The Effect of Keratinized Mucosa Width on Peri-Implant Outcome under Supportive Postimplant Therapy

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ABSTRACT

Background: Long-ranging data on the influence of keratinized mucosa (KM) on peri-implant tissue status have been scarce.

Purpose: Retrospective evaluation of peri-implant diseases and KM width in patients with versus without mucogingival surgery.

Materials and Methods: Under supportive postimplant therapy (SIT) in a private practice, 68 patients with peri-implant KM widths <1 mm were identified between 1992 and 2011 (eight dropouts). Thirty patients rejected surgery (control [C] group), and 30 patients agreed (intervention [I] group). After at least 1 year, KM width, mucositis, and peri-implant conditions were assessed.

Results: Sixty nonsmoking patients ($n = 105$ implants) were available for assessment after 12.10 ± 4.93 years. No implants were lost (survival rate: 100%). An average of 10.69 years after surgery, the I group implants showed a mean KM gain of 3.10 ± 1.43 mm (C group: 0 mm).

The mucositis rates were as follows: I group: 38.98%; C group: 31.91%. Peri-implantitis was detected in two implants (1.87%) and two individuals (6.67%) in the I group.

No significant differences between groups were found, except that the KM width values were significantly greater in the I group ($p < 0.001$).

Conclusions: Low incidences of peri-implant diseases over long periods can be expected in patients attending SIT programs, independent of the absence or presence of KM.

KEY WORDS: connective tissue graft, dental implant, free gingival graft, keratinized mucosa, long-term results, maintenance, peri-implant mucositis, peri-implantitis

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INTRODUCTION

It has been known for several decades that the absence of keratinized mucosa (KM) around teeth and the resulting mobility of the marginal tissues promote bacterial invasion of the gingival sulcus.[1] KM improves the long-term prognosis of restored teeth in particular.[2–4] The relevance of a sufficiently wide zone of KM to the long-term success rate of oral implants remains controversial. A causal relationship has been postulated between the accumulation of bacterial plaque on implants and the progression of inflammatory processes in the peri-implant soft tissue.[5] Mucositis around implants is very similar to gingivitis around natural teeth, a fact that has been demonstrated in both animals[6] and humans.[7] This

similarity is independent of the nature of the implant system used.[8]

A number of earlier studies showed that peri-implant tissues could be maintained in a healthy state in the presence of adequate plaque control. No correlation was found in those studies between implant survival or success rates and the presence of KM.[9–11] This lack of correlation was confirmed in a recent review article.[12]

Other studies, however, have indicated that in clinical reality, consistently good oral hygiene around restorations is very difficult to maintain if no KM is present.[13] Several studies have demonstrated increased levels of plaque and inflammation around implants in the absence of KM.[14–16] More recent studies have shown that despite good oral hygiene and maintenance therapy, implants with less than 2 mm of KM in the peri-implant region were significantly more prone to bleeding, and they exhibited greater radiological bone loss and buccal soft-tissue recession.[17–21] Moreover, a negative correlation was observed between the width of KM and buccal soft-tissue recession on the one hand, and elevated values for immunological parameters (Prostaglandin E2) on the other hand.[22]

Various proposals have been made regarding the potential surgical extension of the zone of KM around implants.[23–31] Indications for mucogingival surgery procedures at implants (MGSI) have been discussed, but the topic remains controversial. Today, data on the possible benefit of MGSI and on the possible impact of a professional postimplant supportive therapy (SIT) program on the long-term stability of implants without KM have been rare.

The purpose of this study was to retrospectively investigate the long-term data on the success/survival rates and incidences of peri-implant diseases (mucositis, peri-implantitis) for implants with and without KM.

Hypothesis: In this study, we sought to determine whether implants with KM width <1 mm would show significantly inferior rates of peri-implant diseases after MGSI compared with implants without surgical intervention in patients in compliance with a SIT program.

MATERIALS AND METHODS

Study Design

This retrospective clinical study was undertaken in a private practice specializing in implants (Northern Hessia Implant Center, Hofgeismar, Germany). It was based on an analysis of the primary data of patients, and it evaluated the clinical outcomes of MGSI versus no surgical intervention at implants without KM. The study was reviewed and authorized by the Ethics Commission of the Albert-Ludwigs University in Freiburg, Germany (application no. 46/10–120,329). The recommendations for strengthening the reporting on observational studies in epidemiology were followed.[32]

Study Population

The patients enrolled in the study attended a SIT program in a private practice and exhibited a KM width <1 mm at a minimum of one implant. Between January 1993 and December 2011, the patients had been approached for a surgical intervention aimed at creating KM around their implants. Some of the patients agreed (the intervention [I] group), and others refused (the control [C] group). These patients were approached during their annual maintenance appointments and were asked to participate in the study after they had received written information regarding the aims and course of the study. The patients who provided written informed consent and who met the inclusion criteria were included. The following inclusion criteria were applied:

- Age ≥18 years old;
- Surgery, prosthodontic treatment, and SIT performed in the study center;
- Regular (at least annual) appointments in the SIT program;
- Complete and continuous documentation of technical and biological complications during the entire functional period;
- Periodontal examination, including pocket probing depth (PPD) and bleeding on probing (BoP) at four sites per tooth/implant within 6 months prior to data acquisition, using a periodontal probe;
- KM width <1 mm, examined by inspection and by roll test using a periodontal probe;
- Complete medical history including the following potential risk factors: medication (immune suppression and bisphosphonate), diabetes, cardiovascular disease, rheumatoid arthritis, and smoking habits;
- Availability of medical data, including general illnesses, medications, and smoking habits; and
- Postoperative (MGSI) observational period ≥1 year.

The following exclusion criteria were applied:

- Tobacco smoking;
- Noncompliance with the postimplant maintenance program (minimum 1×/year);
- Functional time documented <1 year; and
- Other missing data.

Data Collection

The patients were evaluated according to the following parameters using patient records: age and sex, medical history, anatomical implant position, number of implants, loss of implants, date of intraoral delivery, type of MGSI technique, and observation period. Moreover, after introral deliverance of the prostheses (baseline) and during the last maintenance appointment, the included patients were clinically examined by an experienced dentist (E.F.). A periodontal examination was performed for all implants and included the following parameters:

- Evaluation of the peri-implant hygiene status using the Quigley-Hein plaque index (QHI);
- Measurement of the PPD using a millimeter-scaled periodontal probe (PCP 15, Hu-Friedy, Chicago, IL, USA) at four locations per implant (mesiobuccal, distobuccal, mesio-oral, disto-oral);
- Noting any BoP (30 seconds following probing); and
- Assessment of KM width at the vestibular aspect of the implants using the same periodontal probe.

Diagnostic Criteria

Every recorded incident of BoP was defined as peri-implant mucositis.[33] No true endpoints have been identified to diagnose peri-implantitis[34–36]; therefore, the following surrogate endpoints were used: positive BoP, PPD ≥ 5 mm, and a maximum bone loss ≥3.5 mm. All of the radiographic data (intraoral radiographs taken via the long-cone parallel technique) were analyzed using a PC program (Sidexis XG, Sirona Dental Systems GmbH, Bensheim, Germany). The procedure was described previously.[37] For diagnosing of peri-implantitis, radiographic analysis was performed in implants with BoP+ and PPD ≥ 5 mm. Postoperative radiographs were considered as baseline measurements.

Course of Treatment

The implants were placed according to the protocol recommended by the manufacturer. Second-stage surgery was performed after a healing period of 3 months. After the delivery of the prostheses, all of the patients were instructed with regard to implant hygiene. The patients were then included in a SIT program at the study center with a 3-month recall interval. Compliance was defined as participation in a minimum of one prophylaxis appointment/year. These sessions included the above-described evaluation of the peri-implant tissue status and radiographs for implants with positive BoP and PPD ≥ 5 mm. Following this evaluation, motivation was reinforced, and the patients were reinstructed in home-based plaque-control techniques. Finally, at each follow-up visit, all of the implants and teeth were professionally cleaned with polishing paste and a rubber cup (FSI Slimline, De Trey GmbH, Konstanz, Germany). During the SIT appointments, patients with KM < 1 mm at a minimum of one implant were approached, and MGSI was recommended to increase the KM width.

Surgical procedures: The MGSI procedures were performed under local anesthesia, and the patients were postoperatively provided with analgesics (ibuprofen 400 mg) and were advised to rinse with chlorhexidine 0.2% (Chlorhexamed, GlaxoSmithKline Consumer Healthcare GmbH & Co. KG, Bühl, Germany) for up to 4 weeks. No chlorhexidine-related tooth staining was observed. Sutures were removed 7 days after surgery. The grafted sites were protected with periodontal dressings. All of the MGSI procedures were performed under fourfold magnification loupes.

Connective tissue graft (CTG)[38,39]: Along the implant's sulcus, a partial thickness incision was made and was extended approximately 5 mm both mesially and distally, following the mucogingival junction and separating the vestibular mucosa from the KM. The vestibular mucosal flap was then dissected from the periosteum to create an envelope approximately 15 mm in depth. Using a scalpel with two parallel blades, grafts were harvested from the palate between the distal aspect of the lateral incisor and the mesial aspect of the first molar[40] in the following manner. With a minimal distance of 2 mm to the gingival margins, two parallel incisions were made to a depth of approximately 10 mm. Then, the graft was dissected using a single-blade

scalpel. After suturing, the donor area was covered with a previously fabricated stent (Erkodent 1.5 mm, Erkodent GmbH, Pfalzgrafenweiler, Germany). After the keratinized part was dissected, the CTG was placed into the envelope that had been created at the recipient site and was then sutured to the local tissues. To optimize the blood supply to the graft, the mucosal flap was sutured to widely cover the CTG, and the grafted site was protected with a periodontal dressing.

Free gingival graft (FGG)[41–43]: In contrast with the CTG surgery, the first incision lines were more extended (10–12 mm). FGG harvesting was performed with a single-blade scalpel, and the FGG was not covered by local flaps. These flaps were not sutured to the periosteum but were kept away with the periodontal dressing.

Data Analysis

The primary endpoint of the statistical analysis was KM width; the secondary endpoints were peri-implant mucositis and peri-implantitis. Baseline points for the radiographic assessment were the postoperatively taken radiographs. Baseline values for the clinical evaluation were taken after intraoral deliverance of the prostheses. To evaluate differences between the groups, linear mixed models (for continuous data) and logistic mixed models (for binary data) were fitted (one model per outcome), and the structure of the data (i.e., several measurements per patient [several teeth]) was accounted for.

All of the calculations were performed with STATA statistical software version 12.1 (StataCorp LP, College Station, TX, USA).

RESULTS

Patients

A total of 68 patients were included in the study. The dropout rate was 11.76% (two patients moved out of the area, three patients changed their dental providers, and three patients died). Therefore, 60 patients with a mean age of 53.87 ± 12.04 (range: 16.65–71.95) years old were available for assessment. Of these, 39 were female (65%), and 21 were male (35%). The medical histories revealed cardiovascular disease in 24 (40%) patients. Table 1 summarizes the pertinent patient data. All of the patients attended one to four SIT appointments per year.

Implant Treatment (Tables 2 and 3)

In total, 105 implants with a mean observation period of 12.10 ± 4.93 (range: 2.37–20.35; median: 11.37) years were included. Of these, 49 (47%) were Ankylos implants (Dentsply Friadent, Mannheim, Germany), 29 (28%) were Branemark implants (Nobel Biocare, Köln, Germany), and 27 (26%) were Biomet 3i (Biomet 3i, Karlsruhe, Germany), ITI Bonefit (Straumann, Freiburg, Germany), or Astra implants (Astra Tech, Elz, Germany). The number of implants included in one restoration ranged from 1 to 4. The mean length was 12 ± 2.1 mm (range: 8–18). For a better understanding of the distribution of the sample, the patients were divided in subgroups according to the range of years of follow-up (Table 4). None of the implants were lost during the observation period (implant survival rate: 100%).

TABLE 1 Pertinent Data of Patients (*n* = 60) and Implants (*n* = 105)

Age in Years (mv ± SD)			53.9 ± 12
Sex (*n*)		Female	39 (65%)
		Male	21 (35%)
Smoking habits (*n*, [%])		Nonsmoker	60 (100%)
		Smoker	0
General illnesses		Diabetes mellitus	0
		Coronary heart disease	24 (40%)
Observation period in years (mv ± SD; median)			12.1 ± 4.9 (11.4)
Number of implants (*n* = 105)			
n	Jaw	Maxilla (*n*, [%])	44 (42%)
		Mandible (*n*, [%])	61 (58%)

Mv = mean value; SD = standard deviation.

TABLE 2 Distribution of Implants according to the FDI scheme (I Group: *n* = 59; C Group: *n* = 46)

Maxilla																
Tooth position	18	17	16	15	14	13	12	11	21	22	23	24	25	26	27	28
I group [*n* = 25]	0	0	1	5	2	1	1	1	2	1	1	5	3	1	1	0
C group [*n* = 19]	0	0	2	1	3	5	2	0	0	1	1	2	1	1	0	0
Mandible																
Tooth position	48	47	46	45	44	43	42	41	31	32	33	34	35	36	37	38
I group [*n* = 34]	0	0	0	2	3	4	2	1	1	3	4	5	2	5	2	0
C group [*n* = 27]	0	3	6	3	1	2	1	0	0	2	0	1	1	5	2	0

C = control; FDI = Fédération Dentaire Internationale; I = intervention.

Surgical Outcomes (I Group, *n* = 59 Implants)

MGSI was performed after a mean interval of 2.98 ± 3.32 (median: 1.44) years after implant placement. Therefore, after MGSI, a mean observation period of 10.69 ± 5.61 (range: 1.17–18.63; median: 12.79) years elapsed. Two different grafting procedures were used: CTG at 27 implants (45.76%) and FGG at 32 implants (54.24%; Table 5 summarizes the clinical outcomes according to surgical technique). Wound healing was uneventful, and no patients reported extraordinary pain, bleeding, or swelling. The stents were left in place for 48 hours at the donor sites, followed by application for five additional days during meals and at night only.

TABLE 3 Number and Percentage of Included Implant Types

Implant Type	*n*	%
Ankylos	49	46.67
Branemark	29	27.62
ITI Straumann	10	9.52
Astra	3	2.86
3i	14	13.33
Total	105	100

TABLE 4 Partition of the Sample in Subgroups according to the Range of Years of Follow-Up

Follow-Up Time (years)	Number of Patients	Number of Implants
0–5	10	10
5–10	24	35
10–15	21	22
15–20	12	13

All of the donor sites showed normal wound healing. The sutures were removed after 7 days. At that time, all of the grafts were in place and appeared to be well nourished. After 4 weeks, no signs of inflammation were observed.

KM Width (I Group, *n* = 59 Implants)

At an average of 10.69 years after MGSI, all of the implants showed an increase in KM width, which yielded a mean of 3.10 ± 1.43 mm (range: 1–6; median: 3). The mean values of KM gain between the two subgroups – FGG (3.30 ± 1.51 mm) and CTG (2.87 ± 1.31 mm) – yielded a difference that favored FGG but was not statistically significant. No KM gain was observed in the C group. FGG and CGT demonstrated the ability to increase KM width reliably at the implants over long periods of time with high significance ($p < 0.001$).

Peri-Implant Mucositis/Peri-Implantitis (Table 6)

No patients had histories of peri-implantitis prior to MGSI. The mean plaque index (mod. QHI) was

TABLE 5 Clinical Peri-Implant Outcomes of the Intervention Group (*n* = 30 Individuals) according to Surgical Procedure (10.7 Years Postoperatively)

Surgical Procedure	CTG	FGG
Number of implants (%)	27 (45.76)	32 (54.24)
KM gain, mm	2.87 ± 1.31	3.30 ± 1.51
Pocket probing depth (PPD), mm	3.78 ± 0.88	3.84 ± 1.10
Mucositis (pos. BoP value) (%)	9 (33.33)	14 (43.75)
Peri-implantitis (%)	1 (3.70)	1 (3.13)

BoP = bleeding on probing; CTG = connective tissue graft; FGG = free gingival graft; KM = keratinized mucosa.

TABLE 6 Clinical Peri-Implant Outcomes of the I Group versus the C Group

	Intervention Group	Control Group	Total	Significance
Number of patients (%)	30 (50)	30 (50)	60	
Number of implants (%)	59 (56.2)	46 (43.8)	105	
KM gain	3.10 ± 1.43 mm	0	—	Yes ($p < 0.001$)
QHI values	0.34 ± 0.48	0.33 ± 0.47	0.34 ± 0.48	No ($p = 0.77$)
Pocket probing depth (PPD)	3.81 ± 0.99 mm	3.86 ± 0.89 mm	3.83 ± 0.94	No ($p = 0.85$)
Mucositis (pos. BoP value)	23 (39%)	15 (32.6%)	38 (36.19%)	No ($p = 0.47$)
Peri-implantitis	2 (3.39%)	0	2 (1.87%)	No ($p = 0.99$)

BoP = bleeding on probing; C = control; KM = keratinized mucosa; I = intervention; QHI = Quigley-Hein index.

0.34 ± 0.48 (median 0). The mean peri-implant probing depth was 3.83 ± 0.94 mm (range: 2–6.75, median: 3.7). A mean PPD value of >5 mm was assessed at 13 implants (12.15%). Of these, nine implants (8.41%) also showed positive BoP. Peri-implant mucositis (positive BoP value) was observed in 38 implants (36.19%) and progressed to peri-implantitis in two (1.87%) implants (both in the I group), according to the selected criteria. Therefore, the I group showed a success rate of 96.61%, and the C group showed a success rate of 100%, resulting in an overall success rate of 98.13%.

No statistical significance was found between the I group and the C group in terms of QHI ($p = 0.77$), PPD ($p = 0.85$), peri-implant mucositis rate ($p = 0.47$), or peri-implantitis rate ($p = 0.99$).

DISCUSSION

Peri-implantitis is a growing problem in clinical dentistry. Because no existing guidelines for the treatment of peri-implantitis have yet been defined, prevention strategies are of increasing interest. The absence or presence of KM and the installation of postimplant maintenance programs may influence the incidence of peri-implantitis. This study was a retrospective long-term evaluation of KM width and peri-implant disease rates in implants with versus without mucogingival surgery under supportive postimplant therapy in a private practice. CTG and FGG proved to be well suited to reliably and permanently increase KM width for dental implants. In patients with >12 years of compliance with a SIT program, this study revealed high survival/success rates and low incidences of peri-implant diseases at implants with KM width <1 mm, irrespective of whether the patient had undergone MGSI. Therefore, the hypothesis of this study could not be confirmed.

Because there are no evidence-based guidelines for the treatment of peri-implantitis, prevention strategies have become increasingly important. The integration of postimplant maintenance programs could contribute to the long-term stability of peri-implant tissues. Several studies have demonstrated the positive influence of regular participation in a professional SIT program.[37,44–48] These findings were explicitly underlined by our results. In our study, after a mean observation period of 12 years and a total of 105 implants, the survival rate was 100%, and the success rate (i.e., no diagnosis of peri-implantitis) was 98.1%. A recent review that included 2,652 implants in 904 subjects with observation periods ≥10 years revealed survival rates of 94.8–99.6% and success rates of 83.1–94.2%.[49]

Because all of the patients included in this study attended a SIT, good oral hygiene scores were expected. With a mean QHI score of 0.35 and no recorded values >1, this expectation was fulfilled. Patients with deficient or lacking compliance with periodic implant aftercare can be expected to show considerably higher plaque scores, which could exert a relevant influence on peri-implant disease rates. This fact must be considered in the interpretation of our findings.

It is not definitively known whether the presence or absence of KM influences the peri-implant soft-tissue status. Regarding peri-implant mucositis rates (positive BoP scores), some studies have revealed significantly higher mucositis rates around implants encircled with a KM width ≤2 mm.[17–19,22,50,51] Other studies could not confirm this correlation.[20,52–54] The overall mucositis rate in our study was 38.19%. This finding is in accordance with Roos-Jansaker and colleagues[55] who found mucositis rates between 39.6% and 52.3%. No significant difference was found between the I group and C group;

therefore, our findings cannot support a statistical relationship between mucositis rates and the presence/absence of peri-implant KM.

The surgical outcomes of our study showed both CTG and FGG to be successful for dental implants as no graft necrosis could be observed, and considerable KM gains of 2.87 mm (CTG) and 3.30 mm (FGG) were recorded. This difference did not reach a statistical significance, and no other periodontal parameters revealed any statistical significance between these two subgroups. Therefore, both techniques could be judged as appropriate for increasing KM width around dental implants.

Our study could not find reliable data to support the hypothesis that periodontal soft-tissue grafting procedures aimed at increasing KM width exerted a positive influence on the incidence of peri-implant diseases.

Unfortunately, there is a considerable lack of data at the present time regarding clinical long-term outcomes associated with surgical peri-implant soft-tissue augmentation procedures and SIT programs. This investigation presents the long-term results of implants (KM width <1 mm) in a SIT program with encouraging clinical outcomes over a follow-up period of up to 20 years. Limitations of this study include the relatively small number of treated patients and implants and the inclusion of different types of prosthodontic rehabilitations. Implant systems with different shapes and surgical protocols included what has to be considered in the evaluation of PPD and bone loss. Two different surgical procedures were performed. In interpreting our findings, it should be noted that all of the patients included in the present study showed compliance with a strict postimplant prophylaxis program. Therefore, conclusions can only be drawn for this group of patients. No comparable data are available for patients without SIT compliance.

Despite these limitations, our study is one of the first investigations focusing on the long-term outcomes of peri-implant mucogingival surgery procedures. These findings could contribute to further evaluation of the long-term performance of MGSI because of the study's comparably long observational period of >10 years and because all of the data were assessed in patients attending a SIT program under the typical conditions of a private practice.

The excellent biologic long-term results of the implants in our study were achieved independent of KM width values. Therefore, it stands to reason that SIT compliance may exert a substantial influence on long-term peri-implant success and should consequently be recommended to all patients after implant therapy. Future prospective evaluations should be conducted to examine the effectiveness of SIT programs on peri-implant tissue status over the long term. The findings of our study should be compared with those of a study population without SIT compliance. Further research is needed to evaluate a possible relationship between peri-implant tissue quality and incidences of midfacial recession.

CONCLUSION

High survival/success rates and low incidences of peri-implant diseases over long periods of time can be expected in patients who attend professional SIT programs regardless of the absence or presence of peri-implant KM. FGG and CTG can be successfully performed at dental implants and can permanently increase KM width. No significant differences between these techniques were observed.

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