Clinical and Radiographic Evaluation of Soft and Hard Tissue Changes Around Implants: A Pilot Study

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Clinical and Radiographic Evaluation of Soft and Hard Tissue Changes Around Implants: A Pilot Study

Julio Cesar Joly,* Antonio Fernando Martorelli de Lima,* and Robert Carvalho da Silva*

Background: The aim of this study was to evaluate the clinical and radiographic changes in the peri-implant tissues around one-stage implants with different smooth neck portion lengths before and after functional prosthetic loading.

Methods: Twelve one-stage implants were placed in adult patients with bilateral edentulous posterior mandibular ridges. The sites were randomly assigned into two groups of six each: group 1: 2.8 mm neck implants and group 2: neck implants. The parameters plaque index (PI), gingival index (GI), probing depth (PD), gingival margin level (GML), relative clinical attachment level (r-CAL), and optical density (OD) were measured at loading (4 months) and 12 months after implant placement. The radiographic parameter osseous level (OL) was measured at implant placement, loading, and at 12 months. Analysis of variance and the paired Student *t* test were used to detect difference over time and between groups.

Results: The results showed significant differences ($P<0.05$) for both groups for PD, r-CAL, and OL for intragroup comparisons over time. However, no significant differences were found for PI, GI, PD, GML, OD, and OL for between-group comparisons.

Conclusion: Bony loss occurred before loading, supporting the soft tissues and maintaining the biologic width irrespective of the smooth portion length. *J Periodontol 2003;74:1097-1103.*

KEY WORDS

Bone loss/prevention and control; follow-up studies; peri-implant diseases/prevention and control.

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The classic parameters to evaluate the success rates of endosseous implants are the lack of mobility, discomfort, and persistent infection; absence of pain; and continuous periapical radiolucence.[1,2] These criteria evaluate the integration of the mineralized bone to the implant but provide little information about the soft tissues adaptation.

Historically, these features accounted for the popularity of the submerged two-stage implants.[3] In the early 1980s, Schroeder et al.[4] used one-stage non-submerged implants to demonstrate the soft tissue attachment/contact around the transmucosal portion, and since then, clinical and histometrical parameters have been used to define the peri-implant mucosa response.[5]

The peri-implant tissue is an adaptation of the masticatory mucosa. It is composed of connective tissue coated by layers of epithelial cells[6] that attach to the implant surface forming the junctional epithelium.[7] Gingiva around teeth and peri-implant mucosa have been shown in human studies to have similar epithelial and connective organization.[8,9]

Cochran et al.[10] stated that the biologic width around one-stage implants is physiologically and dimensionally stable before and after loading. Hermann et al.[3] performed histometric analysis from the transmucosal region of unloaded and loaded one-stage implants. They observed dynamic changes over time in the dimensions of gingival sulcus, junctional epithelium, and connective tissue zone; however, the overall biologic width did not change, under

loaded or unloaded conditions. These results suggest that the biologic width is a stable tissue unit.

The guideline that vertical bone height loss during the first year after loading should not exceed 1.5 mm is frequently used to evaluate the success of submerged implants.[1,2] The reason peri-implant bone loss may reach the first threads is not completely understood. One possible explanation is the necessity of maintaining the biologic width in order to accommodate the soft tissues.[10]

Weber et al.[5] evaluated the changes around one- and two-stage implants and observed that the alveolar crest level was similar for both non-submerged and submerged approaches. However, the extension of the epithelial cells was increased in the latter and it was always placed apical to the implant-abutment gap.

The aim of this study was to evaluate the clinical and radiographic changes in the peri-implant tissues around one-stage implants with different smooth neck lengths, before and after functional prosthetic loading.

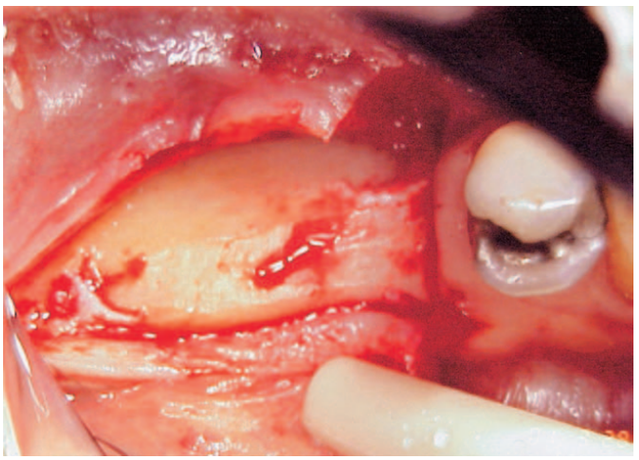

Figure 1.
Surgical procedure; the mucoperiosteal flap raised.

MATERIALS AND METHODS

Four patients (31 to 60 years old) with bilateral edentulous posterior mandibular ridges were selected at the clinic of the School of Dentistry of Piracicaba, University of Campinas, SP, Brazil. Exclusion criteria were smoking, systemic diseases, usage of any medication that might interfere with the peri-implant healing process, untreated periodontal disease, parafunctional habits like bruxism, and full maxillary dentures. This study was performed in accordance with the University's Committee for Research Ethics Protocol. All patients signed informed consent forms.

The patients were treated with one-stage 10.0 mm implants† with a machined smooth suprabony portion of 2.8 or 1.8 mm. The intrabony portion had a titanium plasma-sprayed (TPS) surface and a diameter of 4.1 mm. Mandibular sites were randomly assigned to group 1 (2.8 mm) and group 2 (1.8 mm) implants. Twelve implants were placed in a split-mouth design, with each patient receiving at least one implant of each length. Two patients received one implant on each side of the mandible, whereas the other two patients received two contralateral implants.

Patients received initial periodontal therapy consisting of oral hygiene instructions and removal of plaque-retentive factors, following which the dichotomic plaque index (PI) and gingival index (GI) were assessed. All patients had a PI and GI below 20% before initial surgery. Periapical and panoramic radiographs were obtained, and in two cases, conventional tomography was also taken to assess whether the bone was wide enough to receive the implants. Impressions of the mandible were obtained and a duplicate cast made for prosthetic planning and template fabrication.

Extraoral antisepsis was done with 2.0% chlorhexidine solution‡ and intraoral with 0.12% chlorhexidine rinse§ for 1 minute. Local infiltration with 2.0% lidocaine solution with 1:100000 epinephrine was used for anesthesia.‖

The implants were placed according to the manufacturer's protocol. Briefly, a supracrestal horizontal incision was accomplished and completed with mesial vertical releasing incision preserving the distal papillae from the adjacent tooth (Fig. 1). Mucoperiosteal flaps were raised, the mandible bone was inspected, planed with cutting burs, and the recipient beds were prepared under abundant irrigation with sterile saline solution. The implants were then placed with their border between the plasma-sprayed and machine surfaces at the level of alveolar crest. The flaps were repositioned and sutured with 5.0 nylon monofilaments¶ so that the cover screw was completely exposed (Fig. 2). The sutures were removed after 1 week.

One hour before surgery each patient was given a single dose of 5 mg diazepan,# 4 mg betamethasone,** and 2 g amoxicillin.†† Acetaminophen‡‡ (750 mg) was prescribed every 6 hours for 2 days for pain control.

The plaque control protocol was established with local application and rinses with 0.12% chlorhexidine digluconate solution twice daily during the period of wound healing. The patients were recalled for professional plaque control weekly in the first month and then monthly until the end of the study.

† ITI Dental Implant System, Institute Straumann AG, Waldenburg, Switzerland.
‡ Proderma Farmácia de Manipulação Ltda., Piracicaba, SP, Brazil.
§ Proderma Farmácia de Manipulação Ltda.
‖ Lidocaina-Alphacaina, Adrenalina 1:100.000, DFL Ind. e Com. Ltda, Rio de Janeiro, RJ, Brazil.
¶ Superlon, Cirumédica S/A, Cotia, SP, Brazil.
# Valium, Roche Produtos Quím. e Farm. S/A, São Paulo, SP, Brazil.
** Celestone, Schering-Plough Ind. Quím. e Farm. S/A, Rio de Janeiro, RJ, Brazil.
†† Amoxil, SmithKline/Beecham Farmacêutica, Rio de Janeiro, RJ, Brazil.
‡‡ Tylenol, Cilag Farmacêutica Ltda., São Paulo, SP, Brazil.

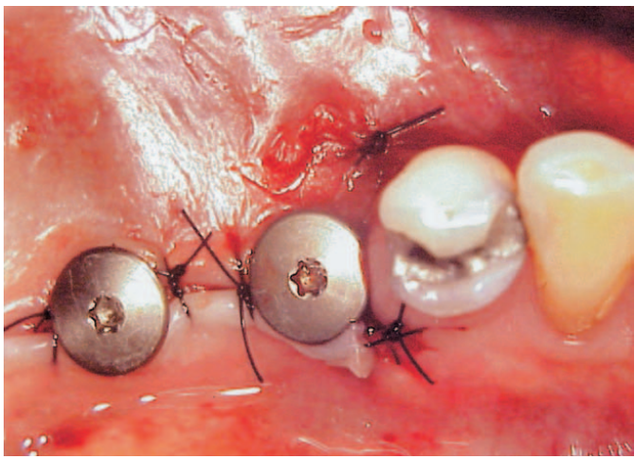

Figure 2.
Surgical procedure; suture after implant placement.

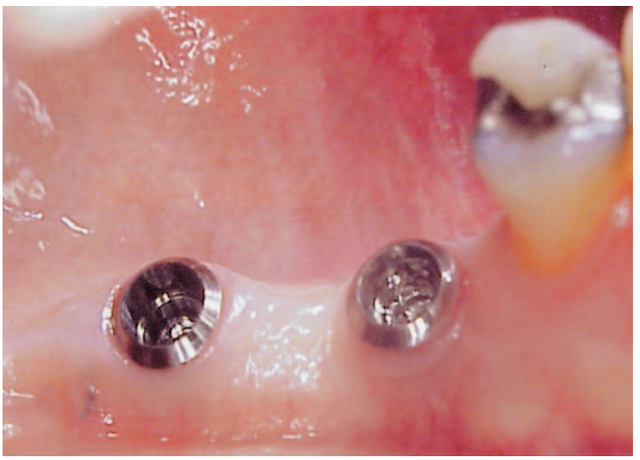

Figure 3.
Healing after 4 months.

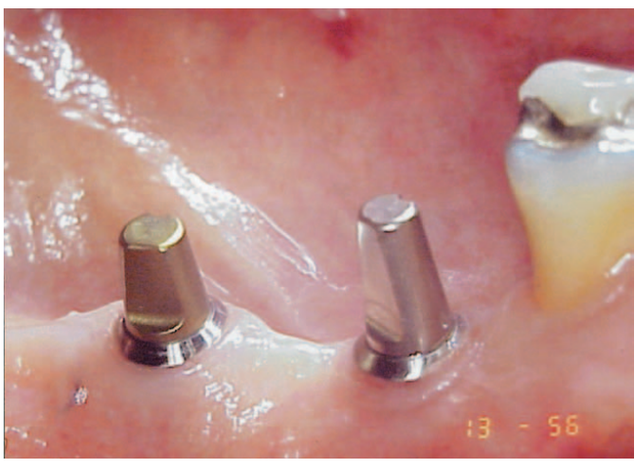

Figure 4.
Prosthetic phase; abutment adapted.

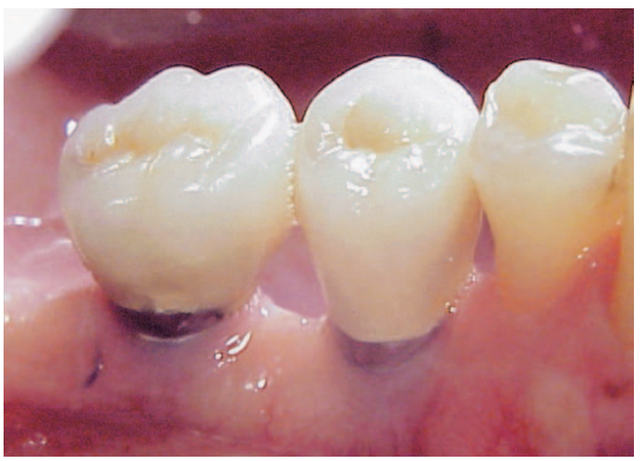

Figure 5.
Final aspect immediately after loading.

Four months after surgery (Fig. 3), the implants were loaded according to the manufacturer's protocol (Fig. 4). The abutments§§ were selected based on the interocclusal space, and adapted to the implant body with a definitive torque of 35 N/cm. Vinyl polysiloxane‖‖ was used to obtain impressions with a double-mix technique. Metalloceramic crowns were built and retained with resin cement¶¶ or zinc phosphate.¶¶

Clinical parameters were measured 4 months postoperatively, when the implants were loaded (Fig. 5), and 12 months after surgery (Fig. 6). The following linear parameters were assessed in 6 sites around the implants using an automated probe:## probing depth (PD) measured as the distance between the gingival margin and the peri-implant sulcus; gingival margin level (GML) measured as the distance between the gingival margin and the implant shoulder; relative clinical attachment level (r-CAL), the sum of PD and GML, dichotomic plaque index (PI); and gingival index (GI). The data of the independent sites were transformed in one implant mean value for each parameter.

A digital system*** was used for the radiographic analysis. For the placement of the sensor, an acrylic device coupled to a bite block in vinyl polysiloxane over the occlusal third of all lower teeth was built. The

§§ ITI Dental Implant System.
‖‖ Dentsply Indústria e Comércio Ltda., Petrópolis, RJ, Brazil.
¶¶ Vigodent S/A Indústria e Comércio, Rio de Janerio, RJ, Brazil.
Florida Probe, Gainesville, FL.
*** Sens-A-Ray, New Image do Brasil. Imp. Exp. Ltda., São Paulo, SP, Brazil.

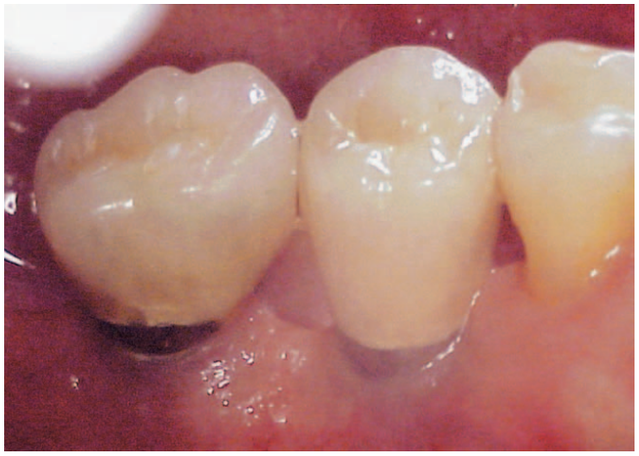

Figure 6.
Twelve months after surgery.

equipment was mounted in an aiming device††† to retain reproducible projection with exposure settings of 60 kV and 10 mA for 0.2 + seconds. The osseous level (OL, measured as the distance between the implant shoulder and the most coronal point of the bone) was calculated using the digital image in the distal and mesial aspect in each implant. The mesial and distal values were transformed in one implant mean value, based on when the implants were placed; i.e., 4 and 12 months after surgery.

The digital images obtained at 4 and 12 months were initially equalized by a non-parametric method[11] to reduce variation in density and contrast, and superimposed until the reference points in both images were completely aligned. The images were then subtracted and analyzed to assess changes in optical density (OD). After adjustment of the two radiographs, the structures that did not change were not evaluated. To eliminate noise, the standard OD of the subtracted image was calculated, considering the mean and standard deviation of the OD from five different regions adjacent to the implant. Changes in OD were analyzed in the region of interest determined by the area at 3 points: 1) the implant shoulder; 2) the first implant thread; and 3) the bone crest.

Density increase was defined as the values above the sum of the standard OD and the standard deviation (green areas after pseudocolor conversion), and density decrease as the values below the standard OD value minus the standard deviation (red areas after pseudocolor conversion) (Fig. 7).

Descriptive statistics were expressed as mean ± standard deviation per implant. Data were analyzed using Student *t* test for paired observations to assess changes obtained between groups and analysis of variance to assess changes through time within each group. The significance level for rejection of the null hypothesis was set at alpha = 0.05.

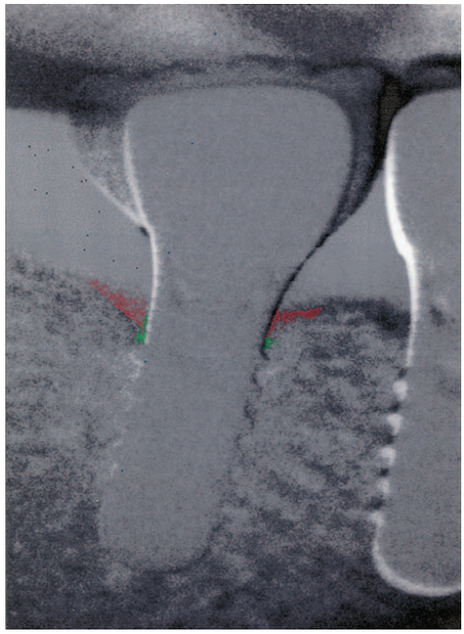

Figure 7.
Subtraction radiography.

Table 1.

Plaque (PI) and Gingival (GI) Indexes

Parameter	4 Months	12 Months	*P*
PI	13.8 ± 12.5	8.3 ± 9.1	0.087
GI	11.1 ± 8.6	5.5 ± 8.6	0.087

Student paired *t* test; $P < 0.05$.

RESULTS

Clinical

Mean values and standard deviations for PI and GI over the experimental times are presented in Table 1. The overall mean PI was 13.8 ± 12.5% 4 months after surgery, and 8.3 ± 9.1% 12 months after surgery, while the mean GI was 11.1 ± 8.6% and 5.5 ± 8.6% in the same periods. No statistically significant differences ($P > 0.05$) were found for these parameters.

Table 2 shows the mean values and standard deviation for r-CAL, PD, and GML for the intra- and between-group comparisons.The mean r-CAL in group 1 was 2.82 ± 0.17 mm after 4 months and 3.50 ± 0.15 mm after 12 months;

††† Rinn Corporation, Elgin, IL.

Table 2.

Clinical Measurements (mm) at 4 and 12 Months

	Group 1			Group 2		
Parameter	4 Months	12 Months	*P*	4 Months	12 Months	*P*
r-CAL	2.82 ± 0.17	3.50 ± 0.15	0.0002	2.88 ± 0.16	3.40 ± 0.15	0.0002
PD	2.65 ± 0.19	3.30 ± 0.23	0.0001	2.83 ± 0.16	3.37 ± 0.18	0.0001
GML	0.17 ± 0.07	0.20 ± 0.12	0.2325	0.05 ± 0.03	0.03 ± 0.04	0.3054

Student paired *t* test; $P < 0.05$.

Table 3.

Mean Changes in Clinical Parameters

	Group 1	Group 2	*P*
r-CAL	0.68 ± 0.19	0.52 ± 0.15	0.0462
PD	0.65 ± 0.17	0.53 ± 0.09	0.1004
GML	–0.03 ± 0.09	0.02 ± 0.07	0.1816

ANOVA; $P < 0.05$.

Table 4.

Radiographic Measurements (mm) at Baseline and 4 and 12 Months

Time	Group 1	Group 2	*P*
Baseline	2.96 ± 0.33 [a]	2.51 ± 0.31 [a]	0.0831
4	3.28 ± 0.34 [b]	3.07 ± 0.27 [b]	0.1195
12	3.82 ± 0.55 [c]	3.50 ± 0.27 [c]	0.0642

ANOVA; $P < 0.05$.
Different letters within column (intragroup comparison) indicate statistically significant differences over time.

Table 5.

Digital Subtraction Results

Group 1	Group 2	*P*
4.17 ± 4.52	5.08 ± 4.31	0.3188

Student paired *t* test; $P < 0.05$.

for group 2 the corresponding values were 2.88 ± 0.16 mm and 3.40 ± 0.15 mm. There were statistically significant differences ($P < 0.05$) for the intra- and between-group comparisons. The change for r-CAL within groups was 0.68 ± 0.19 mm for group 1, and 0.52 ± 0.15 mm for group 2 (Table 3), indicating that there was a smaller attachment loss in the implants with a shorter neck portion.

The mean PD in group 1 was 2.65 ± 0.19 mm and 3.30 ± 0.23 mm after 4 and 12 months, respectively, while in group 2, the mean values were 2.83 ± 0.16 mm and 3.37 ± 0.18 mm. There was a statistically significant difference ($P < 0.05$) in the PD change in both groups (Table 2); however, no statistically significant difference ($P > 0.05$) was found in the intergroup comparison (0.65 ± 0.17 mm in group 1 and 0.53 ± 0.09 mm in group 2) (Table 3).

The mean GML in group 1 was 0.17 ± 0.07 mm and 0.2 ± 0.12 mm after 4 and 12 months, respectively (Table 2). The corresponding values in group 2 were 0.05 ± 0.03 mm and 0.03 ± 0.04 mm. No statistically significant differences ($P > 0.05$) were found within or between groups (Table 2), although in group 1, there was a slight decrease in this parameter (–0.03 ± 0.09 mm), whereas in group 2, there was a minute increase (0.02 ± 0.07 mm) (Table 3).

Radiographic

The mean OL values in group 1 were 2.96 ± 0.33 mm when the implants were placed (baseline), 3.28 ± 0.34 mm at loading (4 months), and 3.82 ± 0.55 mm 12 months after surgery (Table 4). The corresponding values for group 2 were 2.51 ± 0.31, 3.07 ± 0.27 mm, and 3.50 ± 0.27 mm, respectively. There was significant peri-implant bone loss ($P < 0.05$) in all periods examined for both groups. However, no statistically significant differences ($P > 0.05$) were found between groups.

The digital subtraction showed a mean OD decrease of 4.17 ± 4.52 gray level in group 1 and 5.08 ± 4.31 in group 2. No statistically significant differences ($P > 0.05$) were found between groups (Table 5).

DISCUSSION

This study evaluated the impact of the transmucosal length of non-submerged one-stage implants in the peri-implant tissues. The smooth neck portion of standard implants is 2.8 mm long. However, in some clinical situations where esthetics are of concern the transmucosal portion can be 1.0 mm smaller (1.8 mm).[12,13]

Our medication regimen was effective in controling anxiety and preventing postoperative pain, swelling, and infection. The plaque control program was satisfactory during the entire study, since both PI and GI were at low levels between the baseline and final exams (Table 1). The split-mouth design eliminated any possible interference inherent to the patients that could bias the comparisons.

The clinical parameters r-CAL, GML, and PD evalu-

ated the changes in the peri-implant soft tissues. An electronic probing system was used to take precise measurements and the data stored in a computer.[14,15]

The peri-implant clinical changes that occurred around the implants in group 1 between 4 and 12 months were r-CAL decrease (0.68 ± 0.19 mm), and increase in the GML (–0.03 ± 0.09 mm) and PD (0.65 ± 0.17 mm). The corresponding changes in group 2 were r-CAL decrease of 0.52 ± 0.15 mm, GML increase of 0.02 ± 0.07 mm and PD increase of 0.53 ± 0.09 mm. The intragroup comparison revealed significant changes (P <0.05) for r-CAL and PD. In the intergroup comparison, there was a statistically significant difference (P <0.05) only for r-CAL (Table 3). No differences were found in the other clinical and radiographic parameters. The size of sample and the evaluation methods used in this study may have influenced the results.

The GML mean values after 4 months of healing were 0.17 ± 0.07 mm in group 1 and 0.05 ± 0.03 mm in group 2 (P <0.05). These results indicate that the changes in gingival margin level occurred during the initial healing phase before loading, and suggest that the shorter transmucosal portion is sufficient to support the soft tissues around the implants not interfering with the development of gingival recession.

Several clinical[12,13] and histologic trials in humans and animals[3,5,8] support our results. These studies investigated clinical changes as well as the histometric extension of the peri-implant soft tissues around one-stage implants.

The radiographic evaluation helps in the prosthetic planning phase to the surgical procedure and in early diagnosis of osseous changes after loading.[16] However, conventional non-standardized images limit the accurate diagnosis of the osseous peri-implant changes and may suggest false gain or loss. This indicates the necessity of more sensitive methods capable of detecting minute bone changes with small mineral loss.[17-19]

The linear radiographic OL parameter evaluated osseous loss over time (Table 4). In our study, no statistical differences were found between groups, suggesting that the crestal bone resorption is an expected event after the implant placement and before loading. The bone loss occurs to create the space necessary for the adaptation of the connective tissue zone. After 4 months, the bone loss was 0.32 mm and 0.56 in groups 1 and 2, respectively, with no difference between groups. The bone resorption progressed after loading until the final exam (12 months). The total loss around the implants in group 1 amounted to 0.86 mm and to 0.99 mm in group 2. These results suggest that both sizes of polished smooth neck portion of the non-submerged implants are sufficient to accommodate the dimensions of the peri-implant sulcus and epithelial attachment.

Our findings are in accordance with the results from those by Brägger et al.[13] who evaluated the peri-implant changes around non-submerged implants before and after loading using linear radiographic measurements. They observed significant bone loss 1 year after implant placement.

The difference from the r-CAL and OL values is the space occupied by the supracrestal fibers forming the connective zone. Lang et al.[20] showed that in peri-implant health, the connective adaptation area is resistent to probing penetration and will be always present coronal to the interface between bone and implant.

Hämmerle et al.[12] demonstrated that there was more marginal bone resorption if the implant polished neck was placed in a subcrestal location in an effort to improve esthetics. The authors suggest that the crestal resorption can be accounted for by the smooth polished surface in contact to bone rather than to the transmucosal height. The shorter polished neck implant in our study did not result in more bone resorption, suggesting that 1.8 mm is sufficient to adapt and maintain the peri-implant soft tissues.

The digital subtraction method allows for early detection as well as qualitative and quantitative subtle bone density changes.[16,18] Caton and Greenstein[21] showed that digital subtraction using standardized radiographs is a reliable tool for evaluating bone behavior following therapy.

The evaluation of the subtracted images revealed a mean OD loss of 4.17 ± 4.52 gray level in group 1 and 5.08 ± 4.31 in group 2 (P >0.05) (Table 5). However, these results should be interpreted with caution due to the short experimental period of observation and the limits of the software used.[22]

Variation in voltage and exposure time might influence the density and contrast of serial images jeopardizing the results of subtraction radiography. In this study, we used stable electric current and standardized exposure times. This, coupled with immediate observation of the images and the possibility of repetition, contributed to the attainment of images with good quality.[23,24] The extraoral positioning device associated with acrylic templates and occlusion biting blocks were effective in minimizing variations on the images.[25] However, even with these precautions, detected differences between the radiographic pairs were identified and corrected.

Our results also suggest, that for the connective adaptation, bone loss will always occur regardless of the transmucosal length; this is supported by Weber et al.,[5] who observed that bone loss around non-submerged implants is related to connective tissue, and not influenced by the epithelial dimensions.

Since the junctional epithelium migrates on the transmucosal smooth polished neck portion regardless of its length, that the long transmucosal implant seems not to inhibit bone resorption, and generally there is a deep peri-implant sulcus, we can assume

that the shorter transmucosal implants are indicated in almost all clinical situations.

From the clinical point of view, implants with a short, smooth neck portion promote smaller attachment loss and avoid gingival recession during the early healing phase, mainly in thin alveolar mucosa. Our results also suggest that the bone loss was initiated prior to loading and progressed until the end of the experimental period.

ACKNOWLEDGMENTS

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