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Effects of post-surgical cleansing protocols on early plaque control in periodontal and/or periimplant wound healing

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Abstract

Objective: The aim of this RCT was to evaluate early wound healing following specific post-surgical care protocols.

Material and Methods: Following periodontal flap surgery, 60 patients were randomly assigned to follow one of two post-surgical protocols. Subjects smoking >20 cigarettes per day were excluded. Patients following the control protocol rinsed twice daily for 1 min with 0.1% of chlorhexidine (CHX) for 4 weeks. In addition to CHX rinsing, patients assigned to the test protocol applied CHX locally using a special very soft surgical toothbrush (Chirugia®) from days 3 to 14, and a soft toothbrush (Ultrasuave®) from days 14 to 28, twice daily. Baseline measurements included gingival crevicular fluid (GCF) flow rate, probing depth, probing attachment level, presence of bleeding on probing and full-mouth plaque score. Measurements were repeated at 1, 2 and 4 weeks after surgery.

Results: Both post-surgical protocols resulted in successful wound healing and optimal wound closure at 4 weeks. There were no statistical differences in the GCF flow rate between test and control protocols. There was a lower incidence of recession of $\geqslant 2$ mm following the test protocol.

Conclusion: The use of specific post-surgical cleansing protocols including the introduction of mechanical cleansing at day 3, using local application of CHX in addition to daily rinsing with CHX may be recommended.

Key words: flap surgery; mechanical plaque control; periimplant mucosa; periodontology; wound healing

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The inhibitory effect of bacterial contamination and infection on post-surgical wound healing has been well documented (Burke 1971, Blomlöf et al. 1988, Sanz & Herrera 1998). Following surgical intervention, the healing process develops by an inflammatory response and subsequently the presence of inflammation promotes the rapid formation of a biofilm (Daly & Highfield 1996). In the presence of minimal plaque amounts, periodontal wounds appear to heal faster and with fewer complications than when gross amounts of plaque are allowed to accumulate (Flores de Jacoby & Mengel 1995). Thus, it would seem logical that post-surgical removal of newly formed biofilms plays an important part in the early healing phase after periodontal surgery. In fact, the first European Workshop on Periodontology (Lindhe & Echeverria 1994) stated that the maintenance of a high standard of (post-operative) plaque control is the determining factor for the successful outcome of periodontal surgery.

It is not surprising that a variety of debridement and/or anti-infective measures have been advocated to improve clinical outcomes following surgical intervention. These concepts include (1) meticulous professional mechanical debridement, (2) application of antiseptics in dressings and/or rinses, and (3) administration of systemic antibiotics.

The value of mechanical debridement such as tooth brushing and flossing as a health-promoting concept at large has been extensively documented (Lang et al. 1973, De la Rosa et al. 1979, Axelsson & Lindhe 1987, Boyd et al. 1989, Cutress et al. 1991, Van der Weijden et al. 1995, 1996). However, only a few studies have addressed the

role of meticulous mechanical plaque control enforced by professional supervision following periodontal surgery (Nyman et al. 1975, 1977, Rosling et al. 1976a, b). Nevertheless, the results of these studies have clearly established that optimal plaque control must be a prerequisite for successful treatment outcomes (Nyman et al. 1975, Rosling et al. 1976a). Furthermore, performing periodontal surgical procedures in plaque-infected dentitions results in deterioration rather than improvement of the periodontal conditions (Rosling et al. 1976b, Nyman et al. 1977, Westfelt et al. 1983b). However, there is only limited evidence describing optimum timing, frequency and detailed technique of patient-performed mechanical debridement in the time immediately after periodontal surgical procedures (Bakaéen & Strahan 1980, Sirirat & Tulananda 1985, Noguerol et al. 1991).

This is likely because of discomfort and sensitivity at the surgical site (Noguerol et al. 1991). Sirirat & Tulananda (1985) compared chlorhexidine (CHX), periodontal dressing, and mechanical cleaning post-periodontal surgery, starting brushing the day after surgery, but did not describe the protocol in detail. Similarly, Bakaéen & Strahan (1980) tested 0.1% CHX gel; however, they did not describe the brush, nor the technique, and the brushing presumably began on the day of the surgical intervention.

Many and varied post-surgical-phase oral hygiene protocols have been described in the literature. Studies describing the (longer-term) periodontal outcome of surgical techniques and of post-surgical-phase care describe varying degrees of complexity of mechanical and chemical regimens. Many of these include local anti-microbial application (mostly CHX rinse), a systemic antibiotic, and initial cessation and subsequent reinstatement of mechanical debridement. This cessation often continues for weeks.

Extensive research has been performed to explore the beneficial clinical effects of CHX rinses in controlling supragingival plaque formation (Löe & Schiøtt 1970, Schiøtt et al. 1970). For all oral rinsing products with anti-microbial and anti-plaque properties, CHX has long been considered as the gold standard (Lang & Brecx 1986, Jones 1997). Hence, its application following periodontal surgical procedures should promote the healing process, reduce post-surgical complications, as well as improve clinical parameters (Asboe-Jørgensen et al. 1974, Hamp et al. 1975, Plüss et al. 1975, Langebaek & Bay 1976, Westfelt et al. 1983a).

In experimental animals, improved wound healing was reported following standardised gingivectomy when a 0.2% aqueous solution of CHX digluconate was applied (Hamp et al. 1975). The histometric analysis verified only a slight inflammatory reaction at the test sites, while sites treated with physiologic saline healed by a pronounced inflammatory reaction.

Healing of periodontal wounds was significantly improved by applying a 2% CHX digluconate wound dressing following periodontal flap surgery (Asboe-Jørgensen et al. 1974). Compared with control sites, percentages of bleeding sites following standardised probing and the amount of gingival exudate were significantly lower for up to 5 weeks at the test sites. A planimetric study (Plüss et al. 1975) demonstrated that the amount of plaque forming under a periodontal dressing was significantly smaller when CHX dihydrochloride powder had been incorporated into the dressing.

Finally, a clinically controlled study on post-surgical treatment outcomes clearly established favourable healing conditions when 0.2% CHX digluconate rinses were applied for 2 min twice daily (Westfelt et al. 1983a). In fact, twice daily CHX rinses for 6 months yielded the same treatment outcomes after 6, 12, and 24 months than if a professional tooth-cleaning programme had been instituted every 2 weeks for the same 6-month healing period (Westfelt et al. 1983a, b). These studies definitively established the key role of meticulous plaque removal following surgery as an assurance for optimal healing outcomes.

In contrast, there seems to be no consensus for the use of antibiotics following periodontal surgery. Various protocols, ranging from short-term use of potent antibiotics, such as metronidazole and ciprofloxacin, to relatively long-term (20 days) administration of penicillin V and doxycycline have been proposed (e.g. dos Anjos et al. 1998, Smith Macdonald et al. 1998). However, absolutely no evidence exists to document the superiority of one or the other regimen or the benefit of the use of antibiotics per se following periodontal surgery. In the absence of guidelines for the administration of antibiotics after periodontal surgery, basic principles imported from general surgery and consideration of the ecological and microbiological aspects should govern a very restricted use of these adjunctive measures. It is obvious, however, that the administration of antibiotics must not be considered as a substitute for meticulous plaque control following periodontal surgery.

The purpose of this study was to investigate the clinical effects of two protocols aimed at the regular and complete removal of newly formed biofilms on the early healing following periodontal surgical procedures, including one-stage implant installations.

Material and Methods

Subjects

From the patient pool of the Department of Periodontology and Fixed Prosthodontics, University of Berne, Switzerland, 40 patients aged between 21 and 94 years with 27 female and 33 male surgical sites were recruited after having signed informed consent. Patients younger than 21 years of age, with a medical condition recognised to potentially influence healing conditions, with allergies, having taken antibiotics in the previous 6 months or heavy smokers (more than 20 cigarettes per day or >14 g of nicotine/day) were not included in the study. Patients also had to fulfil the following oral conditions: (1) A full-mouth plaque score (FMPS) and a full-mouth bleeding score (FMBS) of $<25\%$; (2) at least 2 mm of keratinised gingiva at surgical sites; (3) no need for graft or membrane placement during surgery. The State Ethics Commission of the Canton of Berne approved the study protocol before commencement.

All patients were partially edentulous and in need of implant installation or were diagnosed as having chronic periodontitis. The latter patients received systematic periodontal therapy including motivation of the patient, instruction in oral hygiene procedures, and scaling and root planing under local anaesthesia. Following this, the tissues were allowed to heal for a minimum of 6 weeks. At re-evaluation, the need for periodontal surgical intervention was determined on the basis of the presence of residual periodontal pockets >4 mm

with concomitantly achieved low levels of FMPS.

For the partially edentulous patients in need of fixed reconstructions, initial periodontal therapy was implemented as needed prior to implant placement.

Experimental procedures

Within the logistical constraints of using a single examiner, an attempt was made to enrol a sequence of 60 consecutive surgeries performed at the Department of Periodontology and Fixed Prosthodontics. With the exception of one patient all eligible patients accepted to participate in the study.

After completion of the surgical procedures, randomisation into two groups, constituting 30 test and 30 control procedures within the 40 patients, was performed by opening concealed envelopes.

The surgical procedures were performed by eight periodontal specialists from the Department of Periodontology and Fixed Prosthodontics**,** University of Berne. Standardised peri-operative analgesia consisted of 600 mg ibuprofen at the time of surgery and 4 h later, with subsequent doses as required. Sutures were removed at day 7. The healing period under observation lasted 4 weeks following the surgical intervention. All patients were provided with written and oral instructions immediately post-operatively. All post-operative care and instruction was performed by one investigator (F. H.). Patients were instructed to brush teeth not involved in the surgical site twice daily with usual toothbrush dipped in CHX and then rinse with 0.1% CHX mouthrinse timed for 1 min. They were asked to clean these teeth interdentally as usual, but avoid using toothpaste for the 4 weeks (Fig. 1).

At the examinations, teeth immediately adjacent to the surgical sites were debrided professionally. This consisted of supragingival prophylaxis with a rubber cup and CHX gel 0.2% (Plak Out Gel®, KerrHawe, Bioggio, TI, Switzerland) and supragingival interproximal cleaning performed with Triofloss® (Dr Wild & Co. AG, Basel, Switzerland) and CHX gel.

Test group special oral hygiene instructions

In addition to the mentioned post-surgical protocol, the patients assigned to the test procedures were asked to gently wipe the surgical area with the prescribed ultra-soft Chirurgia® (Vitis, Barcelona, Spain) toothbrush from days 3 to 14 post-operatively. The toothbrush was loaded with CHX gel 0.2% (Plak Out Gel®) and used to wipe the dento-gingival area with light vertical strokes. It was emphasised that the brush was to be used purely as a delivery device for the CHX gel. From days 14 to 28, the Chirurgia® toothbrush was replaced with a slightly firmer, but still very soft Ultrasuave® (Vitis) toothbrush. Patients were, again, instructed to load the toothbrush with CHX gel 0.2% (Plak Out Gel®), but now to gently brush the dento-gingival area using a roll technique (Fig. 1).

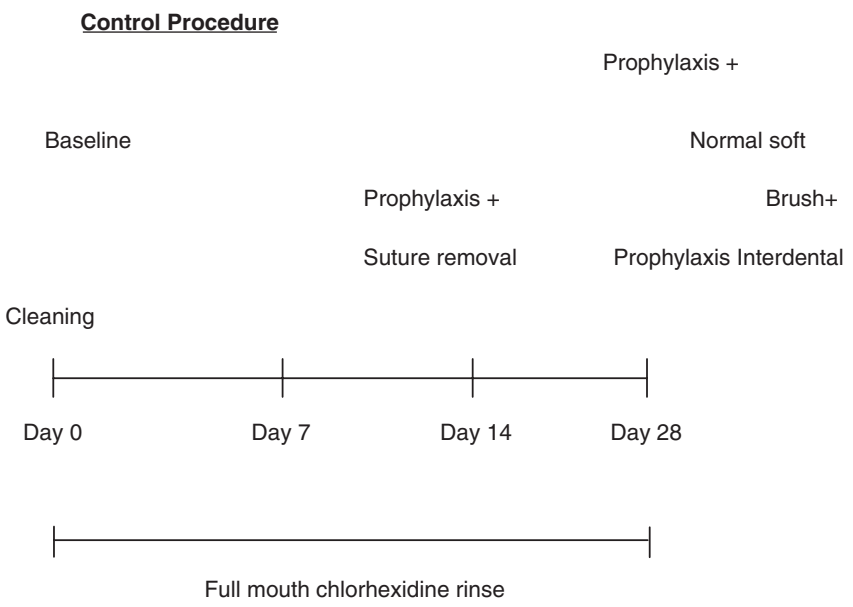

Fig. 1. Experimental design for control and test procedure.

Clinical parameters

The baseline evaluation took place on the day of the surgery in most cases. In four cases, however, this was done 1 week previously. Follow-up examinations were performed at days 7, 14, and 28 post-operatively prior to the professional debridement sequence. For each surgical procedure the most mesial tooth involved in the surgery was evaluated. Suppuration was recorded as present if detected visually at any time or site during the evaluation appointment.

Flap resistance to pressure was measured by applying 0.25 N using a Hawe™ Click-Probe® (KerrHawe), and presence or absence of bleeding following this was noted.

Discomfort at the surgical site was recorded as being present or absent and usage of analgesics (number and type taken the day previously) was noted.

FMPS was determined as percentage of plaque (score $\geqslant 1$; Silness & Löe 1964) at four sites (mesiofacial, mid-facial, distofacial and mid-oral) per tooth. A site-specific plaque score was recorded at the evaluation tooth at six sites per tooth.

At baseline, days 14 and 28, probing depth (PD) and probing attachment level (PAL) measurements were performed using a UNC 15 calibrated periodontal probe with a tip diameter of 0.45 mm by a trained examiner applying light probing force. The probing force had been standardised to 0.3 N or less and the examiner calibrated for reproducibility prior to the study. Bleeding on probing (BOP) was scored following the assessment of PD and PAL.

At all examination periods, gingival crevicular fluid (GCF) flow rate was registered around the evaluation tooth (Holm-Pedersen & Löe 1971). The area was isolated with cotton rolls and air dried for 10 s. Then, the tip of a Periopaper® (ProFlow™ Inc., Amityville, NY, USA) strip was placed at the orifice of the gingival sulcus for 10 s. A Periotron™ (IDE-Interstate, Amityville, NY, USA) instrument at operating temperature was zeroed and calibrated with 5 μl distilled water. Three consecutive measurements of GCF were then

averaged and corrected for the standardised calibration.

In addition, clinical photographs of the pre-operative site with standardised film, exposure, and magnification were obtained.

Data analysis

Data were recorded on patient forms and transferred manually into an SPSS data sheet (SPSS Standard Version, Release 10.1.0). For each surgical procedure the most mesial tooth involved in the surgery was evaluated. The obtained data were first analysed on a patient level. Subsequently, data were analysed on a procedure level. Non-parametric tests were used to compare test and control procedures, respectively.

Results

The 40 patients recruited for the study contributed a total of 60 surgical interventions divided into two groups with different post-operative care protocols. Twenty-four patients had one surgical intervention, 12 had two, and four had three. One patient (assigned two control protocols and one test protocol) did not complete the study because of change of residence. All subjects requested more CHX rinse at week 2 indicating good compliance with the protocols.

The surgical interventions included 35 placements of ITI® (Institute Straumann, Waldenburg, Switzerland) endosseous implants and 25 periodontal flap procedures. The randomisation resulted in equal proportions of post-surgical protocols being attributed to either implant installation or other periodontal surgical (flap) interventions.

Mean FMPS are shown in Fig. 2. Both test and control procedures demonstrated reductions in FMPS from baseline at all subsequent examinations. The FMPS showed a significantly greater decrease from baseline to week 1 and to week 2 in the test group when compared with the control group ($P<0.05$). However by week 4, the difference was no longer significant. The percentage of single surgical sites colonised by plaque was 2.2% (12 out of 540 sites) and 3.5% (19 out of 540 sites) for test and control areas, respectively.

No significant change in GCF volume was detected for either group over the study period, as shown in Tables 1 and 2.

Frequency of change in recession measurements post-surgically is shown in Table 3. It is evident that no sites of the test protocol showed increased recession ($\geqslant 2$ mm) when compared with baseline, while seven control protocol sites yielded increased recession ($\geqslant 2$ mm) following the surgical procedure. The difference in the number of increased recessions following the two protocols was statistically significant ($P<0.05$).

Decreased recession ($\geqslant 2$ mm) compared with baseline (oedema) was found in 23 control and 19 test protocol sites, respectively, while most of the measurements of the post-surgical location of the free gingival margin in relation to the cemento-enamel junction stayed within 1 mm of the baseline measurement.

Table 4 shows the number of wounds without primary closure at each observation period. Although this occurred in only approximately 10% of the interventions, there was a 3:1 ratio of wounds not being closed primarily for control versus test procedures, respec-

Table 1. Mean GCF volume (μl)

	Mean (SD)
Baseline	
test	0.10 (0.14)
control	0.06 (0.06)
Week 1	
test	0.14 (0.18)
control	0.10 (0.07)
Week 2	
test	0.09 (0.15)
control	0.06 (0.05)
Week 4	
test	0.07 (0.15)
control	0.08 (0.14)

GCF, gingival crevicular fluid.

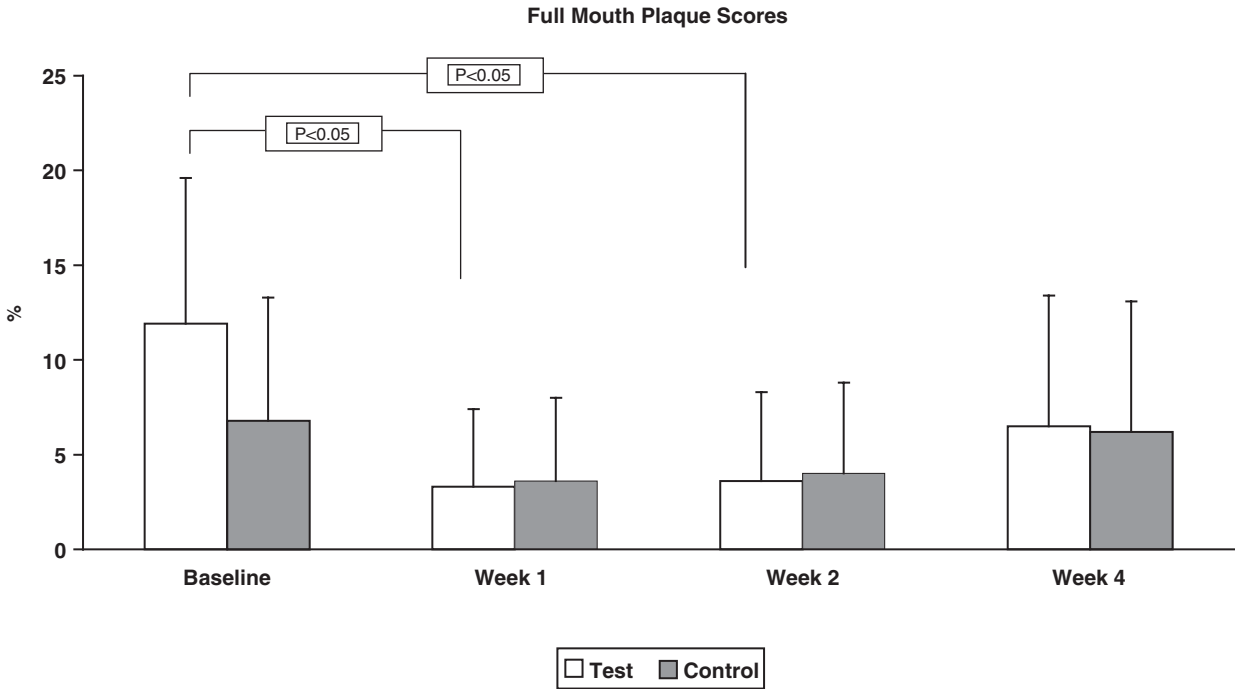

Fig. 2. Full-mouth plaque scores (plaque control record in %, O'Leary et al. 1972) of both test and control post-surgical protocols at baseline, weeks 1, 2, and 4.

Table 2. Difference in GCF volume (vol) from baseline to 1, 2, and 4 weeks

	t-test for equality of means				
	significance (two-tailed)	mean difference	standard error difference	95% confidence interval of the difference	
				lower	upper
vol week 1	0.990	− 0.0005	0.03915	− 0.07887	0.07788
vol week 2	0.415	− 0.0296	0.03593	− 0.10173	0.04261
vol week 4	0.117	− 0.0637	0.03996	− 0.14378	0.01645

GCF, gingival crevicular fluid.

Table 3. Frequency of change in recession post-surgically for control and test procedures

Change in recession from baseline (mm)	Control, $n = 30$	Test, $n = 30$
− 4	1	0
− 3	1	0
− 2	4	0
+2	3	3
+3	1	1
+4	1	0

Table 4. Number of wounds with secondary closure ($n = 60$)

	Baseline	Week 1	Week 2	Week 4
control	4	6	3	0
test	3	2	1	0
Fisher's exact	0.5	0.127	0.276	1

Table 5. Discomfort reported ($n = 60$)

	Baseline	Week 1	Week 2	Week 4
control	0	4	1	0
test	1	2	0	0
Fisher's exact	0.5	0.335	0.481	1

tively. Also, there was an increase in wound dehiscences after 1 week noted in the control protocol, while in the test protocol, the initially three wound dehiscences were reduced by 1 after 1 week and another 1 after 2 weeks. After 4 weeks, all dehiscences in test and control protocols were closed. These observations, however, did not reach statistical significance owing to the small number of dehiscences at the time of surgery.

No suppuration was observed at any time during the study. Discomfort on the day of observation was reported infrequently (Table 5). No statistically significant difference in PD was found between groups at any observation period.

Bleeding in response to the flap displacement test was detected in one subject of each group. Both subject sites tested BOP positive at weeks 1 and 2, but negative at week 4. The BOP assessment yielded 30 positive sites (from a possible 720 sites), evenly distributed between test and control sites.

Discussion

In the present study, attempts were made to post-surgically control the formation of biofilms by mechanically and chemically interfering with early plaque formation, and consequently, to promote the wound-healing process. In comparison with a routine protocol applied following periodontal and implant surgical procedures, the novel cleansing protocol consisted of diligent mechanical cleansing of the wounded area commencing on the third day after the intervention. Specially designed multi-tufted very soft bristle brushes were used both for diligent mechanical cleansing as well as for the application of a 0.2% CHX gel to the site.

Both protocols resulted in similar successful healing outcomes at 4 weeks. The combined mechanical and chemical approach showed a tendency of improvement for a number of subjective and objective wound-healing criteria assessed, when compared with the routine post-surgical protocol. While discomfort was infrequently reported in both groups and at 4 weeks there were no patients experiencing discomfort, fewer patients reported discomfort at 1 and 2 weeks when using the test protocol. These subjective findings paralleled the findings about secondary wound closure. At 1 and 2 weeks, more surgical sites yielded discontinuity between the wound margins. However, at 4 weeks all wounds in both test and control groups were closed.

Wound-healing studies (Stahl 1965, Engler et al. 1966, Harrison & Jurosky 1991a, Selvig & Torabinejad 1996) established that epithelial closure begins immediately following wounding of the gingiva. Epithelial migration from the edge of incisional periodontal wounds on the first post-operative day provided an epithelial barrier by day 3. However, connective tissue healing was not evident before day 14 following wounding (Harrison & Jurosky 1991b). In human extraction sockets, Amler (1969) provided evidence of epithelialisation at day 4 and noted migration at a rate of about 1 mm/day. This resulted in an epithelial wound closure after 3 weeks following tooth extraction. After excisional gingivectomy, most specimens showed formation of new crevicular epithelium at 7 days (Stahl et al. 1968). After an incisional flap, attachment to dentine occurred immediately by formation of a fibrin clot, and decontamination of the wound by neutrophils began within 6 h. At 3 days, fibroblast proliferation, angiogenesis, and matrix production were observed (Wikesjö & Selvig 1999).

On the basis of the fact that the first 2–3 days of wound healing are characterised by a fragile site and an inflammatory reaction to promote decontamination of the area, the third post-surgical day, in the present study, was chosen to start with the mechanical cleansing protocol using a very soft brush to disrupt the forming biofilms. Also, the start of mechanical and chemical plaque control on day 3 after the surgical intervention was considered early enough to interfere with the maturation of existing biofilms (Lang et al. 1973). Earlier studies on the application of CHX containing dressings (Asboe-Jørgensen et al. 1974, Hamp et al. 1975, Plüss et al. 1975, Langebaek & Bay 1976) or rinses with CHX during a post-surgical healing period of 2 months (Westfelt et al. 1983a) have demonstrated the beneficial effects of CHX in a post-surgical care protocol. Also, control of patient oral hygiene as measured by FMPSs and FMBSs were shown by Tonetti et al. (1996) to have a significant effect on success and complication rates of periodontal regenerative surgery. These studies clearly documented the beneficial effects of optimal plaque control during the wound-healing process. The post-surgical protocol of the present study appeared to result in similar

outcomes to the protocols elaborated in the previous studies.

While there is only limited data available supporting the widely held view that soft toothbrush bristles cause less abrasion (Skinner & Tabata 1951, Harrington & Terry 1964), a very soft brush was chosen in the present study as it was considered gentle enough to apply to a fresh surgical site after 3 days. The patients were instructed in the use of a very gentle technique; using the brush was primarily a carrier for the topical application of CHX. In addition, round-ended bristles, similar to those used, have been shown to produce reduced epithelial abrasion compared with sharp-edged bristles (Alexander et al. 1977).

The value of a mechanical delivery aid for CHX was previously shown to be highly effective (Epstein et al. 1994). The ultra-soft toothbrush used in the present study was considered preferable to the foam brush used in the latter study and appeared to have high patient acceptance.

The application of a 1% CHX gel applied to the whole mouth with a toothbrush in a post-surgical protocol, however, showed no difference in GCF flow rate when compared with a placebo application (Bakaéen & Strahan 1980). The present study also failed to yield any differences in the GCF flow rate between test and control protocols, most likely because GCF flow rate determination is affected by the marked inflammatory reaction encountered in early wound healing. No measure of BOP or PPD was done at 3 days, because of an expectation of tenderness of the surgical site (Asboe-Jørgensen et al. 1974).

The post-surgical protocol of the present study yielded no additional gingival recession $\geqslant 2$ mm in the test sites, while in the controls, slightly over 20% of the sites demonstrated significant recession ($\geqslant 2$ mm). This indicates that the proposed post-surgical protocol may indeed affect the wound margins in a very gentle way and allow for undisturbed healing.

This study showed that both protocols used resulted in successful wound healing and optimal wound closure 4 weeks following periodontal flap or implant surgery. Although the beneficial effects on wound-healing parameters such as inflammation did not reach statistical significance, the introduction of gentle mechanical cleansing at day 3 in the test protocol showed a tendency towards improved wound healing with less recession. In light of the fact that the addition of the use of the very soft brush to apply the CHX did not result in any adverse events, and showed a tendency for less discomfort following surgical intervention, it may be routinely used for periodontal and implant surgical procedures.

It was not within the scope of the present study to evaluate long-term effects of the proposed protocol. Therapeutic endpoints of success of periodontal surgical treatment are typically stable or increased attachment levels and elimination of inflammation. The advantages of faster clinical healing and fewer complications are beneficial to the patient in the short term. Whether this translates to a clinically significant long-term effect is a subject for future study.

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