

Do we need keratinized mucosa for a healthy peri-implant soft tissue?

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The presence of keratinized mucosa plays a fundamental role in peri-implant soft tissue health. This study assessed the impact of the width of keratinized mucosa (WKM) on peri-implant soft tissue parameters. A cross-sectional study was conducted on 110 bone-level implants in 36 patients. A minimum of 6 months had passed since the loading of implants, and the patients had at least 1 implant in 1 quadrant at the molar or premolar site restored with a single crown or fixed partial denture. The health of peri-implant soft tissue was assessed with a modified bleeding index (MBI), modified plaque index (MPI), and modified gingival index (MGI). Probing depth (PD), gingival recession (GR), and WKM were also measured. History of smoking and oral hygiene methods were recorded. A significant inverse correlation existed between WKM and the parameters MBI, MPI, MGI, and GR ($P < 0.05$). Values of MBI, MPI, MGI, and GR were significantly lower in areas with $WKM \geq 2$ mm and higher in areas with $WKM < 2$ mm ($P < 0.05$). The WKM was greatest in subjects using the vibratory toothbrushing technique and narrowest in those using the horizontal toothbrushing technique ($P < 0.05$). The mean WKM was significantly greater in smokers than in nonsmokers ($P < 0.05$). Results of this study indicate that an association exists between WKM and peri-implant soft tissue health. A minimum of 2 mm of keratinized mucosa around implants is recommended.

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In light of the increasing demand for dental implants, their long-term efficacy and clinical service have become more important than ever. The health of the peri-implant soft tissue is a fundamental factor that guarantees the survival of an implant. The presence of keratinized mucosa (KM) has always been a topic of interest, as it is an influential factor in the success of implants as well as the health of the surrounding soft tissue.^{1,2} Knowledge about the role of KM in the health of peri-implant soft tissue is essential, and ignoring this issue may significantly decrease the success rate of implant treatment.^{3,4} An inadequate width of keratinized mucosa (WKM) does not definitely cause clinical treatment failure but may negatively impact an implant's prognosis.^{2,5-7}

Lang & L oe were the first to suggest a significant correlation between the WKM and the health of the surrounding peri-implant and peri-tooth soft tissue.⁸ The authors stated that the presence of a minimum of 2 mm of KM—including 1 mm of attached gingiva—contributes to a healthy periodontium. Miyasato et al showed that the health of the gingival margin might be preserved even with a $KM \leq 1$ mm.⁹ They found no significant difference between subjects with $KM \leq 1$ and $KM \geq 2$ mm in terms of clinical symptoms of inflammation. Controversy exists regarding the role of WKM in the health of peri-implant soft and hard tissues.^{1,5,7} Lindhe et al evaluated the peri-implant and peri-tooth soft tissue responses to plaque accumulation and reported a resemblance between implants and natural teeth in this regard.¹⁰

Several studies have reported a positive correlation between the WKM and the health of peri-implant tissues.^{1,5,7,11-13} For instance, Zigdon & Machtei evaluated the effect of microbial plaque on gingival recession (GR) and clinical attachment loss around implants in areas with and without KM.¹³ The GR and clinical attachment loss were greater around implants that were not surrounded by KM than around those in areas with adequate WKM.¹³ However, other studies did not find a significant difference in this regard.¹⁴⁻¹⁸ Esper et al found no significant difference in the gingival inflammation (GI) and plaque index (PI) between groups with $WKM < 2$ mm and $WKM \geq 2$.¹⁷ The authors reported that the WKM had no effect on bleeding upon probing and plaque control.

If the presence of such a correlation can be confirmed, the WKM can be enhanced with methods such as apically positioned flaps in the second-stage surgery, gingival augmentation, or vestibuloplasty to guarantee the long-term health of the peri-implant tissue.^{13,19,20} However, controversy still exists regarding both the necessity of the presence of KM around implants to ensure long-term soft tissue health and the minimally required amount of KM.^{7,13,17,18} Therefore, the present study aimed to assess the correlation of the WKM with peri-implant soft tissue health and related factors.

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Table 1. Measured values of the clinical parameters used in this study.

Clinical parameter	Mean (SD)	Median	Minimum	Maximum
WKM (mm)	2.580 (1.420)	2.000	0.000	6.000
PD (mm)	2.600 (0.355)	2.500	1.500	3.750
MBI	0.681 (0.400)	0.750	0.000	1.750
MPI	0.784 (0.332)	0.750	0.000	1.750
MGI	1.120 (0.646)	1.000	0.000	2.000
GR (mm)	0.170 (0.403)	0.000	0.000	2.000

Abbreviations: GR, gingival recession; MBI, modified bleeding index; MGI, modified gingival index; MPI, modified plaque index; PD, probing depth; WKM, width of keratinized mucosa.

Materials and methods

Subjects

This cross-sectional study was conducted on patients who presented to the Implant Department of Islamic Azad University, Tehran, Iran, during the years 2009-2012 and met certain criteria.

To be included in the study, patients had to be over the age of 18 years and have an implant and implant prosthesis present in their mouth. Implant loading had to have taken place more than 6 months previously. Patients had to have at least 1 implant in 1 quadrant of the jaws in the molar or premolar sites restored with a single crown or fixed partial denture. Implants had to be at bone level, submerged, and placed by a 2-stage surgery. The patients had to have a suitable cemented, porcelain-fused-to-metal restoration (normal occlusion, suitable emergence profile and proximal contacts, adequate crown-implant ratio, absence of overcontouring, and no marginal gap in the crown).

Patients who had received bone grafts or gingival grafts at the implant recipient site as well as those with a history of alcohol consumption or drug abuse, recent steroid therapy or chemotherapy, immunodeficiency, bruxism, clenching, or use of systemic antibiotics in the past 6 weeks were excluded from the study. Subjects with systemic conditions necessitating antibiotic therapy, those with systemic diseases affecting bone metabolism and soft tissue (such as uncontrolled diabetes mellitus, hyperthyroidism, or hyperparathyroidism), and pregnant women were also excluded.

Each subject gave a written informed consent, and the patients were briefed about the study. The study protocol and consent form were reviewed and approved by the ethics committee of the Dental Branch of Islamic Azad University. The study was conducted in full accordance with the World Medical Association's Declaration of Helsinki.²¹

Periodontal parameters

Peri-implant soft tissue was assessed by measuring the following periodontal parameters: WKM, modified bleeding index (MBI), probing depth (PD), modified plaque index (MPI), modified gingival index (MGI), and GR. Each parameter was measured twice by the same person, and the values were recorded.

Width of keratinized mucosa

The WKM was measured at the midbuccal surface of each implant with a UNC 15 periodontal probe. The distance from the gingival margin to the mucogingival junction was measured and

Table 2. Correlation coefficients between the width of keratinized mucosa (WKM) and clinical parameters.

Variable pairs	Correlation coefficient	P value
WKM and PD	-0.131	0.171
WKM and MBI	-0.395	0.001
WKM and MPI	-0.240	0.012
WKM and MGI	-0.488	0.001
WKM and GR	-0.256	0.007
WKM and age	-0.054	0.575

Abbreviations: GR, gingival recession; MBI, modified bleeding index; MGI, modified gingival index; MPI, modified plaque index; PD, probing depth.

rounded to the nearest millimeter. Differences in color, texture, and mobility between the KM and the loose junctional epithelium indicated the location of the mucogingival junction.⁶ Data were categorized into 2 groups: WKM \geq 2 mm and WKM < 2 mm.

Probing depth

A UNC plastic probe was inserted into the gingival sulcus along the longitudinal axis of the implant, and the distance from the pocket base to the gingival margin was measured at 4 points (midbuccal, midlingual, mesiobuccal, and distobuccal).¹⁴

Modified bleeding index

A UNC plastic probe was inserted 1 mm deep into the gingival sulcus around the implant at 4 points (midbuccal, midlingual, mesiobuccal, and distobuccal) according to the MBI described by Mombelli et al in 1987.²²

Modified plaque index

The presence or absence of plaque was determined by moving the probe tip across the 4 surfaces of the crown (buccal, lingual, mesial, and distal) according to the MPI described by Mombelli et al.²²

Modified gingival index

The level of gingival inflammation was assessed at 4 surfaces (buccal, lingual, mesial, and distal) according to the MGI described by Mombelli et al.²²

Table 3. Comparison of clinical parameters in 2 groups: width of keratinized mucosa (WKM) \geq 2 mm and WKM $<$ 2 mm.

Clinical parameter	WKM \geq 2 mm (n = 48)		WKM $<$ 2 mm (n = 62)		P value
	Mean	SD	Mean	SD	
PD (mm)	2.531	0.366	2.653	0.339	0.175
MBI	0.500	0.364	0.822	0.371	0.001
MPI	0.677	0.252	0.866	0.364	0.002
MGI	0.710	0.544	1.440	0.532	0.001
GR (mm)	0.100	0.309	0.230	0.459	0.007

Abbreviations: GR, gingival recession; MBI, modified bleeding index; MGI, modified gingival index; MPI, modified plaque index; PD, probing depth.

Table 4. Mean (SD) width of keratinized mucosa (in mm) based on the method of toothbrushing and history of cigarette smoking.

Parameter	No. of patients	Mean (SD)	P value
Method of toothbrushing			
Vertical	47	2.979 (1.410)	0.0001 ^a
Horizontal	30	1.767 (0.740)	
Circular	19	3.158 (1.633)	
Vibratory	3	3.833 (2.021)	
Rolling	11	1.773 (1.148)	
History of smoking			
No	82	2.384 (1.364)	0.012 ^b
Yes	28	3.161 (1.479)	

^aAnalysis of variance.

^bIndependent samples *t* test.

Gingival recession

The distance from the gingival margin to the margin of the crown was measured at the midbuccal point.⁶

Other parameters

Any history of cigarette smoking and the type of occlusion with the opposing jaw, in terms of presence of natural teeth, fixed partial denture, removable partial denture, or edentulism, were recorded. The method of plaque control and use of oral hygiene aids were also noted.

Statistical analysis

Data were analyzed using SPSS version 18 software (IBM Corporation), the Pearson correlation coefficient, independent *t* test, and an analysis of variance (ANOVA).

Results

This cross-sectional study was conducted on 110 implants in 36 patients (19 males and 17 females) with a mean age of 57.04 years (range: 30-76 years). A summary of the measured clinical parameters can be found in Table 1.

Table 2 shows the correlation of WKM with the clinical parameters. The Pearson correlation test revealed an inverse significant correlation between WKM and MBI, MPI, MGI, and GR ($P < 0.05$). Thus, the results showed that the greater the WKM, the lower the MBI, MPI, MGI, and GR values. No significant association was found between the WKM and PD or age ($P > 0.05$).

The WKM was categorized into 2 groups, $<$ 2 mm and \geq 2 mm (Table 3). Statistical analysis revealed that areas with a WKM \geq 2 mm had significantly lower MI, MPI, MGI, and GR and areas with a WKM $<$ 2 mm had greater MBI, MPI, MGI, and GR ($P < 0.05$). However, there was no statistically significant difference in PD in areas with WKM $<$ 2 mm and WKM \geq 2 mm ($P > 0.05$).

The ANOVA revealed a significant association between the WKM and the method of toothbrushing ($P = 0.0001$). The WKM was the greatest in subjects using the vibratory technique and the narrowest in those using the horizontal technique (Table 4). A significant association also was noted between the WKM and a history of smoking ($P = 0.012$); the mean WKM was greater in smokers than in nonsmokers. No significant

association was found between WKM and sex, use of oral hygiene aids, the frequency of daily toothbrushing, or the dental status of the opposing jaw ($P > 0.05$).

Discussion

Controversy exists regarding the necessity of KM around dental implants for the preservation of peri-implant health.⁷ Several studies have pointed to the importance of KM for peri-implant soft tissue health and patient comfort.^{1,5,7,11-13} Other researchers have claimed that a successful implant treatment and healthy clinical parameters can be achieved irrespective of the WKM.¹⁴⁻¹⁸ The results of the current study showed that the WKM was inversely correlated with MBI, MPI, MGI, and GR ($P < 0.05$), but no significant association was found between WKM and age, sex, PD, use of oral hygiene aids, frequency of daily toothbrushing, or dental status of the opposing jaw ($P > 0.05$).

Bouri et al noticed that the MPI and MGI were greater in subjects with WKM < 2 mm than in subjects with WKM ≥ 2 mm, which is in accord with the results of the present study.⁵ Bouri et al also reported no significant difference between the 2 groups in terms of PD, which is similar to the findings in the present study.⁵ However, in contrast to the present study, which found that nonsmokers had narrower KM than smokers, Bouri et al found no significant association between the WKM and cigarette smoking.⁵ Such a difference may be due to the different methods of assessment of smoking status in the 2 studies. Bouri et al evaluated the number of cigarette packs smoked per year, while the present study only assessed a positive history of smoking.⁵

In a study by Kim et al, the GI, PI, and buccal PD were not significantly different in the presence or absence of KM.¹⁴ The authors' findings regarding PI and GI were not in accord with the findings in the present study, but the results regarding PD were. Also, Kim et al showed that in areas with a smaller WKM, the odds of GR were greater; this was in accord with the present study.¹⁴ The difference in PI and GI between the 2 studies may be due to the different types of indexes used and the methodology of studies. Kim et al evaluated implants with different surface textures in the anterior and posterior areas, whereas only posterior implants with the same surface texture were evaluated in the present study.¹⁴

A study by Strub et al showed that peri-implant soft tissue health was maintained in two-thirds of sites.² Gingival recession was not present, regardless of the presence or absence of attached gingiva and adequate KM. Moreover, the authors demonstrated that gingival grafting increased the WKM but did not promote peri-implant soft tissue health. No association was found between GR and WKM, which is in contrast to the present study. However, Strub et al conducted their research on dogs, and the anatomical differences between canines and humans—such as different responses to plaque accumulation, difference in type of crown placed over the implant, and lack of occlusal and mesiodistal contacts—may explain the difference in results in comparison to the present study.²

Esper et al reported that the PD around implants with WKM ≥ 2 mm was greater but the mean PD did not exceed 3 mm in any patient.¹⁷ The authors did not find an association between WKM and the GI and PI, which is in contrast to the findings in the present study. Esper et al concluded that the WKM had no correlation with oral hygiene around dental implants.¹⁷ The

authors did suggest an ideal 2-mm WKM around implants (1 mm of junctional epithelium and 1 mm of connective tissue) and stated that a WKM < 2 mm may lead to bone loss.¹⁷ In a study by Crespi et al, implants with a narrow KM had significantly higher MPI, GI, MBI, and radiographic bone loss.¹⁸ On the other hand, the authors found that GR was correlated with the WKM, and implants with a narrow KM had a higher risk for development of peri-implantitis. The findings by Crespi et al regarding the correlation of MPI, GI, GR, and MBI with the WKM were in accord with the findings of the present study, both indicating that a narrow KM is less resistant to inflammation, which can lead to GR and vice versa.¹⁸

The KM creates a barrier that is resistant against plaque-related inflammation and gingival recession.^{23,24} The KM also distributes functional and masticatory stresses in the margin of the tooth or crown and leads to more favorable esthetics, greater patient comfort, and easier toothbrushing.^{5,9} Thus, the presence of an adequate WKM around implants has been shown to play a significant role in the prevention of gingival inflammation, plaque accumulation, and GR. The present study confirmed these findings.

Chung et al evaluated the role of WKM in the health and survival of dental implants with different surface textures and concluded that absence of adequate KM around dental implants was associated with greater PI and GI and that this finding was irrespective of the surface texture of implants.¹ This finding concurred with the results of the present study. However, Chung et al found no significant association between the WKM and the PD or MBI, which is in contrast to the findings in the present study.¹ Such a difference in results may be attributed to the methodology used by Chung et al wherein implants placed in the anterior region were evaluated, and the evaluation included implants with fixed and removable partial dentures, which is different from the methodology used in the present study.¹

In a systematic review, Gobbato et al evaluated clinical soft tissue parameters around dental implants and concluded that GI, PI, and MPI were significantly higher in a group with a narrow KM; the difference for MBI was only marginally significant.¹⁶ The difference in PD between the 2 groups of narrow and wide KM was not statistically significant.

In the present study, the KM was evaluated as a whole, and no difference was considered between attached and free gingiva. This was considered a point of strength in this study, since the PD is deeper around implants than around teeth due to anatomical differences. Thus, it is difficult to determine the upper limit of the biologic width because the probe often passes the junctional epithelium. If the width of attached gingiva had been measured instead of the WKM, the value for the attached gingiva would have been underestimated.²⁵

One limitation of the present study was that the correlation of the WKM with GR was evaluated only at the midbuccal point, and not at the interproximal surfaces, as the dimensions of bone at the mesiodistal, buccolingual, and apicocoronal interproximal areas affect the interdental soft tissue status.^{26,27} Also, the interdental bone level varies in different areas and between different teeth.²⁸ Since radiographic assessment was not performed in the present study, the interdental bone and its correlation with the soft tissue or KM were not evaluated. The inconsistencies and controversies among the results of different studies with regard

to the correlation of clinical parameters with the presence or absence of KM indicate the significant role of oral hygiene since, in the absence of KM, the peri-implant health is maintained only with favorable oral hygiene.²⁹ Yeung recommended KM augmentation around dental implants to enhance plaque control, whereas Esposito et al stated that sufficient evidence does not exist to support increasing the width of keratinized gingiva to preserve peri-implant health.^{29,30}

Eventually, the decision on augmentation of KM will be made by the clinician. Augmentation appears to be a logical choice for patients who present with chronic inflammation in spite of good oral hygiene and periodontal treatment or with progressive GR accompanied by redness and pain during toothbrushing as well as for patients who desire improved esthetics.⁷

Conclusion

Based on the results, an association exists between the WKM and peri-implant soft tissue health. The MBI, MPI, MGI, and GR were significantly greater in areas with a WKM < 2 mm than in areas with ≥ 2 mm of WKM.

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