Keratinized mucosa around implants in partially edentulous posterior mandible: 10-year results of a prospective comparative study

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Abstract

Objective: The aim of this research was to investigate the clinical conditions around dental implants placed in the posterior mandible of healthy or moderately periodontally compromised patients, in relation to the presence or not of keratinized mucosa (KT).

Materials and methods: One hundred and twenty-eight patients who needed an implant in the posterior mandible were consecutively enrolled in a private specialist practice. Only one implant per patient was examined originally placed either within KT or alveolar (AM) mucosa. At 10 years, clinical and radiographic measures were recorded by a calibrated operator. The number of sites treated according to therapy modalities C and D (antibiotics and/or surgery) during the 10 years was also registered.

Results: Ninety-eight patients completed the 10-year study. The absence of KT was associated with higher plaque accumulation, greater soft-tissue recession (REC), and a higher number of sites that required additional surgical and/or antibiotic treatment. Patient-reported outcomes regarding maintenance procedures presented major differences between the groups. In 11 of the 35 AM cases, additional free gingival graft (FGG) was successfully employed to reduce discomfort and to facilitate optimal plaque control.

Conclusion: Implants that are not surrounded by KT are more prone to plaque accumulation and REC, even in patients exercising sufficient oral hygiene and receiving adequate supporting periodontal therapy (SPT). In selected cases, particularly in the edentulous posterior mandible, where ridge resorption leads to reduced vestibular depth and lack of KT, additional FGG can be beneficial to facilitate proper oral hygiene procedures.

Key words: dental implants, keratinized mucosa, maintenance, patient-centered outcomes, peri-implant tissues, supporting periodontal therapy

Introduction

The width of keratinized soft tissue (KT) around implants may vary between zero and several millimeters and may be useful to facilitate plaque control. Even though it has been proposed that a circumferential sealing effect is a prerequisite for the long-term success, the question of whether a sufficient amount of KT is necessary for peri-implant health has been controversial for many years (AAP 2000; Greenstein & Cavallaro 2011; Wennström & Derks 2012; Gobbato et al. 2013; Levine et al. 2013; Lin et al. 2013; Brito et al. 2014).

Wennström et al. (1994), evaluating the soft-tissue conditions at implants in relation to the width of masticatory mucosa, found that the lack of an attached portion of masticatory mucosa, was observed at 61% of all implants, with no major differences in the clinical parameters between sites with and without an “adequate” width of masticatory mucosa. Multiple regression analyses revealed that neither the width of masticatory mucosa nor the mobility of the border tissue had a significant influence on (i) the standard of plaque control or (ii) the health condition of the peri-implant mucosa, as determined by bleeding on probing. Hence, the study failed to support the concept that the lack of an attached portion of masticatory mucosa may jeopardize the maintenance of soft-tissue health around dental implants. It must be noted, however, that most of the implants were placed in the anterior region of the mandible, where oral hygiene procedures are facilitated.

On the contrary, the importance of peri-implant KT was emphasized by Warrer et al. (1995) who reported that experimentally ligated implants without KT accumulated more dental plaque and had significantly more recession and attachment loss than implants with KT. In the same years, Bengazi et al. (1996) evaluated the position of the peri-implant soft-tissue margin, 2-year after insertion of fixed prostheses, and found that lack of masticatory mucosa and mobility of the peri-implant soft tissue at time of bridge

installation were poor predictors of soft-tissue recession (REC) occurring during the follow-up. Notwithstanding, it must be noted that a 2-year follow-up was somehow limited, and it could not be considered a useful source of clinical information for a long-term prognosis.

At the 3rd European Workshop on Periodontology, it was suggested that in the presence of good oral hygiene, the nature of the mucosa may have little influence on the long-term survival of implants. Nevertheless, suboptimal oral hygiene may lead to greater tissue damage around implants within alveolar mucosa (AM) than around implants within KT, and proper oral hygiene procedures may also be facilitated in the presence of an adequate band of KT. It was not clear, however, in which clinical conditions soft- tissue augmentation should be recommended. The consensus report confirmed that the maintenance of the soft-tissue seal is a prerequisite for progression marginal bone loss over time and that “5-to-10-year studies are mostly recommended” (Lang et al. 1999).

Due to the fact that, at that time, no definite conclusions could be drawn on the protective role of KT around implants, a prospective two-arm long-term cohort study was initiated to evaluate the relationship between the presence of KT and the soft-tissue conditions around posterior mandibular implants. The aim was to assess the significance of peri-implant KT for long-term soft- tissue health and stability, to evaluate the need for additional surgical procedures or special care during maintenance therapy.

Material and methods

All patients attending the principle investigator (M. R.), a specialist in periodontology, for dental implant therapy between December 1998 and 2002 were screened for possible inclusion in the study. The criteria used for excluding patients were as follows: (i) mucosal diseases; (ii) alcohol and drug abuse; (iii) pregnancy or breast

feeding; (iv) uncontrolled metabolic disorders; (v) severe or aggressive periodontitis; (vi) no interest in participating into the study.

In order to be incorporated in the study, patients had to present a treatment plan that included a site with one implant in the posterior mandible as a distal element, supporting either a single crown or a fixed dental prosthesis. The implant could be in the position of either a molar or a premolar, but no natural dentition could be present distally to it. The implant could not be placed in con- junction with an augmentation procedure or following Guided Bone Regeneration. No distal cantilevers were allowed. Only one implant per patient was selected for the examination. In case of two or more implants were placed at the same time, only the distal one was selected for the analysis (Figs 1–5).

Patients were informed that their data would be used for statistical analysis and gave their informed consent to the treatment. No ethical committee approval was sought to start this study, as it was not required by national law or by ordinance of the local inspective authority. The prospective study was performed in accordance with the principles stated in the Declaration of Helsinki and the Good Clinical Practice Guidelines.

Subjects were clinically and radiographically monitored at baseline. Full-mouth plaque score (FMPS), full-mouth bleeding score (FMBS), pocket depths (PD) were measured, at four sites of all teeth, by means of a periodontal probe (XP23/UNC 15; HuFriedy, Chicago, IL, USA), and rounded off to the nearest millimeter. Following selection, all patients received appropriate initial therapy, consisting, depending on the cases, in motivation, oral hygiene instruction, scaling, and root planning with the aim to reduce to a minimal level periodontal pathogens. No implant surgery was performed before the assurance of excellent motivation and compliance from each single patient (FMPS < 20%; FMBS < 20%).

One hundred and twenty-eight patients (52 males and 76 females; mean age: 52.4

± 10.2 years; 21 smokers) were consecutively treated, by means of SLA dental implants (Institut Straumann AG, Basel, Switzerland). The baseline demographic parameters are listed in Table 1. Implants were placed, by the same operator (M. R.), with the border of the rough surface approximating the alveolar bone crest leaving the machined neck portion in the transmucosal area with a close adaptation of the wound margins to the implant shoulder. Abutment connection was carried out at 35 Ncm 6–10 weeks postsurgery to provide patients with cemented implant-supported fixed restorations. Therefore, each test implant-supported either single crows or the distal portion of a 3–4 unit bridge. All restorations were fabricated to facilitate both the oral hygiene procedures and the probing along their circumference. Baseline probing measurements were also recorded around the implants. Radiographic data were collected, after prosthesis installation, to establish a baseline reference for the following controls.

Follow-up

Patients were placed on an individually tailored maintenance care program (SPT), including continuous evaluation of their ability to perform proper plaque control. Motivation, re-instruction, instrumentation, and treatment of sites with inflammation were performed as needed. Patients were asked to indicate whether discomfort was present during oral hygiene procedures (1 = YES, 0 = NO). If AM patients showed insufficient plaque control due to soreness during oral hygiene procedures, they were given the option to receive an additional free gingival graft (FGG) around the implant. When a patient either expressed the desire not to attend follow-up examinations or was not able to attend the requested visits, he/she was classified as “dropout.”

Final clinical examination

After 10 years, an examiner (S.G.) with more than a dozen years of experience as

hygienist, blinded to the initial classification of the patients, recorded, for each test implant, probing depth (PD) measured at four sites (mesial, buccal, distal, and lingual) by means of a periodontal probe (XP23/UNC 15; HuFriedy) and rounded off to the nearest millimeter.

Soft-tissue recession was measured from the implant shoulder to the coronal margin of the mucosa, by means of a Castroviejo Caliper Short (Salvin Dental Specialties, Inc., Charlotte, NC, USA) and rounded off to the nearest ½ millimeter.

The distance between the base of the implant shoulder and the most coronal visible bone-to-implant contact, measured in millimeters, both at the mesial and at the distal aspect of each implant, was calculated using standardized periapical intraoral films with a long-cone technique (Bornstein et al. 2005) and compared with the baseline values according to the technique described previously by Roccuzzo et al. (2008).

Furthermore, the following parameters were collected:

- implant loss;
- plaque score (presence/absence): total score for both teeth and implants (FMPS) and for the implant alone (PI), measured at four sites per implant and expressed as a percentage of examined sites;
- bleeding on probing score (presence/absence): total score for both teeth and implants (FMBS) and for the implant alone (BOP), measured at four sites per implant and expressed as a percentage of examined sites;
- smoking habits;
- number of sites which required, during the SPT, additional treatment with modalities C and D according to the cumulative interceptive supportive therapy;
- presence of soreness/discomfort upon oral hygiene maintenance, evaluated by the patient (1 = YES, 0 = NO).

Statistical analysis

Each patient contributed with one implant and was therefore regarded as the statistical unit. Data were expressed as mean ± SD and median (25–75 percentile) or counts and percentages. As the statistical distribution of the quantitative measures, except the age, was found to be nongaussian (tested by Shapiro–Wilk test), Kruskal–Wallis rank test was used to assess between-group differences. The pairwise comparisons of the groups were performed by Mann–Whitney U-test with Bonferroni's adjustment for multiple comparisons, and $P < 0.017$ were considered statistically significant. For categorical variables, the groups were compared using chi-square or Fisher's exact test, as appropriate. A two-sided P-value of <0.05 was considered to indicate statistical significance. All analyses were performed using STATA SE v13.1 (StataCorp LP, College Station, TX, USA).

Results

Of the initial 128 patients enrolled in the study, three patients lost their test implant during the observation period while 27 patients were lost to follow-up: eight died, five moved to other cities/countries, two developed severe health problems, and 16 refused the final follow-up visit (Table 2).

The final 10-year analysis was therefore performed in 98 patients (38 males and 60 females). The clinical data of the 98 implants, 63 of which were originally surrounded by KT, are listed in Table 3.

During the entire 10-year observation time, KT patients needed in 12.7% of the cases antibiotic or surgical therapy for the treatment of biological complications (Table 3). The corresponding values for AM patients were 51.4%. The statistical analysis revealed a significant difference between the two groups ($P < 0.001$).

This difference is particularly significant from the clinical point of view, as both FMPS (18.40 ± 7.42% vs. 19.57 ± 8.66%, $P = 0.48$) and FMBS (17.46 + 6.97% vs. 18.26

+ 8.33%, P = 0.61) revealed a good long-term compliance in both groups.

No patient-reported pain or discomfort in oral hygiene procedures in KT group, while 15 of 35 (42.9%) of the patients in AM group reported discomfort in performing oral hygiene (P < 0.001). In 11 of these additional FGG was performed to facilitate plaque control.

At the end of the observation period, plaque was found on 21.0 ± 20.2% of the 252 examined surfaces around implants placed in KT, on 37.5 ± 27.6% of the 96 sites around implants in AM, and on 27.3 ± 26.1% of the
44 surfaces around implants originally placed in AM with additional FGG, but only between the KT and AM group was found a significant difference (P = 0.007).

Bleeding on probing was more frequent in the AM group than KT group, without reaching a statistical significant level among the three groups (P = 0.23) (Table 4).

No significant differences were found with respect to mBL (0.34 ± 0.38 mm vs. 0.50 ± 0.38 mm vs. 0.56 ± 0.39 mm, P = 0.07). Patients in AM group received a greater number of C or D interventions during the follow-up compared with the KT ones.

At the final examination, mean REC was 0.16 ± 0.39 mm in KT patients, 2.08 ± 0.71 mm in the AM group, and 1.27 ± 1.17 mm in AM + FGG patients, with a statistical significant difference between the KT group both with the AM (P = 0.0001) and the AM + FGG (P = 0.0001) groups.

Discussion

This is, to the best of our knowledge, the first 10-year prospective study that presents results on the influence of the quality of the mucosa on the long-term implant outcomes, recruited from a private clinic. The benefit, in accordance with the Consensus Report of 6th European Workshop on Periodontology (Lindhe & Meyle

2008), is that subjects recruited from private or public dental clinics, rather than university clinics, provide information on the “effectiveness” rather than “efficacy” in implant therapy.

Several articles and consensus conferences were published in the literature as the present study was initiated. While some studies concluded that the presence of KT could significantly and positively impact tissue stability, others presented opposite results.

The European Association for Osseointegration (EAO) organized a consensus conference in 2006, in Zurich, Switzerland. For the meeting, a systematic review was presented by Rompen et al. (2006) that concluded that to avoid bacterial penetration through this transmucosal piercing, the early formation of a long-standing effective barrier capable of biologically protecting the peri-implant structures is of paramount importance.

Chung et al. (2006), in a retrospective clinical study on implants placed from at least 3 years, found that the absence of adequate KT in endosseous dental implants, especially in posterior implants, was associated with higher plaque accumulation and gingival inflammation but not with more average annual bone loss (ABL).

On the other hand, Roos-Jans0aker et al. (2006) found out, in a 9- to 14-year follow-up of implant treatment, that the presence of KT was associated with mucositis (i.e., probing pocket depth >4 mm and BOP) and bone level at >3 threads. According to the authors, the association between KT and mucositis could possibly be related to the fact that recession, and therefore less pocket formation, may be more common in areas without KT.

Cairo et al. (2008) presented at the 6th European Workshop on Periodontology a review based on several papers mainly expert opinions, case reports and case series. Literature analysis showed that (i) the width of KT did not influence the survival rate of

dental implants; (ii) there was no evidence to recommend a specific technique to preserve/augment KT; and (iii) factors including bone level, KT, and implant features have not been shown to be associated with future mucosal recession around dental implants. The only possible conclusion, approved by the Consensus Report (Palmer & Cortellini 2008), was that although scientific evidence in most part is lacking, soft-tissue augmentation at implant sites may be considered in some clinical situations. However, the outcomes of these procedures have not been evaluated in prospective studies.

Three recent articles support the advantage of increasing KT. Yeung (2008) stated that even though available data so far suggest that with good oral hygiene, peri-implant soft-tissue health can be maintained irrespective if KT surrounding implant is present, good oral hygiene is, indeed, very difficult to achieve around dental restorations without the protection of a band of keratinized gingival tissue. Bouri et al. (2008) correlated the width of KT and the health status of the supporting tissues around dental implants. He found out that increased width of KT around implants is associated with lower mean alveolar bone loss and improved indices of soft-tissue health. Kim et al. (2009) evaluated the peri- implant tissue response according to the presence of KT. He found out that in cases with insufficient keratinized gingival in the vicinity of implants, the risk of the increase of gingival recession and the crestal bone loss is present. Therefore, it is thought that from the aspect of long-term maintenance and management, as well as for the area requiring esthetics, the presence of an appropriate amount of KT is required.

Esposito et al. (2012) attempted a systematic review for the Cochrane collaboration group, but he was not able to find a single acceptable RCT in the world literature to evaluate whether soft-tissue augmentation improves the long-term prognosis of dental implants. According to the author, there is insufficient reliable evidence to provide recommendations on whether techniques to increase the width of keratinized mucosa (KT) are beneficial to patients or not. The review encouraged properly designed and

conducted RCTs, with at least 6 months of follow-up, to provide reliable answer to this question. It must be noted, however, that it is unlikely that such a brief follow-up would show any significant difference even in a large population. Long term, that is, longer than 5 years, should instead be stimulated.

The most recent systematic review (Brito et al. 2014) aimed at evaluating the association between KT width and the peri-implant tissue health, by selecting recent studies, with follow-up >12 months. Seven articles supported the conclusions that the presence of an adequate zone of KT may be necessary because it was shown to be related to better peri-implant tissue health. The authors concluded that further randomized controlled trials are necessary to support this statement, even though it must be stated that practical and ethical reasons, however, make RCTs on this specific topic not easily feasible.

In our opinion, one of the reasons why it has not been possible so far to assess whether or not KT is needed around implants, based on data of current literature, is that most studies present a cut-off at 2 mm KT. In particular, a major concern regards the possibility to make a precise recording when the reference point (such as the gingival margin) lies approximately near the 2 mm marking. For example, while recording the KT lies near the two markings, there may be the possibility that the case is registered as KT or AM. Therefore, cases with a minimal clinical difference may be given to two different groups. In this way, it is possible that implants with a minimal, but present KT, are pooled with those which are surrounded by AM. To avoid this problem in the present study, it was decided to dichotomously differentiate between implants either in KT or AM.

Smoking has been correlated to higher number of complications even in patients enrolled in a SPT (Aglietta et al. 2011). In the present study, even though the smoking habits of all patients were recorded, the relative number of smokers (11 of 98) was limited and did not allow any powerful statistical analysis. Incidentally, it must be noted

that all three patients who lost implants were indeed, smokers.

The results of this study seem to be in contrast with a recent retrospective evaluation of peri-implant diseases and KT width in patients with vs. without mucogingival surgery (Frisch et al. 2015). Under supportive postimplant therapy in a private practice, 68 patients with peri-implant KT widths <1 mm were identified between 1992 and 2011. Thirty patients rejected surgery and 30 patients agreed. After at least 1 year, low incidences of peri-implant diseases over long periods can be expected in patients attending SPT programs, independent of the absence or presence of KT. It must be noted that, because of the retrospective nature of this study, these results should be interpreted with caution. The results of this research reveal that good oral hygiene is, indeed, more difficult to be achieved around dental implants without the protection of a band of KT. Moreover, increased width of KT around implants is associated with improved quality of soft tissues. In 11 of the 35 cases with a subjective problem by the patient, FGG was performed and the situation improved in a marked way. The fact that, despite a higher percentage of plaque found in the AM patients, there was no statistical difference in BOP between the two groups could possibly be related to the fact that recession, and therefore, less pocket formation may be more common in areas without KT. On the other hand, it must clarified that the results of the present investigation do not exclude the possibility that, even in the absence of KT, peri-implant health can be maintained for long term, as it was demonstrated in several of the patients treated, but confirm the previous indication (Lang et al. 1999) that proper oral hygiene procedures may be facilitated in the presence of an adequate band of KT.

An intriguing finding was that both FMPS and FMBS remained below the 20% threshold, both for KT and AM patients, implying that SPT was efficient. However, because in a portion of AM patients an adequate level of

oral hygiene was achieved after additional FGG, it is not possible to draw definitive

conclusions on how effective would have been the maintenance program should FGG had not be included. Indeed, one of the limits of the present investigation is that a number of patients have, in the 10-year observation period, changed their status (i.e., received additional FGG). Even though this could be considered a treatment bias, the patients treated referred a significant beneficial effect. On the other hand, the refusal to improve patients' conditions would be ideal from the statistical point of view, but would not be acceptable from obvious ethical reasons.

At this time, no conclusions can be drawn on the protective role of KT around implants in the maxilla and/or in the anterior part of the mandible, and/or in conjunction with GBR procedures. Similar prospective longitudinal controlled clinical trials will have to be performed to further elucidate the potential role of a sealing effect of masticatory mucosa on peri-implant stability.

One other limit of this study is that the mobility of the marginal soft tissue, that is, lack of an attached portion of masticatory mucosa, was not registered as an independent variable. In this study, the presence of KT was dichotomously (yes or no) assessed regardless of its attached or unattached nature. It must be said, however, that in the presence of AM the mobility of the margin was observed at all implants.

In conclusion, this study represents a first important step forward in the definition of the outcomes to be searched in future studies. Moreover, the results of this 10-year study encourage continuous monitoring of the peri-implant tissue conditions to prevent peri-implant biological complications. Clinicians should keep in mind that soft-tissue grafting seems beneficial in posterior mandibular sites especially when:

- patients complains of soreness during oral hygiene procedures;
- bone grafts and/or bone guided regeneration procedures are expected to stretch the mucosa;
- ongoing REC is found, that is, apical displacement of mucosal margin;

• plaque control is less than ideal and it may be facilitated by a better topography.

Owing to the impossibility to properly design and conduct RCTs on this specific topic for ethical reasons, new long-term multi-center observational studies in the various areas of the mouth, with at least 5–10 years of follow-up, are needed to provide a reliable final answer to the question.

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Table 1. Baseline demographic parameters of patients with test implant in Keratinized Tissue (KT) versus Alveolar Mucosa (AM).

	KT (n=86)	AM (n=42)	*p*
Male	36 (41.2%)	16 (38.1 %)	0.68
Age	51.2 ± 10.6	54.2 ± 9.2	0.12
Smoker	13 (15.1%)	8 (19.0%)	0.57
Moderate PCP†	54 (62.7%)	20 (47.6 %)	0.10

† Moderately periodontally compromised patients

Table 2. Number of implants (patients) lost to the 10-year follow-up.

Patients	Reason for losses
3	Implant loss
8	Death
2	Severe health problems
5	Moved
12	Refused to accept a visit
30 (total)	

Table 3. Clinical parameters during the 10-year follow-up in patients with test implant originally placed in Keratinized Tissue (KT) versus Alveolar Mucosa (AM).

	KT (n=63)	AM (n=35)	*p*
Male	26 (41.3%)	12 (34.3%)	0.50
Age at baseline	52.2 ± 10.7	52.8 ± 9.5	0.79
Adhesion to SPT ¶	52 (82.5%)	24 (68.6%)	0.11
Smoker	9 (14.3%)	2 (5.7%)	0.32
Moderate PCP †	36 (57.1%)	24 (68.6%)	0.27
CIST C/D^	8 (12.7%)	18 (51.4%)	<0.001
FMPS (%) mean±sd median (25-75)	 18.40 ± 7.42 18 (12-23)	 19.57 ± 8.66 20 (12-25)	0.48
FMBS (%) mean±sd median (25-75)	 17.46 ± 6.97 18 (10-25)	 18.26 ± 8.33 20 (15-22)	0.61
Soreness (%)	0	15 (42.9%)	<0.001

CIST, cumulative interceptive supportive therapy; FMPS, full-mouth plaque score; FMBS, full-mouth bleeding score.

¶Supportive Periodontal Therapy program

† Moderately periodontally compromised patients

^ Sites treated according to modalities C and D of cumulative interceptive supportive therapy (antibiotics and/or surgery)

Table 4. Clinical parameters at 10-year follow-up, around the implants according to their status: in keratinized tissue (KT), originally placed in AM without additional FGG (AM), and with additional FGG (AM+FGG).

	KT	AM	AM + FGG		p*		
	n=63	n = 24	n = 11	*p*	*KT vs AM*	*KT vs AM+FGG*	*AM vs AM+FGG*
mBL	0.34±0.38 0.30 (0-0.50)	0.50±0.38 0.50 (0.1-1)	0.56±0.39 0.50 (0.25-1)	0.07			
PD	3.13±0.59 3.25 (2.50-3.50)	2.77±0.70 2.50 (2.25-3.38)	2.95±0.80 2.50 (2.25-3.75)	0.08			
BOP	23.4±18.4 25.0 (0-25.0)	33.3 ± 25.2 25.0 (12.50-50.0)	27.3±26.1 25.0 (0-50.0)	0.23			
PI	21.0±20.2 25.0 (0-25.0)	37.5 ± 27.6 50.0 (12.50-50.0)	27.3±26.1 25.0 (0-50.0)	0.03	0.007	0.47	0.30
Soreness (%)	0 (-)	5 (20.8)	1 (9.1)	0.001	0.001	0.15	0.64
REC	0.16±0.39 0 (0-0)	2.08±0.71 2 (2-2.5)	1.27±1.17 1 (0-2)	0.0001	0.0001	0.0001	0.04

Data are expressed in mean±sd and median (25-75 percentile), unless otherwise specified

FGG, free gingival graft; mBL, mean bone loss (mm); PD, probing depth (mm); PI, presence of dental plaque around the implant (%); BOP, presence of bleeding on probing around the implant (%); Soreness, soreness/discomfort referred by patient during oral hygiene procedures; REC, soft-tissue recession (mm); AM, alveolar mucosa.

*Pairwise comparison with Bonferroni’s adjustment for multiple comparisons.

Fig. 1. Immediately before the cementation of final restoration: distal implant surrounded by mobile alveolar mucosa.

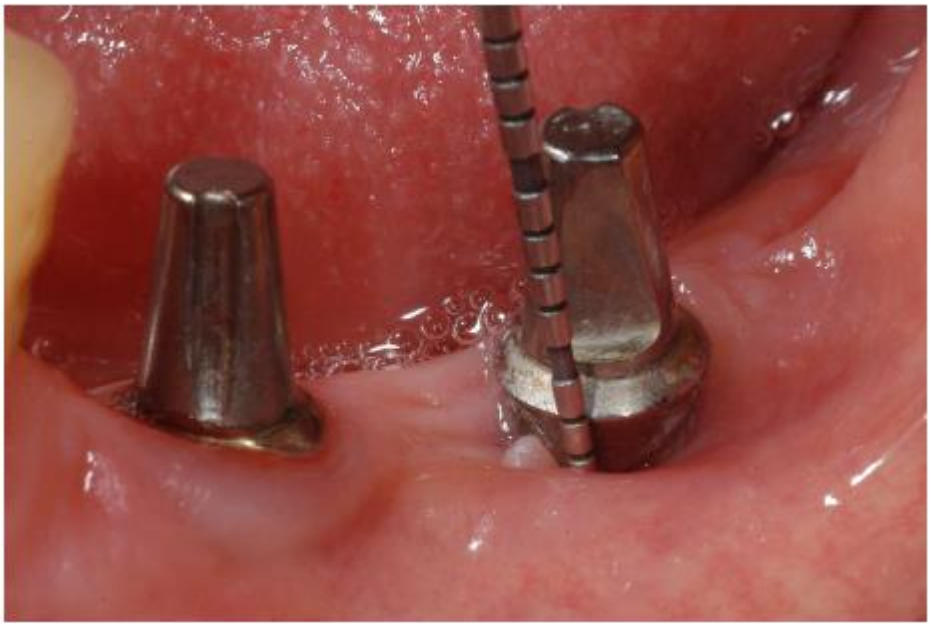

Fig. 2. At 2-year follow-up: patient reports discomfort when performing plaque control around distal implant. Soft-tissue graft is scheduled to increase tissue thickness

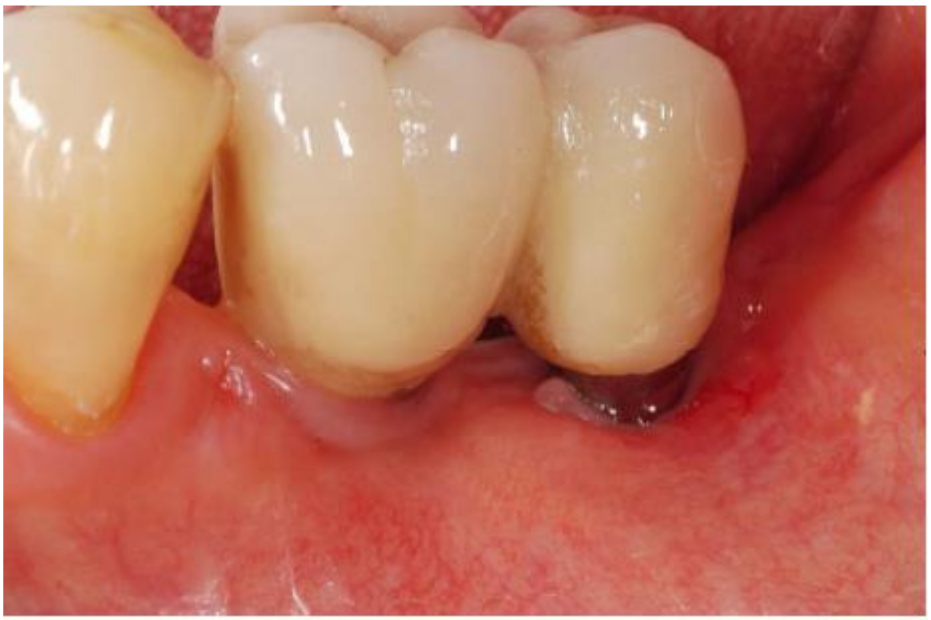

Fig. 3. Free gingival graft is sutured, over a partial thickness flap, to increase tissue thickness.

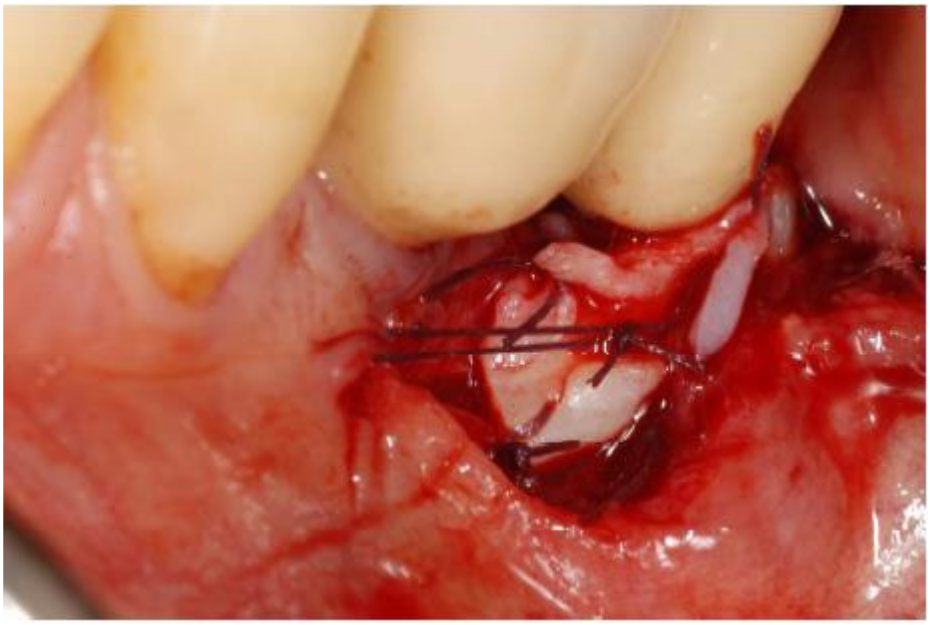

Fig. 4. At 10-year follow-up: patient reports no discomfort when performing plaque control around distal implant. Soft-tissue recession is reduced.

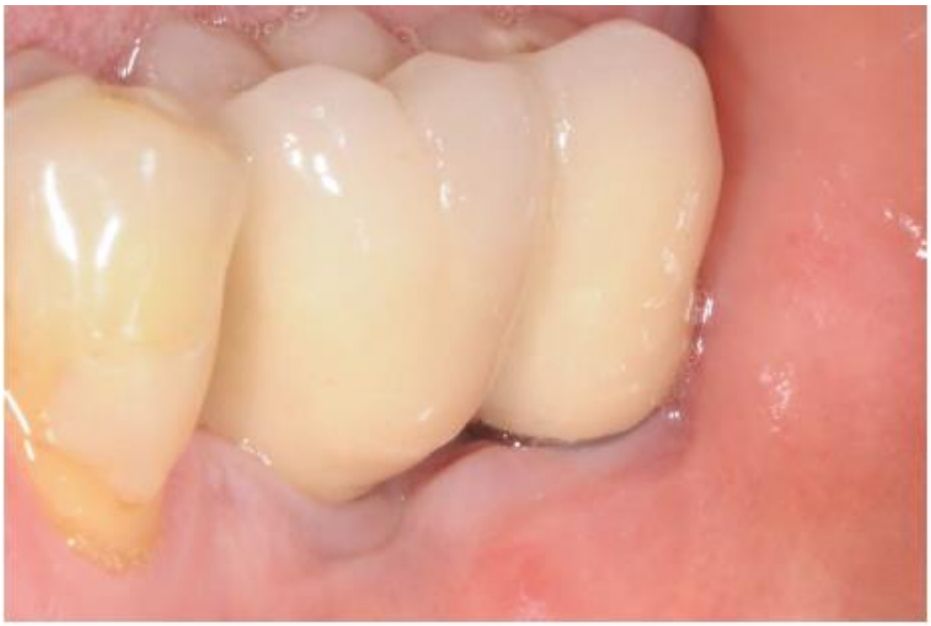

Fig. 5. Radiographic image at 10-year follow-up.