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Early Wound Healing Following One-Stage Dental Implant Placement With and Without Antibiotic Prophylaxis: A Pilot Study

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Abstract

Background—One-stage implant placement has clinically acceptable treatment outcomes. Among other advantages, it may allow investigation of early wound healing. The purpose of this pilot study was to determine whether peri-implant crevicular fluid (PICF) can be used to detect early changes around implants placed with one-stage surgical protocol following 1 week of healing.

Methods—Twenty subjects (11 males and nine females; aged 22 to 72 years; two smokers) were included. Exclusion criteria were allergies to amoxicillin and systemic conditions that may affect healing. Subjects had a healthy periodontium and needed a single implant; eight received antibiotic prophylaxis, and 12 served as controls. Clinical healing was evaluated with plaque and gingival indices (PI and GI, respectively). Gingival crevicular fluid (GCF) from the surgical site was obtained prior to the surgery, whereas PICF was collected at the 1-week visit. Enzyme-linked immunosorbent assay was used to determine GCF/PICF interleukin (IL)-1β and -8 concentrations. Peripheral blood and GCF antibiotic levels were measured by high-performance liquid chromatography.

Results—Postoperative PI and GI were slightly increased. Total GCF and PICF volumes did not show a significant difference between appointments. There was an increase in PICF IL-1β and -8 levels at 1week postoperatively. Mean amoxicillin serum concentration was 5.1 ± 2 μg/ml at 1 to 4 hours following the initial dose, whereas GCF amoxicillin levels were below the limit of detection. Antibiotic prophylaxis had a modest effect on clinical indices (PI and GI) and no appreciable effect on biomarkers.

Conclusions—PICF content can be studied as early as 1 week following one-stage implant placement. The results raise doubts regarding the clinical usefulness of amoxicillin prophylaxis.

Keywords

Cytokines; dental implants; gingival crevicular fluid; wound healing

Patient demand for one-stage dental implant placement and immediate/early/progressive-type loading practices, with associated shorter healing periods, is increasing. However, immediate post-surgical healing outcome is not always predictable, and clinical tools to evaluate different phases of early wound healing are not available. Similarly, there is a lack of information for evidence-based postoperative care protocols. For instance, the routine use of prophylactic

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antibiotics in implant dentistry continues to be controversial.[1–3] Although a limited number of clinical studies[1,4,5] reported a positive effect on implant survival, other studies[2,6,7] showed no significant effect.

Healing around endosseous implants involves hard and soft tissues.[8] Peri-implant bone healing can be defined in distinct phases, including osteoconduction, *de novo* bone formation, and bone remodeling, [9] whereas soft tissue healing proceeds in inflammatory, proliferative, and remodeling phases.[10,11] There is no distinct separation between these phases; the inflammatory phase initiates wound healing through hemostasis, coagulation, increased vascular permeability for specialized cells, and chemotaxis. Implants may differentially interfere with the surrounding gingival tissues and bone, especially early during healing, as a result of the presence of the titanium surface and the lack of periodontal ligament and its blood supply.[12]

Gingival crevicular fluid(GCF) is a complex mixture of substances derived from serum, host tissues, and structural cells of the periodontium as well as from oral bacteria.[13,14] The peri-implant gingival crevice seems to be similar to the periodontal sulcus with respect to crevicular fluid flow and microflora.[15] In addition, GCF and peri-implant crevicular fluid (PICF) basically become wound fluids and may be used to evaluate phases of healing following a specific therapy, including dental implant–placement procedures. Several mediators, such as the proinflammatory cytokines interleukin (IL)-1β and -8, have been investigated in GCF/PICF as potential diagnostic markers for periodontal and peri-implant health and disease conditions.[16–19] IL-1β controls the extracellular matrix degradation activity of the plasminogen activator system during inflammation and wound healing.[20] IL-8 has various effects on the activity and function of neutrophils, including induction of adhesion to endothelial cells, transmigration, chemotaxis, exocytosis of primary and secondary granules, and the respiratory burst.[21] This cytokine makes important contributions to the maintenance of local host–parasite equilibrium and to the limitation of neutrophil-associated tissue damage.[22]

The aim of this pilot study was to determine whether GCF and PICF obtained from surgical sites could be used to evaluate early changes around dental implants placed with one-stage surgical protocol following 1 week of healing. This short-term observation period was chosen to detect very early events occurring at the soft tissue level following surgery. The possible correlation among clinical parameters and the two major proinflammatory cytokines involved in early wound healing was investigated in the presence and absence of antibiotic prophylaxis.

MATERIALS AND METHODS

Subject Selection and Study Design

The study design was based on a previously published protocol.[23] Briefly, 30 partially edentulous subjects who had accepted a treatment plan for a single-tooth, one-stage, dental implant placement were recruited from the patient pool of the Graduate Periodontology Clinic at The Ohio State University (OSU) between September 2005 and March 2007. Inclusion criteria were as follows: age ≥18 years; one bounded edentulous space, i.e., a single missing tooth with intact adjacent teeth; systemically healthy; periodontally healthy or presenting with mild gingivitis; and able and willing to provide informed consent. Exclusion criteria were allergies to amoxicillin, any systemic conditions that may affect the healing process, absence of mesial or distal tooth adjacent to implant site, absence of keratinized tissue at the implant site, need for simultaneous hard or soft tissue grafting, and unable or unwilling to comply with study procedures and visits. Exit criteria were voluntary withdrawal, non-compliance with study procedures or visits, and the development of systemic or oral diseases in conflict with the exclusion criteria. The study protocol and informed consent forms were approved by the Institutional Review Board of OSU. All participants provided written informed consent prior to entry into the study.

The study design was a prospective observational trial. Subjects were assigned to one of the two groups based on their need to take prophylactic antibiotics (e.g., because of a history of complications at the surgical site, such as history of apical lesions, endodontic complications, and/or periodontal abscess). At the time of surgery, all subjects were periodontally healthy as indicated for dental implant–placement procedures. Those who were assigned to take antibiotics were given amoxicillin, 2 g, 1 hour prior to surgery and 500 mg, three times a day, for the first postoperative week.[24] Subjects were required to participate in three visits: initial consultation, surgery/implant placement, and 1 week postoperatively.

Surgical Protocol

Screw-type, root-form, two-piece dental implants,[§][‖] originally designed for one-stage surgery, were placed using a standard one-stage surgical protocol, following the manufacturer's recommendations. Full-thickness flap elevation extending to the mucogingival junction was performed. Following site preparation, all implants were placed flush with the alveolar crest by using a custom-made surgical stent. The manufacturer- provided healing abutment was inserted instead of a cover screw, and soft tissues were sutured with interrupted non-absorbable sutures. The mean height of the healing abutment was 3mm. To avoid injury to the surgical site, subjects were instructed to refrain from performing mechanical plaque control in the surgical area during the first postoperative week. Thus, they were prescribed a 0.12% chlorhexidine rinse twice daily for the same period as standard postoperative care protocol. Sutures were removed at the 1-week postoperative appointment.

Clinical Parameters

Initial documentation, including probing depths, recession, clinical attachment levels on all six sites per tooth, furcation involvement, and tooth mobility, was completed to reach a periodontal diagnosis.[25] Based on inclusion criteria, only periodontally healthy individuals were included in this study. Plaque and gingival indices (PI and GI), using four tooth/implant surfaces, were obtained by a single calibrated examiner prior to surgery on all teeth present within the surgical sextant and repeated for teeth and implant at 1week postoperatively.[26,27] The calibrated examiner, who collected peripheral blood samples and clinical measurements, was not masked to the different groups.

GCF and PICF Collection

GCF for cytokine determinations was obtained from the surgical quadrant immediately prior to surgery, whereas GCF samples to determine local amoxicillin levels were obtained immediately after the surgery. PICF was obtained from the newly forming peri-implant crevice at 1 week postoperatively prior to suture removal. The area was isolated with cotton rolls, and the gingival tissues were dried with a gentle stream of air. GCF and PICF were collected for 20 seconds using a sterile filter paper strip.[¶] Briefly, a paper strip was gently introduced into the newly forming crevice until a slight resistance was felt. Any samples that contained blood or plaque were discarded. GCF/PICF volume on each strip was measured with an electronic volume quantification unit[#] calibrated with distilled water.[28,29] Similar to PI and GI, GCF/PICF samples were collected from four sites per tooth or implant and were repeated twice per site (e.g., mesial, distal, buccal, and lingual sites). Strips assigned for enzyme-linked immunosorbent assay (ELISA) were placed in an enzyme reaction buffer containing 50 mM Tris-HCl, 0.2 M NaCl, and 5 mM $CaCl_2$ at pH 7.5 and centrifuged at 13,000 × g for 10 minutes; the supernatant was kept frozen at −80°C.[30] Strips assigned for high performance liquid

[§]Astra Tech Dental Implant, Astra Tech, Mölndal, Sweden.
[‖]Zimmer Dental, Carlsbad, CA.
[¶]Periopaper, Proflow, Amityville, NY.
[#]Periotron 8000, Oraflow, Plainview, NY.

chromatography (HPLC) assay were placed into a sterile vial with no buffer and kept at −20° C.[31]

Peripheral Blood Sampling

Peripheral blood samples were obtained immediately after surgery from subjects who were prescribed amoxicillin. Blood was drawn into a 5-ml vial using a blood collection set.[**] Vials were stored overnight at 4°C. Serum was separated the next day and kept frozen at −20°C until assay.

ELISA

Commercially available quantitative sandwich enzyme- linked immunoassay kits[††] were used to detect IL-1β and -8 cytokine levels in GCF/PICF samples, following the manufacturer's instructions. Each sample and standard was run as duplicates within the same plate. The intensity of the color was measured by absorbance at 450 nm. The mean minimum detectable concentration was 3.5 pg/ml for IL-8 and 1 pg/ml for IL-1β. Cytokine concentrations were calculated by using a dilution factor for each cytokine for a specific plate and converted back into a concentration derived from the original total GCF/PICF volume collected.

HPLC

Amoxicillin was separated on a column (150 × 4.6 mm)[‡‡] and detected by absorbance at 227 nm. The HPLC method for detecting amoxicillin concentration in serum and GCF was modified from the techniques published by Jehl et al.[32] and Tenenbaum et al.[33] Briefly, a 200-μl serum sample was deproteinized with an equal volume of acetonitrile. The sample was centrifuged, and the supernatant was recovered. Methylene chloride was added to the supernatant, and the sample was mixed by rotation for 10minutes at 20 revolutions per minute(rpm). Ten microliters of this aliquot was injected into the HPLC instrument. GCF samples on paper strips were extracted with the method described by Offenbacher etal.[31] A small opening was prepared at the bottom of the microtubes, and they were placed into 1-ml Eppendorf tubes. Paper strips placed into microtubes were soaked with 150 μl acetonitrile and centrifuged. Collected solution was obtained from the bottom of the 1-mlEppendorf tube. Methylene chloride was added and shaken by rotation for 10 minutes at 20 rpm. Then the mixture was centrifuged at 1,600 × g, and an aliquot of the upper aqueous layer was collected; 10 μl of this aliquot was injected into the HPLC instrument. The detection limit for amoxicillin was 2.5 ng.

Statistical Analysis

Computer software[§§] was used to conduct the statistical analysis. Between-group differences in clinical parameters, total crevicular fluid volume, and cytokine levels at baseline and the 1-week postoperative appointment were analyzed by the exact Mann-Whitney U test. Within-group differences for each parameter between baseline and the 1-week postoperative appointment were analyzed by the exact Wilcoxon signed-rank test. The correlation between clinical indices and cytokine concentrations was analyzed using the Spearman correlation analysis. The level of statistical significance was set at $\alpha = 0.05$.

[**]Becton Dickinson Vacutainer, Becton Dickinson, Franklin Lakes, NJ.
[††]Quantikine, R&D Systems, Minneapolis, MN.
[‡‡]Beckman Ultrasphere ODS C18 column, Beckman Coulter, Chino, CA.
[§§]SPSS version 15, SPSS, Chicago, IL.

RESULTS

Study Population

Of the 30 original subjects, 20 subjects (11 males and nine females) completed the study. Four subjects were removed for treatment considerations (e.g., intraoperative determination of a two-stage dental implant placement instead of one-stage procedure because of the need for bone grafting around the newly placed dental implant), and six subjects were excluded for failure to comply with the requirement of a 1-week postoperative appointment (no variations were allowed to the 7-day protocol). The demographics of the 20 subjects and surgical sites are given in Table 1. Two subjects were smokers. Most implants (81%) were located in the posterior sextant, with a similar distribution between the maxilla and mandible.

Clinical Parameters

Post-surgical PI and GI at surgical sites were increased slightly (Table 2), and both indices were statistically correlated (Spearman correlation analysis, r = 0.5; $P = 0.005$). However, there were no statistically significant changes in GI within the control and antibiotic groups (Wilcoxon signed-rank test, $P = 0.08$ for control group and $P = 0.53$ for antibiotic group). The increase in PI at the 1-week postoperative appointment was statistically significant for the control group only (Wilcoxon signed-rank test, $P = 0.05$ for control group and $P = 0.27$ for antibiotic group). In comparison, GI was significantly lower in the antibiotic group compared to the control group at the 1-week postoperative appointment(Mann-Whitney U test, $P=0.04$; Table 2).

Comparison of the total volume of crevicular fluid per tooth at baseline and per implant at the 1-week postoperative appointment revealed no difference in the control or antibiotic group (Wilcoxon signed-rank test, $P = 0.35$ and $P = 0.48$, respectively; Table 2). There were no statistically significant differences between the groups at any time (Mann-Whitney U test, $P = 0.18$ for control group and $P = 0.23$ for antibiotic group; Table 2).

IL-1β and -8 Concentrations in GCF/PICF During Early Healing

An approximately two-fold increase inPICFIL-1β concentration was observed at the 1-week postoperative appointment compared to baseline GCF levels; however, this increase was statistically significant only in the antibiotic group (Wilcoxon signed-rank test; *P* values for control and antibiotic groups were 0.11 and 0.05, respectively; Table 2). There was no statistically significant difference between control and antibiotic groups at any time (Mann-Whitney U test, *P* values for baseline and 1-week postoperative appointments were 0.82 and 0.67, respectively). However, the increase observed in IL-1β concentrations, in general, was correlated with the increase observed in GI (Spearman correlation analysis, r = 0.5 and $P = 0.003$ for GI and r = 0.3 and $P = 0.106$ for PI).

The IL-8 concentration was also increased at the 1-week postoperative appointment compared to baseline values. Similarly, this increase was statistically significant only in the antibiotic group (Wilcoxon signed-rank test, *P* values for control and antibiotic groups were 0.12 and 0.02, respectively; Table 2). There was a positive correlation between IL-8 concentrations and changes in clinical indices (r = 0.4 and $P = 0.05$ for GI and r = 0.33 and $P = 0.08$ for PI). IL-8 concentration at the time of surgery was statistically lower in the antibiotic group compared to the control group (Mann-Whitney U test, $P = 0.02$).

Amoxicillin Levels in Serum and GCF

Amoxicillin serum levels were determined by using serum samples obtained immediately after surgery (completed between 1 and 4 hours following the initial dose of amoxicillin, 2 g, taken orally). HPLC results revealed a mean amoxicillin serum concentration of 5.1 ± 2 mg/ml

(median, 5.5 μg/ml; range: 2.3 to 8.2 μg/ml). GCF amoxicillin levels were below the detection levels of the experimental technique used in this study.

DISCUSSION

We previously reported changes in clinical parameters together with subgingival flora formation during early wound healing following one-stage dental implant placement.[23] The present pilot study used the same wound model to investigate the clinical and biologic markers of early soft tissue healing around dental implants placed following a one-stage surgical protocol, in the presence and absence of antibiotic prophylaxis. The short-term evaluation of healing (i.e., 1 week) was chosen for this pilot study to determine early events occurring at the soft tissue level within the time limitation of antibiotic prescription. The results indicated that it is feasible to collect PICF samples during the first week of healing following implant placement and detect variations in biomarkers. The results also indicated that systemic amoxicillin may have a modest effect on clinical parameters during the first postoperative week and may have a limited, if any, effect on biomarkers. To the best of our knowledge, the work presented here is the first study to address the effectiveness of a prophylactic antibiotic prescription in early wound healing around dental implants placed with a one-stage surgical protocol.

Indices specific for plaque accumulation and the severity of gingival inflammation were used together with the total volume of crevicular fluid to evaluate clinical wound healing. The purpose of sampling GCF prior to surgery and PICF at 1 week following the surgery was to investigate whether crevicular fluid can be used as wound fluid rather than to compare periodontal and peri-implant structures. Previous studies[34] discussed the sensitivity and specificity issues related to GCF sampling and volume determination methods. To maximize volume collection of GCF, sterile absorbent filter strips were used to collect GCF/PICF samples in the current study. The advantages of this technique are the simplicity, non-traumatic handling, and ability to collect site-specific samples. Some problems associated with GCF collection are possible contamination with blood, saliva, or plaque that could affect the volume recorded.[35] Also, sampling time should be considered because prolonged collection times may affect the protein concentration within the sample.[36] Furthermore, evaporation of the sample is a significant problem in accurate volume determination.[29,34,36] To minimize contamination, careful isolation was performed using cotton rolls in the surgical quadrant, and collection time was limited to 20 seconds/strip.[37] This sampling time was chosen to control blood contamination, yet to collect enough crevicular fluid for ELISA and HPLC. To minimize evaporation, immediate transfer of the sample papers to the electronic gingival fluid measuring device and sealing of the collection tubes after the introduction of each sample strip was confirmed.[27] In addition, the same amount of strips was used for each site and each subject, and all sampling procedures were completed by a single, calibrated examiner. The difference in crevicular fluid volume between two samples obtained from the same site was negligible (data not shown).

Chlorhexidine mouthrinse is generally prescribed as gold standard care following periodontal and implant-related surgeries. Extensive research has been performed to investigate the clinical effect of chlorhexidine rinse on plaque formation and gingivitis at the wound site.[38–40] PI and GI are routinely used clinical parameters to evaluate such responses during early soft tissue healing. As part of the standard postsurgical care protocol in the training center at OSU, subjects were prescribed chlorhexidine (0.12%) for the first week following implant-placement surgery. This may have had an effect on periodontal clinical parameters and crevicular fluid content. However, it would not have had any differential effect between the groups because all subjects were given the same prescription. In addition, it was reported that chlorhexidine is not as effective on clinical parameters and GCF volume if patients have supragingival plaque

accumulation.[41] The postoperative PI was higher in our study, as expected, because the subjects were not allowed to perform mechanical cleaning at the surgical site. An increase in GI at 1 week of postoperative healing is expected because of the normal inflammatory response to injury. The increase in PI and GI in the 1-week postoperative period in the control and antibiotic groups in the presence of chlorhexidine rinse raises doubts regarding the clinical usefulness of amoxicillin prescription on plaque accumulation and gingival inflammation during early peri-implant soft tissue healing.

In the present study, there was no statistically significant difference between the total volume of crevicular fluid per tooth at baseline and per implant at the 1-week postoperative appointment. Previous studies[42,43] reported an association between crevicular fluid production and clinical/histologic signs of inflammation around teeth or implants. The observed difference is partly the result of variations in the sample area from which the fluids were collected, which may depend on sulcus depth or anatomic variations. [34] It may be difficult to detect such individual variations because the sample size was small in the current pilot study. Among the variables, the two implant systems used in this study have different thread pattern designs and require different osteotomy procedures. However, the collar portion is similar (no polished collar versus 1-mm polished collar), and both systems require implant placement flush with the alveolar crest. We previously reported that one-stage surgical placement of these two systems with a standard 3-mm healing abutment was not associated with statistically significant differences in probing depths, which may potentially affect crevicular fluid volume. [23] Probing depths stay fairly stable for up to 12 weeks of healing, independent of the original flap thickness. [23] Also, the anatomic location may affect soft and hard tissue thickness around a newly placed dental implant. Most of the implants in the current study were placed in a posterior sextant with ideal hard and soft tissue support around the dental implant, because this was one of the prerequisites for the one-stage surgical protocol.

For the present study, IL-1β and -8 were chosen as two proinflammatory cytokines possibly involved in the early phases of the inflammatory process related to wound healing. It was reported that surgical wound healing in an inflamed site with plaque accumulation results in prolonged production of IL-1, which may be a reflection of the extent of tissue trauma and delayed wound healing.[44,45] In addition, levels of IL-8 were shown to correlate with levels of IL-1β in GCF.[46] The current study showed an increase in IL-1β and -8 PICF concentrations at the 1-week postoperative control appointment compared to baseline GCF values. Although the variation among individuals was large, this observed increase was statistically significant for both cytokines in the antibiotic group. It is known that the total amount of a cytokine varies based on the volume of GCF in the sulcus.[34] Consequently, the concentration (pg/ml) instead of the total amount of cytokine (total picograms) was reported, with the adjacent tooth or newly placed implant being the unit of statistical analysis. However, the total collected volume of GCF/PICF was very similar between and within the groups.

Various mediators of inflammatory processes have been investigated within PICF in relation to peri-implant pathogenesis.[16,17] Prostaglandins, cytokines (IL-1α and -1β and tumor necrosis factor-alpha), and various growth factors (transforming growth factor-beta and vascular endothelial growth factor) were detected in PICF and/or soft tissue biopsies obtained around osseointegrated implants during the uncovery stage of treatment or from implants with peri-implantitis or mucositis. [16,47,48] Similarly, a correlation of peri-implant health and myeloperoxidase levels was reported for already osseointegrated dental implants.[49] Also, the role of the nitric oxide pathway in dental implant stability before and after loading was investigated by detecting nitrite, a stable end product of nitric oxide oxidation within PICF. [50] In the current study, it was possible to collect PICF as early as 1 week following one-stage implant- placement surgery without blood contamination. This, in turn, allowed the detection of variations in IL- 1β and -8 cytokine concentrations during the first week of actively ongoing

osseointegration. Several other biologic mediators are important in wound healing and should be studied around healing implants to better understand the different phases of healing.

The rationale behind prophylactic antibiotic prescription prior to dental implant placement is the possible contamination risk of the surgical site through the previously existing severely decayed, periodontally and/or endodontically involved teeth. Amoxicillin is generally the preferred penicillin for prophylaxis because it is well absorbed in the gastrointestinal tract and provides high and sustained serum concentrations. [51] Subjects who were prescribed amoxicillin following dental implant–placement surgery were included in this pilot study to determine whether the presence of amoxicillin within the peripheral blood and/or within GCF had any effect on early wound healing. The decision related to a need for antibiotic prophylaxis was finalized prior to consenting and was performed independent from researchers. This was important to control for possible bias in subject distribution between control and antibiotic groups. The mean amoxicillin concentration within peripheral serum samples taken 1 to 4 hours following a 2-g initial dose was in accordance with published data regarding the pharmacokinetics of the drug.[52] The local amoxicillin concentration within GCF obtained immediately after implant-placement surgery was also studied. However, HPLC readings were too low to detect amoxicillin peaks. One significant factor is that amoxicillin is a beta-lactam antibiotic susceptible to beta-lactamases that destroy the beta-lactam ring, resulting in deactivation of the drug.[33] Several bacteria present in the oral flora and GCF are known to release beta-lactamases.[33] Thus, amoxicillin may not be beneficial or it may not be the correct antibiotic to prescribe if the goal is to prevent the negative effects of local bacterial contamination on peri-implant wound healing. These results raise doubts regarding the clinical usefulness of amoxicillin prophylaxis. The current results also suggest that the local concentrations of alternative antibiotics within GCF/PICF and their possible effect on early wound healing merit investigation.

CONCLUSIONS

It is possible to collect PICF as early as1week following one-stage implant-placement surgery without blood contamination. Specific proteins in PICF can be studied to evaluate early wound healing. Amoxicillin can be detected in peripheral blood samples shortly after the initial oral dose. However, it is not possible to detect amoxicillin within GCF collected immediately following one-stage implant-placement surgery. In addition, amoxicillin prophylaxis seemed to have a modest effect on the examined clinical parameters, although it did not seem to affect the observed changes in the investigated biomarkers. Further studies are necessary to investigate the effectiveness of postoperative care protocols. The authors are conducting additional clinical studies to determine the efficacy of various aspects of postoperative care protocols following dental implant –placement surgery, including systemic antibiotics other than the one used in the current study.

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Table 1

Subject Demographics

	Control Group* (n = 12)	Antibiotic Group (n = 8)
Gender (n)		
Male	6	5
Female	6	3
Age (years; mean ± SD)	54.2 ± 13	51 ± 17
Smokers (n)	1	1
Implant location (n)		
UA	2	1
LA	0	1
UP	4	3
LP	8	3
Implant type (n)		
Type 1†	8	5
Type 2‡	4	3

UA = upper anterior sextant; LA = lower anterior sextant; UP = upper posterior sextant; LP = lower posterior sextant.

* In the control group, two subjects provided two independent sites with a missing single tooth.

† Astra Tech Dental Implant, Astra Tech, Mölndal, Sweden.

‡ Zimmer Dental Implant, Zimmer Dental, Carlsbad, CA.

Table 2

Clinical Parameters, GCF/PICF Volume, and GCF/PICF Cytokine Concentrations (median [range]) During Early Wound Healing

	Control Group		Antibiotic Group	
	Baseline GCF	**1-Week PO PICF**	**Baseline GCF**	**1-Week PO PICF**
GI	0.83 (0.16 to 1.33)	1 (0.66 to 1.66)	0.83 (0.3 to 1.33)	0.73 (0.6 to 1)
			0.04	
PI	0.83 (0.66 to 1.4)	1.2 (0.83 to 1.5)	0.83 (0.6 to 1.33)	0.83 (0.4 to 1.33)
		0.05		
GCF/PICF volume (μl)	6.1 (5 to 7.5)	5.3 (3 to 8.3)	7.4 (4.7 to 11)	7.4 (3.2 to 9)
μl/20-second strip	0.56 (0.33 to 0.72)	0.47 (0.25 to 0.68)	0.62 (0.48 to 1)	0.55 (0.25 to 1)
GCF/PICF IL-1β (pg/ml)	297 (41 to 667)	428 (149 to 1,767)	278 (87 to 681)	446 (213 to 882)
				0.05
		0.02		
GCF/PICF IL-8 (pg/ml)	2,368 (1,624 to 5,024)	4,674 (1,952 to 15,668)	1,079 (248 to 2,960)	3,400 (695 to 9,040)
				0.02

PO = postoperative.

Values in **bold** are *P* values for within- and between-group comparisons.