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ORIGINAL ARTICLE

The width of keratinized mucosa around dental implants and its influencing factors

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Abstract

Background: A few evidence is available in the literature concerning the pattern of variation in the width of keratinized mucosa (KMW) around dental implants and factors that may affect the KMW.

Purpose: The purpose of this study is to investigate the KMW at the buccal aspect of dental implants and to analyze its influencing factors.

Materials and Methods: The current study was a retrospective study conducted on 726 patients with 1252 dental implants. The following parameters were evaluated by reviewing the medical records of each patient, including the age, gender and smoking status of each patient, the reasons of teeth loss, the position of implants, the bone augmentation procedures, and the KMW. Binary logistic regression analysis with the generalized estimating equations was utilized to analyze the factors that may affect the KMW of dental implants.

Results: The KMW of implants located in the maxilla was significantly higher than that of implants located in the mandible ($P < .01$), except for the upper and lower canines. The logistic regression analysis indicated that the risk of the implants presenting inadequate KMW (<2 mm) in the periodontitis-caused tooth loss group was 1.91 times of the non-periodontitis-caused tooth loss group. The risk of implants presenting inadequate KMW after receiving simple and complex bone augmentation procedures was 1.65 and 2.62 times of the risk of implants without bone augmentation, respectively. The longer the follow-up period, the higher the risk of implants presenting inadequate KMW will be.

Conclusions: The KMW at the buccal aspect of implants is related to the position of implants. Tooth loss due to periodontitis, the bone augmentation procedures, and the process of functional period would increase the risk of implants presenting an inadequate amount of keratinized mucosa.

KEYWORDS

dental implant, influencing factors, keratinized mucosa

1 | INTRODUCTION

The keratinized mucosa (KM) around dental implants extends from the soft tissue margin to the mucogingival junction, which includes the free and attached mucosa. Histologically, the KM consists of a dense, collagen-rich connective tissue and is covered by keratinized epithelium. The lamina propria of the attached mucosa is firmly connected to the underlying periosteum.[1] Compared with the relatively loose and movable alveolar mucosa, the histological features of KM are claimed to have advantages in resisting mechanical traumas and preventing the progression of inflammation around dental implants.

The importance of KM in the maintenance of long-term health of peri-implant soft and hard tissues has been a matter of controversy, as it did for the natural dentition.[2-12] It is suggested that 2 mm of keratinized gingiva, including 1 mm attached gingiva is adequate to maintain gingiva health at teeth.[2] With regard to dental implants, several studies demonstrated that patients might experience pain and discomfort during daily oral hygiene procedures at implant sites with an "inadequate" amount of KM (<2 mm).[13,14] Implant sites with KMW < 2 mm exhibited more soft tissue recession and was associated with higher plaque index, gingival index, bleeding on probing, and more marginal bone loss.[13-25] Thus, mucogingival surgery including the free gingival graft is recommended to augment the narrow band of keratinized tissue. In contrast, some clinical studies indicated that the lack of KM around dental implants did not negatively affect the health and the long-term stability of peri-implant soft and hard tissues in the presence of good oral hygiene.[26-28] Some reviews with regard to the need for KM around dental implants demonstrated that evidence in support of KM to maintain health and tissue stability is limited,[29,30] while others affirmed the positive significance of KM in preventing tissue inflammation.[31-33] The consensus report of the 2017 World Workshop on the Classification of Periodontal and Peri-implant Diseases and Conditions proposed that the evidence concerning the effect of KM on the long-term health of the peri-implant tissue is equivocal. Despite the controversial results, KM may have advantages in terms of patient's comfort and ease of plaque removal. Furthermore, lack of KM is claimed to be associated with the recession of the peri-implant mucosa.[34]

Based on the data of earlier literature, the prevalence of implants surrounded by KM < 2 mm ranged from 23.8% to 74%.[17,21,23,27,35-38] Many factors have been proposed to have impacts on the width of the attached gingiva around natural teeth, including the position of the tooth, high frenum and muscle attachments and gingiva recession due to inflammation or other reasons.[39] However, relevant literature about the influencing factors of KMW around dental implants is limited. The relatively poor health care consciousness and oral hygiene status of patients in China make a sufficient amount of KM more important in the maintenance of long-term health of peri-implant tissues. Therefore, the aims of the present study were to explore the distribution of the width of the KM at the buccal aspects of dental implants and to analyze the relevant factors that may have an influence on the width of KM.

2 | MATERIALS AND METHODS

2.1 | Study design and patient recruitment

The current study was a retrospective study that was approved by the Ethics Committee of Peking University Health Science Center (Approval No. IRB00001052-10047) and was conducted in accordance with the Helsinki Declaration of 1975, as revised in 2013. Subjects eligible for the study were identified from a population of patients who had completed the implant restorations with fixed prostheses and attended implant maintenance care from July 2008 to July 2018 at Department of Periodontology, Peking University, School and Hospital of Stomatology or at the Second Clinic of Peking University, School and Hospital of Stomatology. All the patients recruited in this study had signed an informed consent form prior to their inclusions. The exclusion criterion was patients' lack of detailed medical records. For patients with multiple implants, all the implants that fulfilled the inclusion criteria would be accepted. The following information was recorded by reviewing the medical record of each patient, including

- The age, gender, and smoking status of each patient;
- The size and position of each implant;
- The reason of tooth loss: tooth loss due to periodontitis, including chronic periodontitis, aggressive periodontitis (AgP), and endodontic-periodontic lesion were divided into Periodontitis group (P) and tooth loss due to other reasons, including trauma, caries, pulp and periapical lesions were divided into Non-periodontitis group (NP);
- The surgical method of bone augmentation procedures: according to the application of bone graft and barrier membrane, the implants were divided into the following three groups:

1 No BA: no bone augmentation procedure during implant surgery,
2 Simple BA: use only bone graft in bone augmentation procedure, and
3 Complex BA: use both bone graft and barrier membrane in bone augmentation procedure.

- The follow-up time: is measured with the time of implant surgery as a baseline.

2.2 | Peri-implant clinical parameters

The following peri-implant clinical parameters were recorded by reviewing the medical records of patients' implant maintenance care. If the patient has multiple follow-up records during the above-mentioned period, only the most recent one is recorded.

1 The width of keratinized mucosa (KMW): measured in millimeters from the soft tissue margin to the mucogingival junction at the mid-buccal aspect of each implant.
2 Peri-implant probing depth (PDi): measured with light force from the peri-implant margin to the bottom of the peri-implant sulcus at six sites (mesiobuccal, buccal, distobuccal, mesiolingual, lingual, and distolingual) per implant.
3 Peri-implant bleeding index (BIi): assessed according to the Mazza Bleeding Index, which is ranging from 0 to 5.[40] The most severe sites among three sites at buccal and lingual/palatal were recorded.
4 Modified implant plaque index (PLIi)[41]: 0—No plaque detection, 1—Plaque only recognized by running a probe across the smooth marginal surface of the implant, 2—Plaque can be seen with the naked eye, and 3—Abundance of soft matter.

Then according to the KMW, the implants were then divided into two groups as follows:

1 Narrow group (KMW < 2 mm),
2 Wide group (KMW≥2 mm).

2.3 | Statistical analysis

Kolmogorov-Smirnov was used to test whether the measurement data are normally distributed. The age of the patient, the width of KM, the follow-up time, and the mean probing depth (mean-PD) did not conform to the normal distribution so that was expressed in the form of the median (interquartile range) [M(QR)]. Mann-Whitney *U* test was used for the comparison between groups. The implants were grouped according to whether the width of KM was less than 2 mm. We performed the binary logistic regression analysis combined with the generalized estimating equations (GEE) to analyze the factors that may affect the width of KM. All statistical analyses were performed with SPSS 22.0 (SPSS Inc, Chicago, Illinois) software. *P*-values <.05 were considered statistically significant.

3 | RESULTS

3.1 | Patients and implants

A total of 1506 implants in 804 Chinese patients were initially included in this study. Among 1506 implants, 254 were excluded due to a lack of detailed medical records. Eventually, 726 patients (291 males, 435 females) including 59 smokers with a median age of 47 years were recruited. A total of 1252 implants with a median follow-up period after implant inserting of 3 years were included. There were 227 out of 1252 implants with a width of KM < 2 mm, which accounted for 18% of the total.

3.2 | The width of KM

The KMW of male patients was significantly higher than that of female patients ($P < .01$). The KMW of the patients with age ranging from 52 to 82 years was significantly lower than that of the patients with age ranging from 22 to 37 years ($P < .01$). The KMWs of the implants in non-periodontitis-caused tooth loss group were significantly higher than that of the implants in the periodontitis-caused tooth loss group ($P < .01$), as presented in Table 1.

TABLE 1 The width of keratinized mucosa in different genders, ages and reasons of tooth loss

Group	*N*	KMW (mm) M (QR)	KMW (mm) Mean ± SD
Sex			
Male	474	3.00 (3.0)	3.38 ± 1.88
Female	778	3.00 (2.0)[a]	3.12 ± 1.90
Age			
22-37	150	4.00 (3.0)	3.72 ± 1.90
37-52	519	3.00 (2.0)	3.37 ± 1.96
52-67	480	3.00 (2.0)[b]	2.96 ± 1.83
67-82	103	3.00 (2.0)[b]	2.96 ± 1.68
Reason of tooth loss			
Periodontitis	445	3.00 (2.0)	2.93 ± 1.79
Non-periodontitis	807	3.00 (3.0)[a]	3.38 ± 1.94

Abbreviations: *N*, the number of dental implants; KMW, the width of keratinized mucosa; M(QR), median (interquartile range).
[a]Mann-Whitney *U* test, $P < .01$.
[b]Compared with 22-37 age group, Mann-Whitney *U* test, $P < .01$.

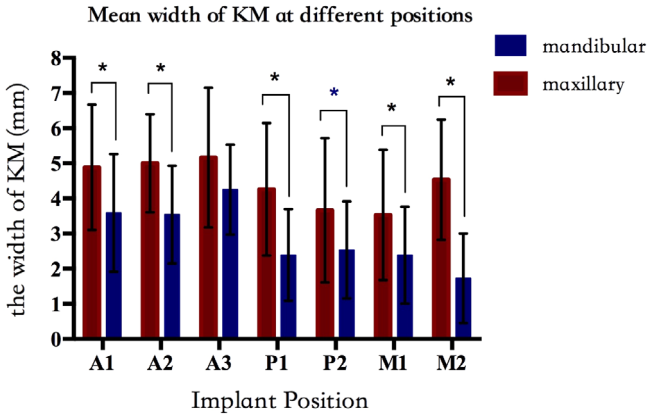

FIGURE 1 Mean width of keratinized mucosa (KM) at different implant positions; A1: central incisor; A2: lateral incisor; A3: canine; P1: the first premolar; P2: the second premolar; M1: the first molar; M2: the second molar.*$P < .01$

3.3 | The width of KM at different implant positions

The KM varied in width with each position (see Figure 1). The KMW of implants located in the maxilla was generally higher than that of implants located in the mandible, the difference was statistically significant ($P < .01$), except for the upper and lower canines. In the maxilla, the narrowest width of KM was found over the first molar region. While in the mandible, the narrowest width of KM overlay the second molar region. We further divided the upper and lower jaws into six areas (see Table 2). The results showed that the KMW of implants located in the upper anterior region was the highest while the KMW of implants located in the lower molar region was the lowest. Compared with the upper anterior region, the KMW of the rest of the regions was significantly lower ($P < .01$).

3.4 | Factors influencing the width of KM around dental implants

Table 3 presented the binary logistic regression analysis of factors that may have an effect on the KMW around dental implants. The results showed that the risk of the implants exhibited with inadequate KMW (<2 mm) was significantly higher in lower molar region (OR value = 53.93; 95% CI: 11.686-248.931; $P = .000$), lower premolar region (OR value = 23.667; 95% CI: 4.714-118.827.487; $P = .000$),

TABLE 2 The width of keratinized mucosa at different implant positions

Group	*N*	KMW (mm) M (QR)	KMW (mm) Mean ± SD
Upper anterior	145	5.0 (2.0)	4.97 ± 1.72
Upper premolar	175	4.0 (2.0)[a]	3.93 ± 2.00
Upper molar	278	4.0 (2.0)[a]	3.74 ± 1.87
Lower anterior	77	3.0 (2.0)[a]	3.64 ± 1.51
Lower premolar	81	3.0 (1.5)[a]	2.51 ± 1.36
Lower molar	496	2.0 (2.0)[a]	2.22 ± 1.38
Total	1252	3.0 (2.0)[a]	3.22 ± 1.90

Abbreviations: *N*, the number of dental implants; KMW, the width of keratinized mucosa; M(QR), median (interquartile range).
[a]Compared with the upper anterior group, Mann-Whitney *U* test, $P < .01$.

upper molar region (OR value = 11.116; 95% CI: 2.550-48.445; $P = .001$) and upper premolar region (OR value = 7.128; 95% CI: 1.608-31.602; $P = .010$) than in upper anterior region. The risk of the implants presenting inadequate KMW (<2 mm) in periodontitis-caused tooth loss group was 1.91 times of non-periodontitis-caused tooth loss group (OR value = 1.908; 95% CI: 1.223-2.978; $P = .004$). The risk of implants presenting inadequate KMW after receiving simple and complex bone augmentation procedures was 1.65 and 2.62 times of the risk of implants without bone augmentation procedure, respectively (complex: OR value = 2.617; 95% CI: 1.235-5.544; $P = .012$; simple: OR value = 1.651; 95% CI: 1.024-2.663; $P = .040$). The longer the follow-up period, the higher the risk of implants presenting inadequate KMW will be (OR value = 1.106; 95% CI: 1.030-1.187; $P = .005$). Furthermore, the results also indicated that the width of KM at implant sites was not significantly affected by sex, patient age, smoking status of patients, and clinical parameters of implants including the PDi, the BIi (buccal), and the PLIi.

4 | DISCUSSION

Much attention has been focused on the importance of KM around dental implants in recent years. However, whether the presence of KM is a prerequisite for the long-term stability of dental implants is still a matter of controversy. The positive significance of KM has been emphasized in several clinical studies.[13-25] The current study aims to explore the pattern of variation in the width of the buccal KM at different positions and to figure out factors that may affect the width of KM around dental implants.

A very few evidence is available in the literature concerning the factors that may affect the width of KM around dental implants. As for the width of attached gingiva around natural teeth, a study reported by Bower et al showed that the following factors including the malposed teeth, high frenum and muscle attachments, and gingival recession were associated with the width of attached gingiva.[40] The current study conducted the binary logistic regression analysis combined with the GEE to analyze the factors that may affect the width of KM around dental implants. The result showed the width of KM at the buccal aspect of implants is influenced by several factors including the position of the implants, the reason of tooth loss, the bone augmentation procedures performed during implant surgery, and the function period after implant insertion.

The results of the current study revealed that the width of KM varied with the implant position. The width of KM of implants located in the maxilla was generally higher than that of implants located in the mandible, the difference was statistically significant ($P < .01$), except for the upper and lower canines. In the maxilla, the narrowest width of KM was found over the first molar region. While in the mandible, the narrowest width of KM overlay the second molar region. Binary logistic regression analysis also indicated that the risk of the implants exhibited with inadequate KMW (<2 mm) was significantly higher in the lower molar region, the lower premolar region, the upper molar region, and the upper premolar region than in the upper anterior region. Lang and Löe studied the pattern of variation in the width of KM at natural teeth and the result indicated that in the maxilla the facial keratinized gingiva was generally wider than mandible,[2] which is in accordance with the result of the current study. However, the facial KG was widest in the area of upper and lower incisors and narrowest adjacent to the maxillary and mandibular canines and first premolars. The reason for the difference may be due to the patients recruited in the above-mentioned study on natural teeth were periodontally healthy with equally distributed tooth types. Nevertheless, the implants recruited in the current study mainly distributed in the posterior region, which accounts for 82.3% of the total. Besides, the healing of the soft and hard tissues after tooth extraction and the flap design and management during implant surgery would have impacts on the KMW, which may lead to the different distributions of KMW between natural teeth and dental implants.

In the present study, the risk of the implants presenting inadequate KMW (<2 mm) in the periodontitis-caused tooth loss group was 1.91 times of the non-periodontitis-caused tooth loss group (OR value = 1.908; 95% CI: 1.223-2.978; $P = .004$). It is noteworthy that tooth loss due to severe periodontitis often accompanied by extensive periodontal soft and hard tissue defects. Gingiva recession will result in a narrower width of KG around the natural tooth and a narrower width of KM in the edentulous area after tooth extraction. In addition, the loss of crestal bone will result in a reduced depth of buccal vestibule. The above two aspects would increase the risk of dental implants with an inadequate width of KM.

The finding of the present study also indicated that the risk of implants presenting inadequate KMW after receiving simple and complex bone augmentation procedures was 1.65 and 2.62 times of the risk of implants without bone augmentation procedure, respectively (complex: OR value = 2.617; 95% CI: 1.235-5.544; $P = .012$; simple: OR value = 1.651; 95% CI: 1.024-2.663; $P = .040$). Due to the application of a large amount of bone grafts and barrier membrane during guided bone regeneration (GBR) procedures, longitudinal incision and/or periosteal releasing incision are expected to be used to reposition the buccal flap coronally and to ensure the wound closure without tension. This procedure would result in the coronal displacement of the

TABLE 3 The binary logistic regression analysis of factors related to the width of keratinized mucosa

Variables	*B*	Wald	*P*-value	OR-value	95% CI	
					Upper limit	Lower limit
Sex (female/male)	−0.111	0.260	.610	0.895	0.584	1.372
Age	0.015	2.936	.087	1.016	0.998	1.034
Smoking status (Yes/No)	−0.557	1.924	.165	0.573	0.261	1.258
Implant position						
LM/UA	3.988	26.116	.000*	53.935	11.686	248.931
LP/UA	3.164	14.771	.000*	23.667	4.714	118.827
LA/UA	0.588	0.471	.493	1.800	0.336	9.651
UM/UA	2.408	10.282	.001*	11.116	2.550	48.445
UP/UA	1.964	6.682	.010*	7.128	1.608	31.602
Reason of tooth loss (P/NP)	0.646	8.102	.004*	1.908	1.223	2.978
Bone augmentation procedures						
Complex BA/ no BA	0.962	6.304	.012*	2.617	1.235	5.544
Simple BA/ no BA	0.501	4.226	.040*	1.651	1.024	2.663
Follow-up time	0.101	7.742	.005*	1.106	1.030	1.187
Mean-PDi	−0.124	1.569	.210	0.884	0.728	1.072
BIi (buccal)						
4/0	−0.765	1.696	.193	0.465	0.147	1.472
3/0	0.152	0.273	.602	1.164	0.658	2.057
2/0	0.205	0.493	.483	1.227	0.693	2.173
1/0	0.432	1.442	.230	1.540	0.761	3.114
BIi (lingual)						
4/0	1.042	4.102	.043*	2.834	1.034	7.764
3/0	0.394	1.811	.178	1.482	0.836	2.629
2/0	0.593	4.882	.027*	1.810	1.069	3.065
1/0	0.223	0.309	.579	1.250	0.569	2.745
PLIi (buccal)						
3/0	0.566	1.968	.161	1.760	0.799	3.879
2/0	0.533	1.969	.161	1.704	0.809	3.586
1/0	0.041	0.032	.858	1.041	0.667	1.627
PLIi (lingual)						
3/0	−0.056	0.023	.735	0.946	0.460	1.942
2/0	0.174	0.360	.538	1.190	0.675	2.098
1/0	0.109	0.187	.585	1.115	0.681	1.824

Abbreviations: LM, lower molar region; LP, lower premolar region; LA, lower anterior region; UM, upper molar region UP, upper premolar region; UA, upper anterior region; P, periodontitis group; NP, non-periodontitis group.
Note: *$P < .05$.

mucogingival junction and further influence the width of KM at the buccal aspect of dental implants. Unfortunately, we could not find relevant randomized controlled trials to support the hypothesis that the GBR procedure had a negative impact on the width of KM at the buccal aspect of the dental implant. However, this finding is in agreement with our clinical findings.

Another finding of the present study indicated that the longer the follow-up period, the higher the risk of implants presenting inadequate KMW will be. It should be noted that the width of KM around dental implants after crown rehabilitation may not be stable and a variety of factors may affect the width of KM, for instance, the inflammatory lesions occurring in the peri-implant soft and hard tissues, the way the patients perform their daily peri-implant maintenance care, and the abnormal anatomical factors, such as the high frenum and muscle attachments. These factors may not have a large impact on the width of KM in short term, but over a long period of time, the risk of the recession of KM around dental implants would increase, especially for patients with thin biotypes. Therefore, for patients with

these high-risk factors, clinicians should intervene early and review the implants regularly to reduce the risk of KM loss. Nevertheless, a cohort study on the width of KM at implant sites in patients treated for generalized AgP demonstrated that during the first 4-year period after implant placement, no significant changes in the width of KM at implants could be shown.[42] A possible explanation for that could be that patients in the above study had regular follow-up at 3-month intervals for 4 years. The intensive oral hygiene instructions and the professional implant maintenance therapy may lower the risk of the mucosa recession. However, it is noteworthy that due to the lack of baseline data of original KMW before implant placement and immediately after implant rehabilitation in the current retrospective study and the lack of related literature with a high level of evidence, the above potential factors need to be verified through further prospective clinical studies. In addition to that, the aforementioned cohort study also indicated that the width of KM at implant sites was not significantly affected by sex, patient age, implant localization, implant length, type of super-structure, bone quality, or atrophy.

This study is a large sample size investigation on the width of KM at the buccal aspect of dental implants and its possible influencing factors. It must be noted that the results of the present study should be viewed within the context of some limitations. First, the current study was a retrospective study based on the data collected during the routine implant maintenance care program. The lack of baseline data including the original KMW before implant placement and the KMW immediately after implant restoration as well as data of some potential influencing factors such as the malposition of implants would to some extent bias the results of the current study. Second, the clinical examination was not performed by the same periodontist. Hence, measurement bias should not be ignored. Further prospective clinical studies should be designed to confirm our findings with the control of confounding factors.

5 | CONCLUSIONS

The KMW at the buccal aspect of implants is related to the position of implants. Tooth loss due to periodontitis, the bone augmentation procedures, and the process of functional period would increase the risk of implants presenting an inadequate amount of KM. However, clinical studies of long-term, longitudinal, and larger sample size are needed to further validate these results.

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CONFLICT OF INTEREST

The authors declare no potential conflict of interest.

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