Influence of Keratinized Tissue on Short Dental Implants: A Parallel Cohort Retrospective Study on 217 Implants with a Mean Follow-up of 4.1 Years

Pietro Felice, MD, DDS, PhD[1]/Lorenzo Bonifazi, DDS[2]/Roberto Pistilli, MD[3]/Agnese Ferri, DDS[1]/
Roberta Gasparro, DDS, PhD[4]/Carlo Barausse, DDS, PhD[5]

Purpose: To assess whether the presence or absence of keratinized tissue height (KTh) may have an influence on marginal bone levels, complications, and implant survival for short implants. ***Materials and Methods:*** The study was designed as parallel cohort retrospective research. Short implants with an implant length < 7 mm were considered. One cohort was composed of patients with short implants surrounded by ≥ 2 mm of KTh (adequate KTh); the other cohort included implants with < 2 mm of KTh (not-adequate KTh). Outcome measures were marginal bone level (MBL) changes, failures, and complications. ***Results:*** One hundred ten patients treated with 217 short and extrashort implants (4 to 6.6 mm long) were retrospectively included. The mean follow-up was 4.1 years after prosthetic loading (range: 1 to 8 years). The differences between KTh groups in MBL were not statistically significant at every follow-up considered: 0.05 mm at 1 year ($P = .48$), 0.06 mm at 3 years ($P = .34$), 0.04 mm at 5 years ($P = .64$), and 0.03 at 8 years ($P = .82$). A total of nine complications were reported: three in the not-adequate KTh group and six in the adequate group; the difference was not statistically significant (OR: 3.03, 95% CI: 0.68 to 13.46, $P = .14$). Five implants failed due to peri-implantitis, two in the not-adequate KTh group and three in the adequate group, without a statistically significant difference (OR: 2.76, 95% CI: 0.42–17.99, $P = .29$). ***Conclusion:*** This study showed no statistically significant differences in MBL, complications, and implant failure rates between short implants with adequate or not-adequate KThs. However, given the importance of patient comfort while brushing and plaque accumulation, keratinized tissue grafts could be important in selected patients, especially for those who are severely atrophic, also taking into consideration all the limitations of this study and the medium-term follow-up. Nevertheless, longer follow-ups, larger numbers of patients, and randomized controlled clinical trials are needed before making more reliable clinical recommendations. *Int J Oral Maxillofac Implants 2023;38:462–467. doi: 10.11607/jomi.9918*

Keywords: keratinized tissue height, marginal bone loss, short implants

Implant fixed prostheses are a reliable and effective treatment option to rehabilitate edentulous arches. Recently, scientific literature has been turning its attention to peri-implant soft tissues, with several authors asserting that having an adequate amount of keratinized tissue (KT) around implants could be relevant for better long-term results. Thus, generalized use of different techniques to increase KT height (KTh) has been promoted.

Several studies have shown that implant sites with a reduced amount of KT present more plaque accumulation.[1–8] Schrott et al evaluated the KT influence on peri-implant tissue health in 73 patients and 386 implants.[6] The authors observed that 5 years after implant loading, the sites with < 2 mm of KT exhibited more plaque and bleeding on probing than sites ≥ 2 mm. Although a more recent review reported that in 5 out of 12 studies presenting plaque scores, sites with < 2 mm of KTh showed significantly higher plaque scores, no conclusions could be drawn about marginal bone level (MBL).[9]

Currently, even if the quality and quantity of soft tissue are important clinical factors in dental implant health and this issue has become as important as in the natural dentition, there is no firm evidence about

[1]Department of Biomedical and Neuromotor Sciences, Unit of Oral Surgery, University of Bologna, Bologna, Italy.
[2]Department of Biomedical and Neuromotor Sciences, Unit of Oral Surgery, University of Bologna, Bologna, Italy; Complex Unit of Odontostomatology, Department of Interdisciplinary Medicine, University of Bari Aldo Moro, Bari, Italy.
[3]Oral and Maxillofacial Unit, San Camillo Hospital, Rome, Italy.
[4]Department of Neurosciences, Reproductive Sciences and Odontostomatology, University of Naples Federico II, Naples, Italy.
[5]Department of Biomedical and Neuromotor Sciences, Centre of Clinical and Surgical Experimental and Molecular Anatomy, and Unit of Oral Surgery, University of Bologna, Bologna, Italy; Postgraduate School of Oral Surgery, University of Modena and Reggio Emilia, Modena, Italy.

Correspondence to: Prof Pietro Felice, Department of Biomedical and Neuromotor Sciences, Unit of Oral Surgery, University of Bologna, Via San Vitale 59, 40125 Bologna (BO), Italy.
Email: pietro.felice@unibo.it

Submitted February 21, 2022; accepted July 15, 2022.

its correlations with MBL.[9–12] This correlation could be even more relevant for short and extrashort implants because MBL stability could have specific prognostic importance.

From this reflection, the authors' interest emerged in retrospectively assessing whether the presence or absence of KT may have an influence on MBL, complications, and implant survival, specifically on short implants.

MATERIALS AND METHODS

The study was designed as parallel cohort retrospective research. One cohort was composed of patients with implants surrounded by ≥ 2 mm of KTh (adequate KTh); the other cohort included patients with implants with < 2 mm of KTh (not-adequate KTh). The study protocol adhered to the ethical principles of the Declaration of Helsinki, where all study participants signed informed consent, agreeing to provide their data for research. The study was approved by the local University Ethical Committee (Prot. N. 234/21). A retrospective chart review was conducted on patients with short dental implants placed in posterior atrophic arches by experienced surgeons at different centers.

Patients had to fulfill the following inclusion criteria: previously partially edentulous posterior arches (molar-to-premolar area); atrophic patients treated with one to three short dental implants; implant length < 7 mm; and patients with at least 1 year of postloading follow-up. Patients were not included in the study if any of the following exclusion criteria were met: immediately loaded restorations and patients without available radiograph or KTh reported 1 year after loading. Smokers were included and were divided into three groups: nonsmokers, moderate smokers (up to 10 cigarettes per day), and heavy smokers (more than 10 cigarettes per day).

Outcome Measures

MBL was considered as the primary outcome; complications (biologic and prosthetic) and implant failure (implant mobility and/or removal of stable implants dictated by progressive marginal bone loss or infection) were the secondary outcomes.

MBL. Peri-implant MBL changes were evaluated on radiographs, when available, at implant placement and 1, 3, 5, and 8 years after loading. OsiriX software was calibrated for every image using the known implant length or diameter. Measurements of the mesial and distal bone crest level adjacent to each implant were made to the nearest 0.01 mm. Reference points for the linear measurements were the most coronal margin of the implant collar and the most coronal point of radiographic bone-to-implant contact.

Predictor and Potential Confounders

The study was designed using KTh as a predictor. According to Souza et al, peri-implant clinical evaluations were performed on each implant with the use of a periodontal probe.[13,14] The distance from the gingival margin to the mucogingival junction was evaluated at the mid-buccal aspect of the implant. For the detection of the mucogingival junction line, differences in color, texture, and mobility between the KT and the oral mucosa were analyzed. Implants were divided dichotomously, according to the width of the band of KT: < 2 mm of KT (not-adequate group) and ≥ 2 mm of KT (adequate group). Potential confounders (factors possibly affecting the outcomes) that were considered are smoking, arch, implant length, and implant diameter.

Statistical Analysis and Sample Size

A descriptive analysis was performed presenting continuous variables as mean ± standard deviation (SD) or median ± interquartile range; categorical variables were presented as absolute and relative frequencies.

Preliminary univariate analyses were carried out for every outcome; then, multivariate models were fitted. A multilevel logistic regression was used to analyze implant failure and complications, considering KT as predictor and smoking, arch, implant length, and implant diameter as confounders. The results are presented as odds ratio (OR) with 95% confidence intervals (CI). Instead, a multilevel multiple linear regression was fitted to analyze marginal bone loss with KT as a predictor and smoking, arch, implant length, and implant diameter as confounders. Implant was used as the statistical unit of the inferential analyses. Model building was performed using a backward stepwise approach.

The significance level was set at .05. All analyses were performed using Stata, version 15 (StataCorp).

A sample size of 200 implants needed was calculated for a test comparing two independent means, considering a power of 0.80, an α error of .05, and an effect size of 0.4, relying on previous preliminary data obtained and collected in the authors' practice.

RESULTS

A total of 370 patients were examined for eligibility; however, only 110 patients fully adhered to the inclusion criteria and were finally included (217 short dental implants were evaluated). Short implants from different companies were considered (length × diameter): 6.6 × 4 mm, 6 × 4 mm, 6 × 7 mm, 6 × 8 mm, 5 × 5 mm,

Table 1 Main Population Characteristics

Sex (patients)	
Male	39
Female	71
Age (y)	58.61 ± 9.60
Smoking habits (patients)	
Nonsmokers	94
Moderate smokers	13
Heavy smokers	3
No. of implants	
Total	217
Maxilla	88
Mandible	129
Implant dimensions	
Mean implant length (mm)	4.98 ± 0.96
Mean implant diameter (mm)	4.51 ± 0.85
Mean follow-up (y)	4.1

5 × 6 mm, 5 × 7 mm, 4 × 4 mm, and 4 × 4.5 mm. The mean implant length was 4.98 ± 0.96 mm, and the mean diameter was 4.51 ± 0.85 mm. The mean follow-up was 4.1 years after prosthetic loading (range: 1 to 8 years). Mean patient age at the time of implant placement was 58.61 ± 9.60 years (range: 25 to 80 years), and 64.55% were women. Regarding smoking, 85.45% of patients were nonsmokers, 11.82% were moderate smokers, and 2.73% self-reported as heavy smokers.

In the mandible, 129 short implants (59.45%) were placed, while 88 (40.55%) were placed in the maxilla. The main baseline patient and intervention characteristics are presented in Table 1.

Keratinized Tissue Height

Of the 217 implants included in the analysis, 97 (44.70%) belonged to the adequate KTh group (Figs 1a and 1b) and 120 (55.30%) to the not-adequate group (Figs 2a and 2b; Table 2).

Marginal Bone Level

Peri-implant marginal bone loss detected was 0.74 ± 0.41 mm at 1 year, 0.87 ± 0.51 mm at 3 years, 1.29 ± 0.46 mm at 5 years, and 1.52 ± 0.40 mm at 8 years. Not-adequate KTh implants lost on average 0.76 ± 0.38 mm at 1 year, 0.89 ± 0.45 mm at 3 years, 1.30 ± 0.47 mm at 5 years, and 1.50 ± 0.51 mm at 8 years, while adequate KTh was 0.71 ± 0.44, 0.83 ± 0.57, 1.26 ± 0.45, and 1.53 ± 0.30 mm, respectively. The differences between groups were not statistically significant at every follow-up considered: 0.05 mm at 1 year ($P = .48$), 0.06 mm at 3 years ($P = .34$), 0.04 mm at 5 years ($P = .64$), and 0.03 at 8 years ($P = .82$; Table 3).

A statistically significant correlation between implant diameter and MBL was found: The wider the diameter, the greater the marginal bone loss ($P = .002$). Moreover, increasing the implant length also seemed to have a negative influence on MBL ($P < .01$).

Complications

A total of nine complications were reported, three in the not-adequate KTh group and six in the adequate group, with the difference not being statistically significant (OR: 3.03, 95% CI: 0.68 to 13.46, $P = .14$). Five implants (three adequate KTh and two not-adequate KTh) were affected by peri-implantitis, which occurred between 8 months and 3 years and 9 months, leading to implant failures. One peri-implant mucositis case (not-adequate KTh) was reported at 4 years and 1 month postloading and was resolved with professional oral hygiene and prosthetic reshaping. Two wide-diameter implants (KTh ≥ 2 mm) were affected by peri-implant soft tissue complications (a fenestration occurred after 9 months and a recession 5 years after loading) with stable clinical condition over time. In a case of an adequate KTh patient, prosthetic screw loosening was also detected and resolved 1 year after loading.

Implant Failures

Five implants failed due to peri-implantitis, two in the not-adequate KTh group and three in the adequate group, without a statistically significant difference (OR: 2.76, 95% CI: 0.42 to17.99, $P = .29$) in the time range 1 year and 4 months to 3 years and 9 months postloading. Two failed implants were replaced after a bone regeneration procedure with two longer implants, and the patient was then rehabilitated, while two other failed implants were instead replaced with extrashort 4 × 4–mm implants that are currently rehabilitated. One lost implant was not substituted because the patient decided not to have it replaced. The cumulative survival rate was 97.70% with a mean follow-up of 4.1 years.

DISCUSSION

The use of short implants in the posterior arch is a procedure well described in the literature, with randomized controlled clinical trials (RCTs) comparing them with standard-length implants. The conclusion is that they could be a valid alternative; however, this is based on the reporting of medium-term data only.[15]

Given that the long-term success of these implants remains unknown, it is crucial to pay even more attention to the several factors that could undermine the survival of the rehabilitation. A key factor among these could be the amount of KT, which is generally reduced in cases of atrophy. In the literature, there are studies on KTh reporting no full consensus results, though they took into consideration only standard-length implants.[16–19]

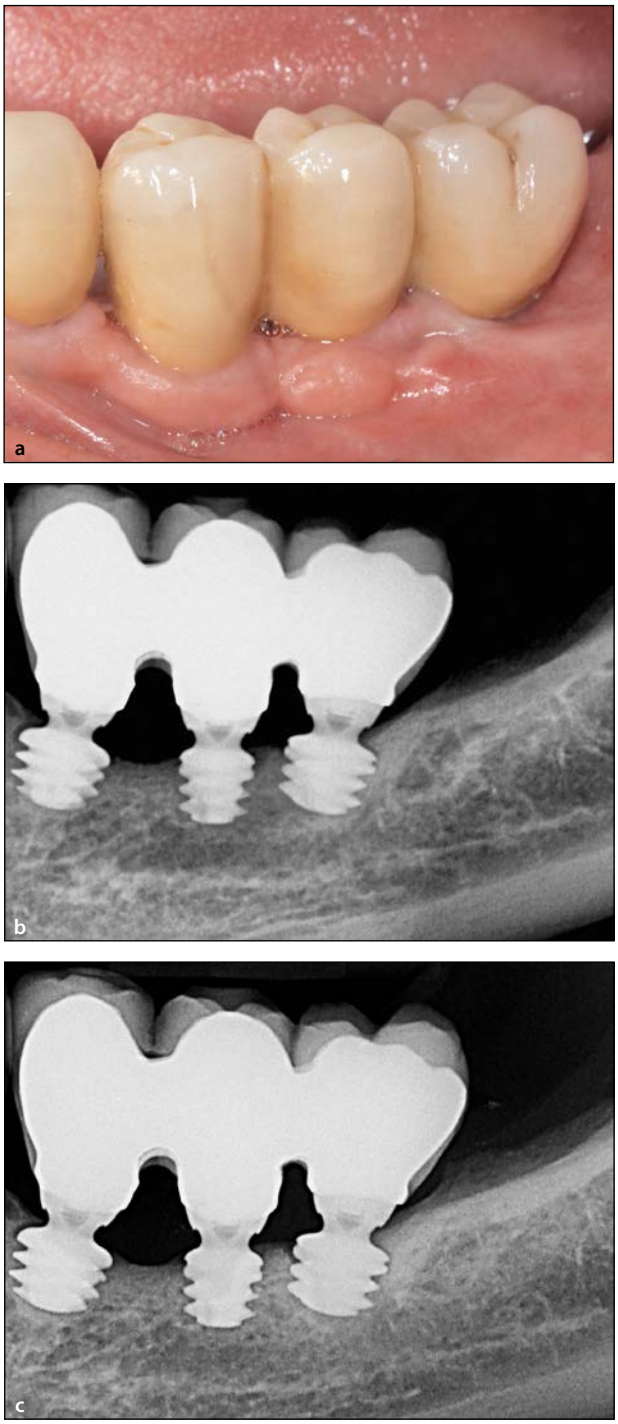

Fig 1 An example of 4-mm extrashort implants with KTh ≥ 2 mm (adequate KTh group): *(a)* photograph, *(b)* 1-year radiograph, and *(c)* 5-year radiograph.

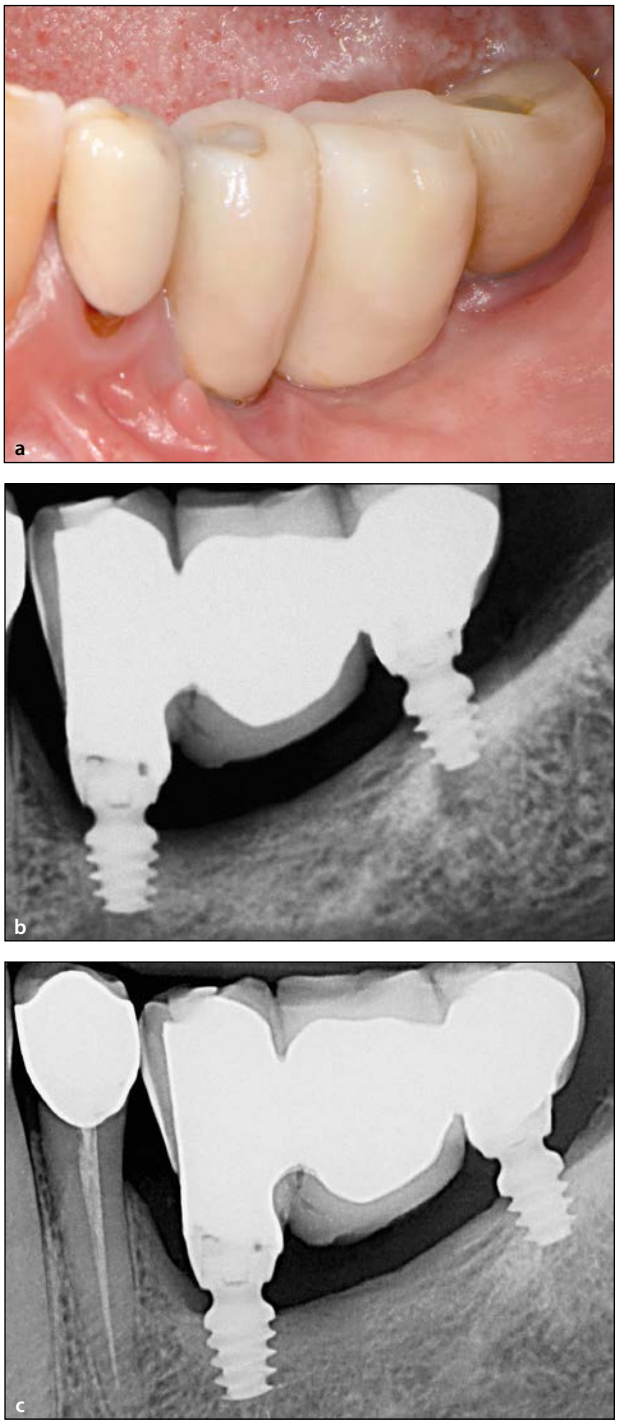

Fig 2 An example of 4-mm extrashort implants with KTh < 2 mm (not-adequate KTh group): *(a)* Photograph, *(b)* 1-year radiograph, and *(c)* 5-year radiograph.

Table 2 Keratinized Tissue Height (KTh) Distribution

KTh	No. of implants	%
Not-adequate group (KTh < 2 mm)	120	44.70
Adequate group (KTh ≥ 2 mm)	97	55.30

Table 3 Mean Changes in Peri-implant Marginal Bone Levels from Baseline

	1 y	3 y	5 y	8 y
Total population	0.74 ± 0.41 mm	0.87 ± 0.51 mm	1.29 ± 0.46 mm	1.52 ± 0.40 mm
Not-adequate KTh group	0.76 ± 0.38 mm	0.89 ± 0.45 mm	1.30 ± 0.47 mm	1.50 ± 0.51 mm
Adequate KTh group	0.71 ± 0.44 mm	0.83 ± 0.57 mm	1.26 ± 0.45 mm	1.53 ± 0.30 mm
Difference	0.05 mm	0.06 mm	0.04 mm	0.03 mm
P value	.48	.34	.64	.82

In the present study, 217 short dental implants ranging from 4 to 6.6 mm were retrospectively analyzed with a mean follow-up of 4.1 years with the aim of evaluating a possible influence of KTh.

According to Souza et al and Perussolo et al, short implants were divided into narrow (KTh < 2 mm) or wide groups.[13,14]

From a clinical point of view, no differences were detected correlating KTh with complications and implant failures with a final survival rate of 97.70% in the time frame between 1 and 8 years.

Regarding MBL, again, no statistically significant differences were found between the two groups, with a slight difference in favor of KTh ≥ 2 mm. This finding is in accordance with Crespi et al reporting a difference of 0.14 mm between groups without a statistical difference at the 4-year follow-up on 13-mm-long implants.[7] Regarding implant diameter, a statistically significant correlation between marginal bone loss and wider implants was found. This can be explained with the reduction of peri-implant bone volume available when placing 6- and 7-mm-diameter implants.[20] The two soft tissue complications were related to the wider implants. Consequently, it could be reasonable to avoid their usage, especially when dealing with short lengths.

However, the presence of adequate KThs could be important to ease patient comfort while brushing, reducing plaque accumulation and peri-implant soft tissue inflammation.[21,22] A 10-year follow-up study by Roccuzzo et al assessed the presence of soreness or discomfort during oral hygiene and found that 42.9% of patients in the non-KT group reported discomfort during oral hygiene, while no patient reported discomfort in the KT group.[23] These findings reflected clinical practice, with some patients complaining of brushing discomfort, and therefore requiring a KT graft. These patients are generally those with more extreme bone atrophy, requiring 4-mm short implants, given the high muscle insertions that make brushing even more irritating. In these cases, especially in the posterior mandible, performing a vestibuloplasty with an autologous epithelial connective tissue graft could ease home oral hygiene procedures. Because there is no firm evidence of MBL reduction, KT graft could be suggested to decrease pain while brushing, given that the short implants are placed in a nonesthetic area.

Overall, the most important factor for long-term stability of implant rehabilitations is probably hygienic maintenance; thus, regardless of the amount of KTh, home procedures and professional recall must be carefully carried out. Ideally, patients with implant rehabilitations on short dental implants should be examined with professional oral hygiene sessions every 3 months, especially in patients refusing KT augmentation. However, a personally tailored maintenance program should be scheduled according to every single specific clinical case.

Moreover, at the present time, the possible long-term importance of KTh is still unclear.[24,25] Other factors, such as peri-implant bone volume and implant diameter and design, may play an important role in short and extrashort implant rehabilitations and should be further investigated. Also, soft tissue thickness should be taken into consideration to reduce food impact facilitating hygienic maintenance.

The quality and quantity of soft tissues are important in every implant rehabilitation regardless of implant length and should be taken into consideration in every treatment plan according to the single specific case.

To the best of the authors' knowledge, this study is the first of its kind to evaluate the influence of KT in short implants. Nevertheless, this study presents limitations and bias: the inclusion of different implant types, the retrospective study design, the number of patients, and the follow-up.

CONCLUSIONS

Taking into consideration that soft tissue volume and type should be considered in every implant rehabilitation, this study showed no statistically significant differences in MBL, complications, and implant failure rates between short implants with adequate or not-adequate KThs. However, given the importance of patient comfort while brushing and plaque accumulation, KT grafts could be important in selected patients, especially for those who are severely atrophic, also taking into

consideration all the limitations of this study and the medium-term follow-up. Above all, adequate hygienic maintenance plays a crucial role especially in short implants but also in standard-length ones.

Nevertheless, longer follow-ups, larger numbers of patients, and RCTs are needed before making more reliable clinical recommendations.

ACKNOWLEDGMENTS

No funding was received to conduct this trial. The authors reported no conflicts of interest related to this study.

REFERENCES

1. Artzi Z, Carmeli G, Kozlovsky A. A distinguishable observation between survival and success rate outcome of hydroxyapatite-coated implants in 5–10 years in function. Clin Oral Implants Res 2006;17:85–93.
2. Chung DM, Oh TJ, Shotwell JL, Misch CE, Wang HL. Significance of keratinized mucosa in maintenance of dental implants with different surfaces. J Periodontol 2006;77:1410–1420.
3. Bouri A Jr, Bissada N, Al-Zahrani MS, Faddoul F, Nouneh I. Width of keratinized gingiva and the health status of the supporting tissues around dental implants. Int J Oral Maxillofac Implants 2008;23:323–326.
4. Zigdon H, Machtei EE. The dimensions of keratinized mucosa around implants affect clinical and immunological parameters. Clin Oral Implants Res 2008;19:387–392.
5. Adibrad M, Shahabuei M, Sahabi M. Significance of the width of keratinized mucosa on the health status of the supporting tissue around implants supporting overdentures. J Oral Implantol 2009;35:232–237.
6. Schrott AR, Jimenez M, Hwang JW, Fiorellini J, Weber HP. Five-year evaluation of the influence of keratinized mucosa on peri-implant soft-tissue health and stability around implants supporting full-arch mandibular fixed prostheses. Clin Oral Implants Res 2009;20:1170–1177.
7. Crespi R, Capparè P, Gherlone E. A 4-year evaluation of the peri-implant parameters of immediately loaded implants placed in fresh extraction sockets. J Periodontol 2010;81:1629–1634.
8. Boynueğri D, Nemli SK, Kasko YA. Significance of keratinized mucosa around dental implants: A prospective comparative study. Clin Oral Implants Res 2013;24:928–933.
9. Wennström JL, Derks J. Is there a need for keratinized mucosa around implants to maintain health and tissue stability? Clin Oral Implants Res 2012;23(suppl 6):136–146.
10. Thoma DS, Naenni N, Figuero E, et al. Effects of soft tissue augmentation procedures on peri-implant health or disease: A systematic review and meta-analysis. Clin Oral Implants Res 2018;29(suppl 15):32–49.
11. Gobbato L, Avila-Ortiz G, Sohrabi K, Wang CW, Karimbux N. The effect of keratinized mucosa width on peri-implant health: A systematic review. Int J Oral Maxillofac Implants 2013;28:1536–1545.
12. Esposito M, Maghaireh H, Grusovin MG, Ziounas I, Worthington HV. Interventions for replacing missing teeth: Management of soft tissues for dental implants. Cochrane Database Syst Rev 2012;2012(2):CD006697.
13. Souza AB, Tormena M, Matarazzo F, Araújo MG. The influence of peri-implant keratinized mucosa on brushing discomfort and peri-implant tissue health. Clin Oral Implants Res 2016;27:650–655.
14. Perussolo J, Souza AB, Matarazzo F, Oliveira RP, Araújo MG. Influence of the keratinized mucosa on the stability of peri-implant tissues and brushing discomfort: A 4-year follow-up study. Clin Oral Implants Res 2018;29:1177–1185.
15. Iezzi G, Perrotti V, Felice P, Barausse C, Piattelli A, Del Fabbro M. Are < 7-mm long implants in native bone as effective as longer implants in augmented bone for the rehabilitation of posterior atrophic jaws? A systematic review and meta-analysis. Clin Implant Dent Relat Res 2020;22:552–566.
16. Del Amo FSL, Yu SH, Sammartino G, et al. Peri-implant soft tissue management: Cairo opinion consensus conference. Int J Environ Res Public Health 2020;17:2281.
17. Oh SL, Masri RM, Williams DA, Ji C, Romberg E. Free gingival grafts for implants exhibiting lack of keratinized mucosa: A prospective controlled randomized clinical study. J Clin Periodontol 2017;44:195–203.
18. Linkevicius T, Puisys A, Linkeviciene L, Peciuliene V, Schlee M. Crestal bone stability around implants with horizontally matching connection after soft tissue thickening: A prospective clinical trial. Clin Implant Dent Relat Res 2015;17:497–508.
19. Iorio-Siciliano V, Blasi A, Sammartino G, Salvi GE, Sculean A. Soft tissue stability related to mucosal recession at dental implants: A systematic review. Quintessence Int 2020;51:28–36.
20. Checchi V, Felice P, Zucchelli G, et al. Wide diameter immediate post-extractive implants vs delayed placement of normal-diameter implants in preserved sockets in the molar region: 1-year post-loading outcome of a randomised controlled trial. Eur J Oral Implantol 2017;10:263–278.
21. Zucchelli G, Tavelli L, McGuire MK, et al. Autogenous soft tissue grafting for periodontal and peri-implant plastic surgical reconstruction. J Periodontol 2020;91:9–16.
22. Tavelli L, Barootchi S, Avila-Ortiz G, Urban IA, Giannobile WV, Wang HL. Peri-implant soft tissue phenotype modification and its impact on peri-implant health: A systematic review and network meta-analysis. J Periodontol 2021;92:21–44.
23. Roccuzzo M, Grasso G, Dalmasso P. Keratinized mucosa around implants in partially edentulous posterior mandible: 10-year results of a prospective comparative study. Clin Oral Implants Res 2016;27:491–496.
24. Turri A, Rossetti PH, Canullo L, Grusovin MG, Dahlin C. Prevalence of peri-implantitis in medically compromised patients and smokers: A systematic review. Int J Oral Maxillofac Implants 2016;31:111–118.
25. Ravidà A, Arena C, Tattan M, et al. The role of keratinized mucosa width as a risk factor for peri-implant disease: A systematic review, meta-analysis, and trial sequential analysis. Clin Implant Dent Relat Res 2022;24:287–300.