treatment assignments and calibrated before the study began, collected the clinical data on all subjects. All measurements were taken on six sites per tooth (mesial-buccal, buccal, distal-buccal, distal-lingual, lingual, and mesial-lingual) on all teeth except third molars and teeth with crown and bridge coverage. Index scores were averaged per tooth then added together and divided by number of teeth for the subject's full mouth score. Teeth were lightly dried with pressurized air prior to the measurements. Teeth were disclosed with Trace ® disclosing solution (Young dental manufacturing company, Earth City, MO, USA) and lightly rinsed for PI. A

pressure-sensitive, 3-6-9 mm periodontal probe with a point tip diameter of 0.5 mm (Kerr-Hawe Click-Probe®, Kerr U.S.A. 1717 West Collins Avenue, Orange, CA 92867) set at 25 N (Newtons) was used to record the PD and BOP.

Statistical Analyses

An intention-to-treat protocol and whole-mouth scores were used in the statistical analyses. Whole-mouth scores for each subject were computed by adding the subject's individual tooth scores and dividing by the number of teeth. The statistical unit was the subject. According to Barbano and Clemmer (1974), subject level scores approach a continuous scale when ordinal scores are averaged to produce full-mouth scores. The continuity is further enhanced by the fact that many of these studies take the difference between a baseline reading and a reading after some subsequent treatment.¹⁷ Cohen (2001) and Sullivan and D'Agostino (2003) also concluded, "(1) Parametric tests are sufficiently robust relative to typical violations of normality; (2) presumed statistical prohibitions against the application of parametric methods to ordinal data do not actually exist; and (3) 'ordinal' dental indices have sufficient quantitative meaning to be considered quasi-interval. For these reasons, parametric tests should not be avoided; they will be valid and usually more powerful and more easily applied to complex designs than non parametric alternatives."^{18,19} Parametric tests have been used in other studies investigating the effects of CHX.²⁰⁻²² Therefore student t-tests, which are statistical tests comparing the difference between the means of two groups,²³ were used for between treatment and within treatment analyses in this study. All data were tested for normality using qq-plots, "a graphical method for diagnosing differences between the probability distribution of a statistical population from which a random sample has been taken and a comparison distribution."²⁴ In situations where the normality assumption appeared questionable, Wilcoxon tests were performed to ensure that the interpretations of the two methods came to the same conclusions. Alpha was set a priori at 5 per cent.

As predetermined in the research protocol, the primary outcome was BOP. GI, PI, and PD were secondary out-

comes to provide additional information regarding the effects of flossing with chlorhexidine compared to flossing with placebo solution. SI was used to monitor for the common side effect known to be associated with chlorhexidine. Only predetermined stipulated hypotheses were analyzed.

Post hoc exploration of the data was done using stratification and analysis of covariance (ANCOVA) with baseline values as a covariate. Stratifications were done using baseline values. PDs were stratified into groups based on the baseline PD, but the outcome measure was in the follow-up value of millimetres. Ratios were used for the PI scores (Week 0:Week 6, Week 0:Week 12) to establish a common baseline point between the two groups.

RESULTS

Twenty-six (18 women and 8 men) of the 27 enrolled subjects completed the 12-week study. One subject withdrew at Week 6 because she was unable to "get into the flossing habit." The subject flossed for 8 days immediately after being randomized and then ceased flossing prior to the Week 6 visit. Another subject, who was on an extended holiday, missed the Week 6 visit, but continued to follow the research protocol and presented at Week 12. The subjects reported no side effects to the clinical examiner and the clinical examiner did not note any intra-oral side effects in the subjects.

At Week 0, the treatment and control groups were clinically similar for GI, PI, SI, PD, and BOP. Slight mean differences between groups were not statistically significant (Student t-test). Nevertheless, to control for the possibility of these differing baseline values on the outcomes, ANCOVA was conducted using the baseline values as a covariate. The adjusted p-values are reported in addition to the p-values from the Student t-tests.

Probing Depths (PD)

A statistically significant reduction in overall PDs was found for the subjects using the floss presoaked with CHX compared to those using the floss presoaked with the placebo solution at Week 6 (p = 0.03, adjusted p-value = 0.02) in Table 1. At Week 12, the mean overall PD for sub-

Initial probing depth sites (PD)	CHX group (n = 12)		QS group (n = 14)		p-value (2 sample t-test or Wilcoxon Rank Sum test)	Adjusted p-value (ANCOVA with baseline as covariate)
	Mean	SD	Mean	SD		
Week 0						
Overall PD	2.31	0.34	2.42	0.32	0.19	
PD < 4mm	2.11	0.05	2.24	0.03	0.06	
PD ≥ 4mm	4.07	0.03	4.14	0.04	0.14	
Week 6						
Overall PD	2.20	0.24	2.40	0.19	0.03	0.02
PD < 4mm	2.06	0.12	2.23	0.16	0.01	0.03
PD ≥ 4 mm	3.73	1.18	4.05	0.09	0.73	0.50

Table 1: Comparison of overall probing depths (PD) and stratified probing depths (PD < or ≥ 4 mm) for chlorhexidine (CHX) and placebo (QS) groups at Weeks 0 and 6.

Initial probing depth (PD)	CHX group (n = 12)		QS group (n = 14)		p-value (2 sample t-test or Wilcoxon Rank Sum test)	Adjusted p-value (ANCOVA with baseline as covariate)
	Mean	SD	Mean	SD		
Week 0						
Overall PD	2.31	0.34	2.42	0.32	0.19	
PD < 4mm	2.11	0.05	2.24	0.03	0.06	
PD ≥ 4mm	4.07	0.03	4.14	0.04	0.14	
Week 12						
Overall PD	2.29	0.35	2.44	0.20	0.18	0.26
PD < 4mm	2.09	0.16	2.26	0.11	0.01	0.01
PD ≥ 4 mm	3.76	1.13	4.04	0.06	0.85	0.32

Table 2: Comparison of overall probing depths (PD) and stratified probing depths (PD < or ≥ 4 mm) for chlorhexidine (CHX) and placebo (QS) groups at Weeks 0 and 12.

jects using the floss presoaked in CHX remained below baseline values compared to those using the floss presoaked in QS, which rose above its baseline value; however, this was not statistically significant ($p = 0.18$, adjusted p -value = 0.26) as shown in Table 2.

Since dental floss is more effective in PDs that are less than 4 mm,²⁵⁻²⁷ further analyses were conducted with the subjects' gingival sites stratified into PD < 4 mm and PD ≥ 4 mm. At Week 6, there was a statistically significant reduction in PD in sites that were originally less than 4 mm for subjects using the CHX-soaked floss compared to those using the QS-soaked floss ($p = 0.01$, adjusted p -value = 0.03), but not in sites that were initially 4 mm or greater ($p = 0.73$, adjusted p -value = 0.50).

At Week 12, the shallow sites continued to demonstrate a statistically significant reduction in PD for the CHX group but not for the QS group ($p = 0.01$, adjusted p -value = 0.01). There was no statistically significant difference for PD between the CHX and QS groups for the sites that were initially 4 mm or greater ($p = 0.85$, adjusted p -value 0.32).

Bleeding on Probing (BOP)

A statistically significant reduction for BOP (mean change of -0.04) occurred for all subjects ($p = 0.02$) from Week 0 to Week 6, with smaller reductions continuing to occur up to Week 12 (mean change of -0.02, $p = 0.18$). Of the initial positive bleeding sites, 83 per cent stopped bleeding in the CHX group and 78 per cent in the QS group.

As the response to CHX might be related to the level of oral health, further analyses were conducted with the subjects stratified according to "mild gingivitis" (defined for the purposes of this RCT as less than 11 initial positive BOP sites, which was the minimal number of BOP sites to be considered for inclusion into the RCT) and "moderate gingivitis" (11 or more initial positive BOP sites). Only the subjects with moderate gingivitis who used the floss presoaked in CHX had a statistically significant reduction in BOP from Week 0 to Week 6 ($p = 0.01$), shown in Table 3.

Since it is easier for subjects to floss the anterior teeth (canine to canine) as opposed to the posterior teeth (first premolar to second molar),²⁶ further analyses were conducted with the BOP sites separated into anterior and

Gingivitis severity (initial BOP sites)	Floss used	N	Mean change from Week 0 to Week 6	SD	p-value (Wilcoxon Signed Rank test)
Moderate (≥ 11)	CHX	8	-0.12	0.09	0.01
Moderate (≥ 11)	QS	6	-0.08	0.06	0.06
Mild (<11)	CHX	4	0.02	0.04	0.50
Mild (<11)	QS	8	0.02	0.06	0.73

Table 3: Comparison of mean change in bleeding on probing (BOP) from Week 0 to Week 6 for subjects stratified according to mild gingivitis (< 11 initial BOP sites) and moderate gingivitis (≥ 11 initial BOP sites) using floss soaked in either chlorhexidine (CHX) or placebo (QS).

Area in subjects' mouth	Floss used	N	Mean change	SD	P-value (Paired t-tests)
Anterior (canine to canine)	CHX	12	-0.02	0.001	0.01
	QS	13	0.00	0.0004	0.40
Posterior (bicusps to molars)	CHX	12	-0.02	0.002	0.04
	QS	13	-0.01	0.0003	0.06

Table 4: Comparison of the mean changes in bleeding on probing (BOP) for sites stratified according to anterior or posterior areas of the mouth in subjects using either the floss soaked in chlorhexidine (CHX) or placebo from Week 0 to Week 6.

posterior areas. Statistically significant reductions in BOP occurred from Week 0 to Week 6 for the CHX group in both anterior ($p = 0.01$) and posterior areas ($p = 0.04$), seen in Table 4. In comparison, the QS group showed no statistically significant reductions in BOP from Week 0 to Week 6 (anterior, $p = 0.40$; posterior, $p = 0.06$).

From Week 0 to Week 12, subjects using the CHX-soaked floss continued to have statistically significant reductions in BOP in the anterior areas ($p = 0.01$). All other comparisons for BOP between the CHX and QS groups were not statistically significant, depicted in Table 5.

Area in subjects' mouth	Floss	N	Mean change	SD	P-value (Paired t-tests)
Anterior (canine to canine)	CHX	13	- 0.02	0.001	0.01
	QS	14	- 0.01	0.0004	0.09
Posterior (bicuspid to molars)	CHX	13	- 0.01	0.001	0.23
	QS	14	0.00	0.0003	0.32

Table 5: Comparison of the mean changes in bleeding on probing (BOP) for sites stratified according to anterior or posterior areas of the mouth in subjects using either the floss soaked in chlorhexidine (CHX) or placebo from Week 0 to Week 12.

Plaque Index (PI)

Over the 12-week study, a constant mean PI was found for subjects using the CHX-soaked floss and this appeared to differ from the increasing PI in patients enrolled in the QS group shown in Figure 1. However, there was no statistical significant difference between these groups.

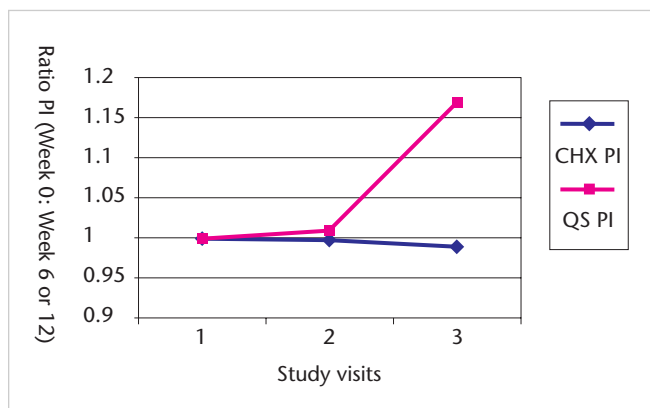


Figure 1: Chlorhexidine (CHX) and placebo (QS) groups ratio plaque index scores Weeks 0 (1), 6 (2), and 12 (3).

Gingival Index (GI)

All subjects had statistically significant reductions in mean GI scores from Week 0 to Week 6 (mean change of -0.56, $p < 0.001$) as well as from Week 0 to Week 12 (mean change of -0.58, $p < 0.0001$) demonstrated in Figure 2.

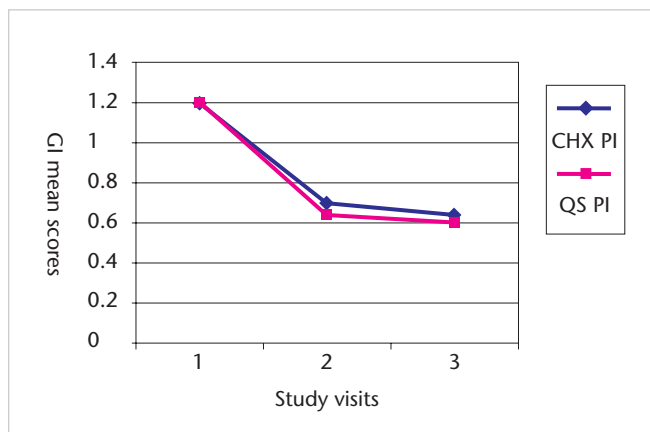


Figure 2: Chlorhexidine (CHX) and placebo (QS) groups mean gingival scores Weeks 0 (1), 6 (2), and 12 (3).

Stain Index (SI)

There was no statistically significant difference between the CHX and QS groups for stain at Week 6 ($p = 0.91$, adjusted $p = 0.52$) or Week 12 ($p = 0.18$, adjusted p -value = 0.32). Both groups had a slight, but not statistically significant, increase in stain over the 12 weeks (mean change 0.05, $p = 0.14$).

Flossing Compliance

Both groups demonstrated high levels of flossing compliance with no statistically significant differences between the groups. At Week 6, the self-reported median flossing compliance was 98 per cent for the CHX group and 97 per cent for the QS group and at Week 12 it was 100 and 93 per cent respectively. Median yards of floss used ranged from 35 to 43 yards (about 32-39 m) per 6-week period.

DISCUSSION

The introduction of a daily flossing regimen resulted in an overall benefit for all study subjects. Flossing, as shown by the results of the positive control group, resulted in statistically significant reductions in BOP scores from Week 0 to Week 6, and to a lesser degree up to Week 12. All subjects also had statistically significant reductions in GI scores over the 12-week study. The reductions in bleeding and gingival index scores found in this RCT are similar to the results found in other studies, which have demonstrated the beneficial effects of flossing for the treatment of gingivitis.²⁵⁻²⁸

However, presoaking the dental floss in CHX solution had additional benefits compared to the floss soaked in the placebo solution. The CHX-soaked dental floss had statistically significant reductions for probing depths in sites that were initially less than 4 mm compared to the floss in placebo solution, which did not demonstrate any statistically significant PD reductions. Both groups did not have statistically significant reductions in PDs for sites that were initially 4 mm or more most likely because dental floss can only effectively deplaque sulcular depths to a maximum of 3 mm.^{25,29,30} The data suggests that the CHX-soaked floss may have been able to carry the CHX into the interproximal area to produce a reduction in PDs less than 4 mm similar to the effects seen by oral irrigation with CHX solution. For example, Flemmig et al. (1990) demonstrated a reduction in probing depths (mean reduction of 4.6 per cent at 6 months, $p < 0.05$) in shallow sulci by irrigating with 0.06 per cent CHX rinse.³¹ Although the method of applying CHX differs, oral irrigation may flush CHX subgingivally into the sulcus³¹ just as dental floss may carry CHX into the sulcus to reduce probing depths.

The CHX-soaked floss also demonstrated additional BOP reductions for subjects with 11 or more initial BOP sites compared to the QS-soaked floss. The subgroup of moderate gingivitis subjects using the CHX-soaked floss had a statistically significant reduction in BOP from Week 0 to Week 6, which continued to a lesser degree up to Week 12. CHX mouth rinse has been shown in other studies to reduce bleeding, with reductions ranging from 46-67%.^{8,9,27,31-35} However, according to Cumming and Løe (1973) and Caton et al. (1993) CHX mouth rinses may have limited effects interproximally.^{4,36} In this study, the

CHX was applied interproximally via a presoaked dental floss and was able to exert an additional effect over what was achieved with flossing alone.

Since individuals can floss the anterior teeth (canine to canine) more effectively than the posterior teeth (first premolar to second molar),²⁶ analyses were conducted with the BOP sites grouped into anterior and posterior sites. The subjects using the CHX-soaked floss had statistically significant reductions in BOP over the 12 weeks for the anterior areas, but only had statistically significant reductions in the posterior areas up to Week 6. The results of this study are similar to those of Wong and Wade (1985) in that the subjects were able to floss the anterior teeth more effectively than the posterior teeth.²⁶

The Silness and Loe (1964) plaque index requires an examiner to see the amount and location of plaque in order to assign a score for the tooth¹⁵; it is the easiest, most portable and cost-effective method to use in the field.³⁷ However, it is not possible to visualize the interproximal surfaces, which were targeted by the CHX-soaked floss. A more sensitive measure that quantifies plaque in the interproximal area needs to be developed.

Numerous studies have shown CHX to be an effective anti-plaque agent.¹¹ In this RCT, the researchers were unable to assess the anti-plaque effects of the CHX-soaked floss because of the limitations of the plaque index; however, the statistically significant reductions in PDs and BOP indicate that the CHX-soaked floss was having a beneficial effect in the interproximal area compared to the placebo-soaked floss in similar sites.

The other benefit of using a CHX-soaked dental floss rather than a CHX mouth rinse is that the floss method may minimize tooth staining. CHX mouth rinse is known to cause tooth staining within a few days of use in 3 out of 4 individuals who use it¹¹ and this is the primary reason for low compliance with the CHX mouth rinse regimen.^{11,21,38-42} However, in this RCT there was no noticeable tooth staining in subjects using the CHX-soaked floss. Both the CHX and QS groups had slight increases in tooth stain over the 12 weeks but this was not statistically significant and may be attributed to dietary sources such as tea and coffee drinking.

Subjects' compliance with the flossing regime was excellent, with most subjects flossing daily. Although the subjects used more than twice the amount of floss than was expected, the high usage corresponded to the high numbers of self-reported flossing days, indicating that compliance was high.

CONCLUSION

In this efficacy study, dental flossing alone reduced GI and BOP scores and therefore, is an effective method for treating gingivitis. However, dental floss presoaked in a 0.12 per cent CHX solution offers additional benefits for the treatment of gingivitis such as, reducing PDs in shallow sulcular sites (PD < 4 mm) and bleeding in subjects with moderate amounts of gingival bleeding. The CHX-soaked floss is also more effective for reducing bleeding in all areas of the mouth, but more so in the anterior sites, than the floss soaked in the placebo solution. Although it was not possible to discern a difference between the groups for

interproximal plaque levels because of the limitations of the PI, the other positive results associated with using the CHX-soaked floss indicates that flossing with the CHX-soaked floss provides additional beneficial effects in the interproximal area compared to flossing alone.

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