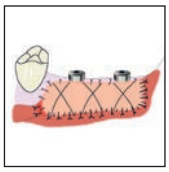
Clinical Effect of Free Gingival Grafts on the Increase in Keratinized Mucosa Width at the Buccal Aspect of Implants in Adjacent Mandibular Molars: A Retrospective Study



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The aim of this retrospective study was to evaluate the effect of free gingival grafts (FGGs) at adjacent mandibular molar implants and to compare the clinical outcomes between the first molar (M1) and second molar (M2) sites. Twenty-one patients with 44 implants were included. At the 3-year follow-up, the mean increase in the keratinized mucosa width (KMW) was 2.35 ± 1.33 mm, and the mean KMW shrinkage rate was 58% ± 23%. M1 sites showed a significantly greater increase of KMW and less graft shrinkage than M2 sites (M1: 2.87 ± 1.40 mm and 49% ± 24%, M2: 1.83 ± 1.06 mm and 66% ± 19%, P < .05). The results show that using FGG to increase KMW in mandibular molar implants was a predictable treatment method, and M1 sites were associated with a greater KMW increase than M2 sites.
Int J Periodontics Restorative Dent 2022;42:649–656. doi: 10.11607/prd.5706

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Submitted February 16, 2021; accepted May 8, 2021.

Whether an adequate amount of keratinized mucosa width (KMW) is necessary for the maintenance of peri-implant tissue health has been discussed controversially.[1–4] Recently, emerging evidence showed that KMW ≥ 2 mm is associated with more favorable peri-implant health.[5–7] Free gingival grafts (FGGs) are an effective method for KMW augmentation around implants.[5,8–10] The increase in KMW after peri-implant FGG treatment ranges between 2.2 and 3.3 mm.[11]

A lack of keratinized mucosa as a result of progressive bone resorption after tooth extraction is common in the edentulous mandibular molar region.[12,13] Studies have shown that an inadequate amount of peri-implant KMW in the mandibular posterior region resulted in plaque accumulation, discomfort during brushing, and mucosal inflammation.[5,14–16] Therefore, in this region, it is necessary to perform KMW augmentation around implants with a limited KMW to achieve good oral hygiene and maintain long-term peri-implant tissue health.[5,6,10] However, previous studies on peri-implant FGG treatment mostly did not distinguish between the anterior and posterior regions.[8,9,17,18] Evidence regarding the effect of FGG at buccal aspect of implants in the mandibular molar region is scarce.[19]

A previous study reported that implant position may influence the effect of FGGs.[20] However, the outcomes of FGG treatment at different implant sites have not been compared previously. Notably, the clinical effect of an FGG is affected by many factors, such as the graft thickness and recipient site preparation.[21,22] Therefore, to control these factors, the present study only included adjacent mandibular molar sites to compare the different effects of FGGs at different implant sites.

The primary aim of this retrospective study was to evaluate the clinical effects of FGG treatment at the buccal aspect of mandibular molar implants; the secondary aim was to compare clinical outcomes of FGG treatment between first and second molar sites.

Materials and Methods

The present retrospective study was approved by the Medical Ethics Committee of Peking University, Health Science Center, School of Stomatology (approval no.: PKUSSIRB-201944059) and conducted in accordance with the Declaration of Helsinki as revised in 2013. Every patient who was referred to the Department of Oral Implantology of Peking University Hospital of Stomatology from January to December 2016 was screened for possible inclusion. The inclusion criteria were as follows: *(1)* having adjacent mandibular first and second molar implants; *(2)* treated with FGG due to a KMW < 2 mm on the adjacent implants; and *(3)* FGG treatment performed before crown insertion. The exclusion criteria were as follows: *(1)* alcohol and drug abuse; *(2)* pregnancy or breastfeeding; *(3)* uncontrolled metabolic disorders; *(4)* FGG used for the purpose of periimplantitis treatment; *(5)* heavy smoking habit (≥ 10 cigarettes/day); and *(6)* unable to be contacted. Patients meeting the inclusion criteria were recalled for further examination 3 years after FGG treatment, and all patients provided written informed consent.

Surgical Procedure

Two surgeons (Y.L. and Y.Z.) with over 10 years of experience performed all the surgeries. After local infiltration anesthesia using Primacaine adrenaline (Acteon), a partial-thickness flap with two vertical releasing incisions was prepared and sutured apically. The connective tissue and muscle attachment were carefully removed to provide stable recipient graft sites. The horizontal and vertical distances of the recipient bed were measured. Then, a graft of a matching length (with a width of 6 to 8 mm and a thickness of about 1 mm) was harvested from the palate. An iodoform sponge (Iodoform dressing, Henan Piaoan Group) was used to cover the donor site. The graft was firmly sutured coronally to the recipient site. After surgery, ibuprofen was administered when necessary. A 0.2% chlorhexidine solution (Koutai, South China Pharmaceutical) was used as anti-infective therapy for 2 weeks. Crowns were delivered 2 months after FGG treatment for all patients.

Clinical and Radiographic Examinations

An investigator (X.F.) who had been previously calibrated for the periimplant probing technique performed the clinical measurements. A UNC-15 periodontal probe was used to obtain all clinical measurements. KMW was measured from the free gingival margin to the mucogingival junction at the buccal midpoint of the abutment/crown.[20] The probing depth (PD) was measured from the gingival margin to the base of the pocket at three points (mesiofacial, midfacial, and distofacial). The modified Bleeding Index (mBI),[23] modified Plaque Index (mPI),[23] and the Gingival Index (GI)[24] were recorded and scored at the buccal aspect of the implants. Vestibular depth was measured from the mucosal margin to the point of greatest concavity of the mucobuccal fold. Vestibular depth was dichotomized as shallow (≤ 4 mm) and adequate (> 4 mm).[25] KMW was measured at baseline (pretreatment) and immediately (T0), 6 months (T1), and 3 years after surgery (T2). PD, mBI, mPI, and GI values were measured at T2. Vestibular depth was measured at baseline.

In all patients, periapical radiographs were taken at T1 and T2. One investigator (X.F.) measured the distances between the implant shoulder and the most coronal bone-to-implant contact level on all radiographs. The marginal bone

loss (MBL) was measured at the mesial and distal aspects of the implants, and these values were averaged to calculate the mean proximal MBL, calibrated with the known implant length.

Statistical Analysis

The change in KMW was considered the primary outcome variable among the clinical variables used to assess the effects of FGG treatment, and secondary outcomes were PD, mBI, mPI, GI, and MBL values. Statistical analysis was performed using SPSS 20.0 (IBM). Quantitative data were recorded as mean ± standard deviation. Differences between first molar site (M1) and second molar (M2) site were analyzed using paired-sample *t* test or nonparametric test. Chi-square test was used to analyze the difference in vestibular depth (≤ 4 mm vs > 4 mm) between M1 and M2 sites. $P \leq .05$ was considered statistically significant.

Table 1 Patient Demographics

Parameter	
Age, y	
Mean ± SD	51.2 ± 11.1
Range	32–74
Sex, n	
Female	11
Male	10
Smoking habit, n	
No	19
Yes	2
Oral parafunction, n	
No	20
Yes	1
Diabetes, n	
No	19
Yes	2
History of periodontitis, n	
No	1
Yes	20
Current periodontitis, n	
No	21
Yes	0
Received SPT, n	
No	0
Yes	21

SPT = supportive periodontal therapy.
All data were recorded at the 3-year follow-up.

Results

The characteristics of the patients at the 3-year follow-up are shown in Table 1. Twenty-one patients with 44 implants underwent FGG treatment at adjacent mandibular molar sites from January to December 2016. All second molar implants were without adjacent third molars. Fifteen patients received an FGG during the second-stage surgery, and 6 patients received an FGG after insertion of the abutment. One patient underwent the FGG procedure in the bilateral mandible. The implant survival rate was 100%. There was a significant difference in vestibular depth between M1 (> 4 mm, n = 18; ≤ 4 mm, n = 4) and M2 (> 4 mm, n = 9; ≤ 4 mm, n = 13) sites ($P = .012$).

Table 2 shows the change in the buccal KMW at different sites at each examination time point. The average increase in KMW from baseline to T2 was 2.35 ± 1.33 mm. The mean shrinkage rate of FGG (from T0 to T2) was 58% ± 23%. At baseline and T0, the mean KMW was comparable between M1 and M2 sites. At T1 and T2, the KMW at M1 sites was significantly higher than that at M2 sites.

After surgery, a constant decrease in KMW was observed at both M1 and M2 sites. The average change in KMW over time at M1 and M2 is shown in Fig 1. The decrease in KMW sites from T0 to T1 and from

Table 2 Change in the Buccal KMW in All Implants and at Different Sites at Each Time Point

	All implant sites (n = 44)	M1 implant sites (n = 22)	M2 implant sites (n = 22)	*P*
Buccal KMW, mm				
Baseline	0.36 ± 0.36	0.40 ± 0.36	0.31 ± 0.36	.335
T0	6.37 ± 1.02	6.43 ± 1.06	6.31 ± 0.99	.311
T1	3.29 ± 1.44	3.82 ± 1.37	2.76 ± 1.33	.005*
T2	2.71 ± 1.45	3.27 ± 1.46	2.15 ± 1.23	.004*
Change (△) in KMW, mm				
△T1–T0	3.08 ± 1.41	2.61 ± 1.41	3.55 ± 1.29	.007*
△T2–T0	3.66 ± 1.48	3.16 ± 1.57	4.16 ± 1.23	.005*
△T2–T1	0.58 ± 0.24	0.55 ± 0.23	0.61 ± 0.25	.313
△T2–Baseline	2.35 ± 1.33	2.87 ± 1.40	1.83 ± 1.06	.005*
Shrinkage rate, %				
T1–T0	48 ± 22	40 ± 22	56 ± 20	.006*
T2–T0	58 ± 23	49 ± 24	66 ± 19	.005*
T2–T1	9.2 ± 3.7	8.5 ± 3.2	9.9 ± 4.0	.218

KMW = keratinized mucosa width; M1 = first molar implant site; M2 = second molar implant site; baseline = preoperative; T0 = immediately postsurgery; T1 = 6 months postsurgery; T2 = 3 years postsurgery.
Data are presented as mean ± SD.
*$P < .05$.

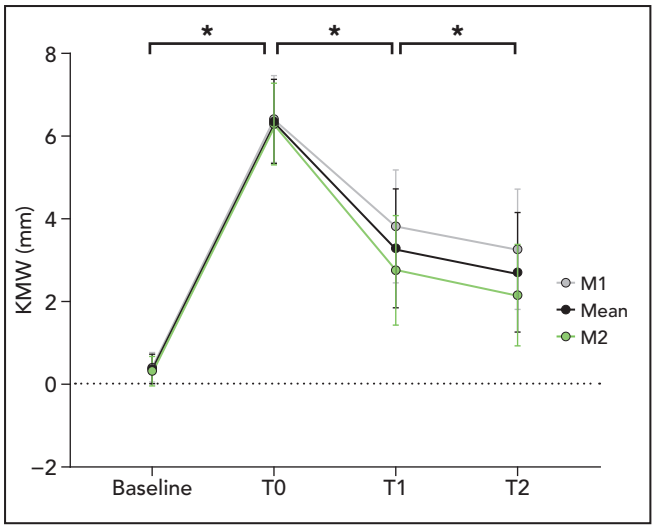

Fig 1 *Changes in the KMW over time at all sites, M1 sites, and M2 sites. *P < .05. M1 = first molar site; M2 = second molar site; T0 = immediately postsurgery; T1 = 6 months postsurgery; T2= 3 years postsurgery.*

T0 to T2 was significantly higher in M2 sites than M1 sites (Table 2). From T1 to T2, the decrease continued but significantly slowed. A representative case with adjacent mandibular molar implant sites is shown in Fig 2.

Table 3 shows the buccal soft and hard tissue health parameters after FGG treatment, compared by implant position. No significant differences were observed between different sites for PD, mBI, mPI, GI, or MBL ($P > .05$).

Discussion

The present study retrospectively observed the effects of FGG treatment at the buccal aspect of mandibular molar implants over a 3-year follow-up period, evaluated the clinical outcomes, and compared the differences at different implant sites.

The average increase in KMW was 2.35 ± 1.33 mm, and the mean shrinkage rate was 58% ± 23%. Schmitt et al[26] investigated FGG around mandibular anterior

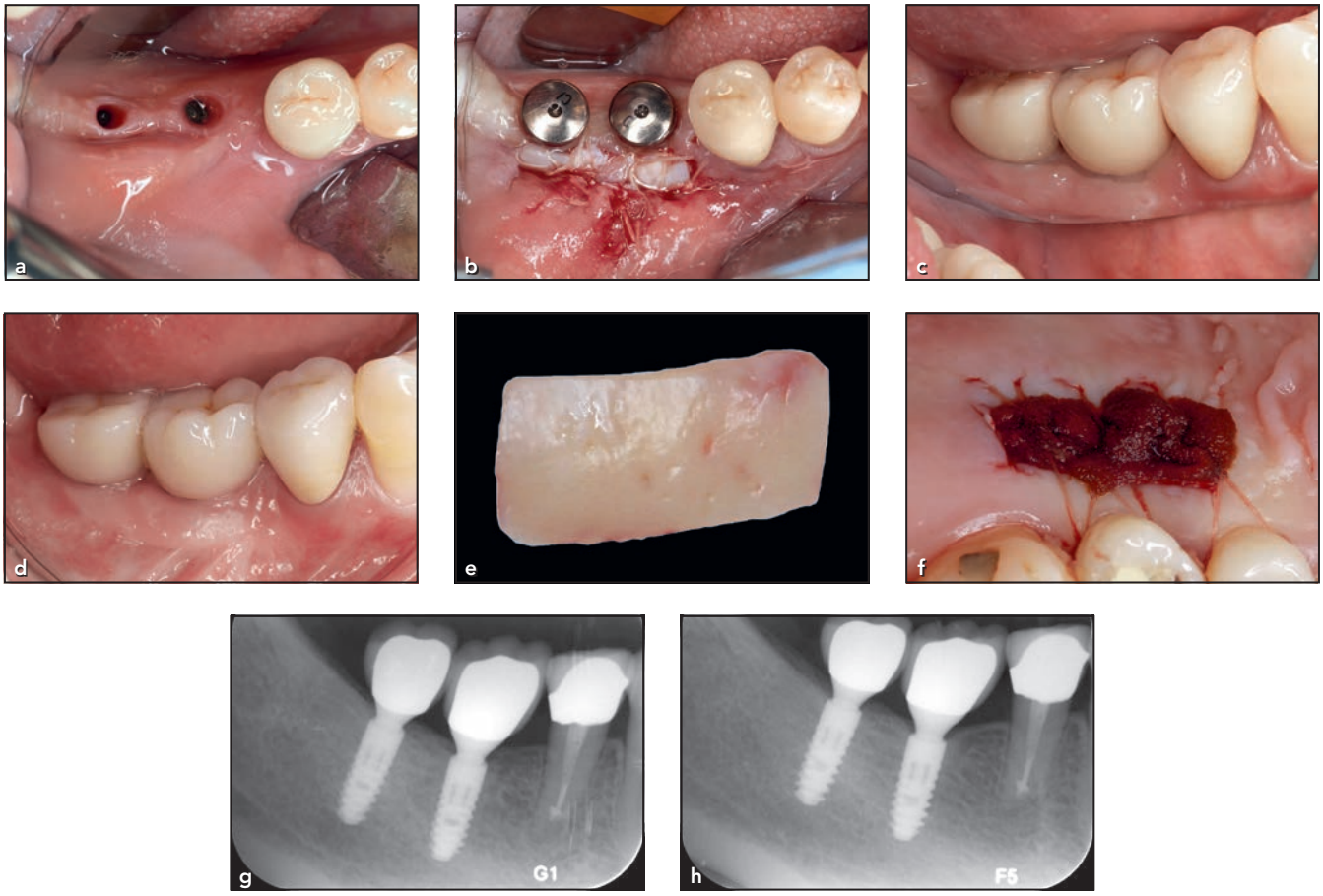

Fig 2 *Representative case of FGG treatment in adjacent mandibular molar implant sites; significantly greater KMW was seen in the first molar, with shallow vestibular depth in the second molar and high muscle attachment.* (a) *Baseline (pretreatment).* (b) *T0 (immediately postsurgery).* (c) *T1 (6 months postsurgery).* (d) *T2 (3 years postsurgery).* (e) *The graft harvested from the palate.* (f) *The donor site was covered with iodoform sponges.* (g and h) *Radiographs show the marginal bone levels at T1 and T2, respectively.*

implants at the same time points and reported more KMW augmentation (13 mm at T0, 8 mm at T2) and a lower shrinkage rate (~40% at 5 years) than the present study. The reason for the difference is that the other study[26] was performed in the anterior mandible, while the present study was performed in the posterior mandible (molar region). Notably, the vertical height of the alveolar process often determines the amount of space available for the preparation of the recipient bed.[27] As a result of the space restriction from the external oblique ridge,[27] the increase in KMW at T0 in the present study was significantly lower than that reported by Schmitt et al at the same time point.[26] Other studies that did not distinguish the implant locations also demonstrated a greater KMW increase than the present study.[8,10,17–19] Though the outcome of the present study was inferior to that of previous studies, an adequate KMW (> 2 mm) was still created. These results suggest that the KMW gain is predictable after FGG treatment at mandibular molar implant sites.

The increase in KMW was significantly greater at M1 sites (2.87 ± 1.40 mm) than M2 sites (1.83 ± 1.06 mm), and more significant KMW shrinkage was observed at M2 sites (66% ± 19%) than M1 sites (49% ± 24%). The present results suggest that the implant location may influence the FGG stability. Zucchelli et al[20] found similar outcomes when using coronally advanced flaps to treat gingival recessions. The possible reasons for the differences between M1 and M2 are as follows: *(1)* Halperin-Sternfeld et al[25] found that a shallow vestibular depth

Table 3 Buccal Soft and Hard Tissue Health Parameters After FGG Treatment According to Implant Position

	All implant sites (n = 44)	M1 implant sites (n = 22)	M2 implant sites (n = 22)	*P*
PD, mm	3.29 ± 1.02	3.43 ± 1.02	3.16 ± 1.04	.110
mBI	0.20 ± 0.51	0.27 ± 0.55	0.14 ± 0.47	.083
mPI	0.39 ± 0.58	0.41 ± 0.59	0.36 ± 0.58	.329
GI	0.32 ± 0.74	0.45 ± 0.86	0.18 ± 0.59	.083
MBL, mm	0.44 ± 0.24	0.48 ± 0.31	0.41 ± 0.12	.204

FGG = free gingival graft; M1 = first molar site; M2 = second molar site; PD = probing depth; mBI = modified Bleeding Index; mPI = modified Plaque Index; GI = Gingival Index; MBL = marginal bone loss.
Data are presented as mean ± SD.

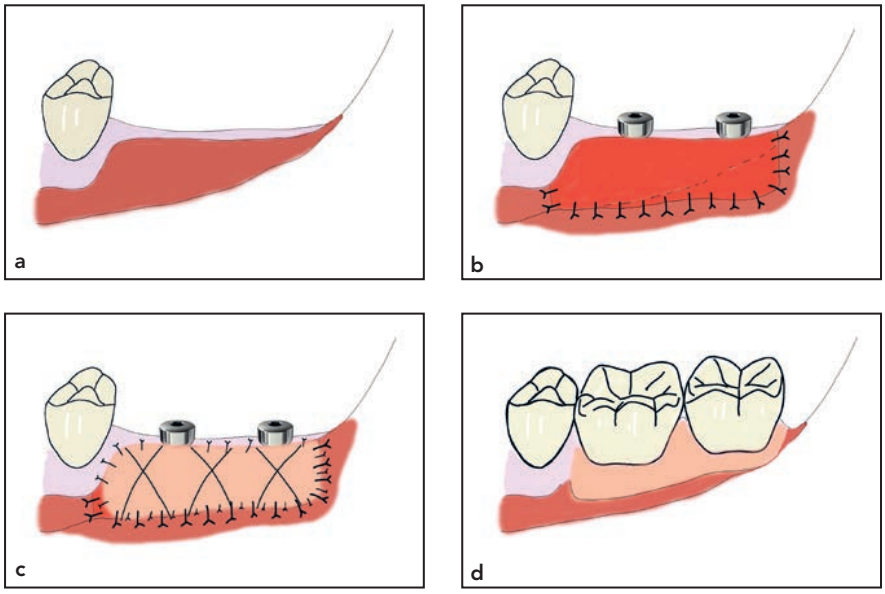

Fig 3 (a) *Vestibular depth at molar sites.* (b) *An apically positioned flap deepened the vestibule (the dotted line represents the bottom of the original vestibule). M2 sites were near the external oblique ridge, and the amount of space available for an FGG was limited.* (c) *The attached gingiva and interdental papillae of the second premolar provide support for FGG treatment.* (d) *The KMW at the buccal aspect of implants after FGG treatment.*

(≤ 4 mm) was associated with a lower peri-implant KMW than sites with an adequate vestibular depth, and the present study found that M2 sites were related to a shallower vestibular depth than M1 sites (Fig 3a); *(2)* the external oblique ridge runs downward and forward along the mandible,[27] and the vertical height of the alveolar process determines the available space for grafts, and in the present results, M2 sites were closer to the external oblique ridge, thus limiting the amount of space available for grafts (Fig 3b); *(3)* the mandibular molar region is next to the attachment of the buccinator muscle[27]; as a result of the shallower vestibule at M2 sites, vestibuloplasty requires repositioning the buccinator muscle insertion more apically (Fig 3b), and the tendency for muscle reattachment might be higher at M2 sites[28]; and *(4)* Miller concluded that interdental papillae could aid in the suturing and in supplying blood to the graft[29]; herein, the mesial aspect of M1 sites was next to a natural tooth, but the distal aspect of M2 sites lacked support from adjacent natural teeth (Fig 3c). In conclusion, M2 sites were associated with more shallow vestibules, closer to the external oblique line and muscle attachment, and lacking adjacent teeth. All of these factors could compromise the effect of FGG, resulting in more shrinkage at M2 sites than M1 sites (Fig 3d).

Peri-implant parameters other than KMW did not show significant differences between M1 and M2 sites. Studies have shown that implants with an inadequate KMW (< 2 mm) had higher PD, mPI, and GI values than those with a sufficient

KMW (≥ 2 mm).[5,14,15] In the present study, the above parameters did not show significant differences between M1 and M2 sites, and the mean KMW at M1 (3.27 ± 1.46 mm) and M2 (2.15 ± 1.23 mm) sites were both > 2 mm at the 3-year follow-up.

The limitations of this study include its retrospective research design, leading to a lack of baseline information such as PD value. To compare with other studies, KMW was measured at the buccal midpoint of the abutment or crown, and thus the midpoints were not necessarily consistent. The time points for measurements were 6 months and 3 years, which overlooked the influence of a crown on KMW. If measured before abutment removal and after crown insertion, the change in KMW would be more concrete.

Conclusions

Within the limits of this study, the 3-year follow-up data showed that KMW gain is predictable following FGG treatment at the buccal aspect of mandibular molar implants. M1 sites were associated with a greater increase of KMW than M2 sites, but no difference in other peri-implant parameters was found between the different sites.

Acknowledgments

The authors would like to thank Dr Xi Jiang, Shuxin Ren, Bo Chen, and Shuai Li from the Department of Oral Implantology at Peking University School and Hospital of Stomatology in Beijing for their support during the study. This work was supported by the National Key R&D Program of China (2018YFC1105302). The authors declare no conflicts of interest.

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