Soft-Tissue Conditions Around Dental Implants: A Literature Review

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Background: *The aim of this article is to review the current understanding regarding periimplant soft-tissue conditions to minimize risk of periimplant mucositis and periimplantitis.*

Materials and Methods: *An electronic search was performed in 4 different databases. Articles were reviewed and summarized if the following criteria were met: published evidence with recommendations on soft-tissue conditions around dental implants.*

Results: *An evaluation of various soft-tissue parameters, including the need of keratinized mucosa, periimplant mucosal height and phenotype, midfacial tissue level, and papillary fill, was performed based on the currently available evidence.*

Comments: *The need of keratinized mucosa is the parameter investigated the most. A trend favors a need of a wide band of nonmobile keratinized mucosa is seen with the benefit of less incidence of periimplant mucositis. In addition, the influence of the mucosal height and tissue phenotype on periimplant tissue health remains inconclusive. Although other soft-tissue parameters, including papillary fill and midfacial tissue level, are not yet proven to be related to periimplantitis, they play a crucial role to achieve successful esthetics.*

Conclusion: *A limited amount of evidence was identified to correlate periimplant soft-tissue parameters with periimplantitis. However, a wide band of nonmobile keratinized mucosa, an adequate periimplant mucosal height, and a thick tissue phenotype might reduce the incidence of tissue inflammation and future complications. (Implant Dent 2019;28:138–143)*

Key Words: periimplantitis, mucositis, gingiva, connective tissue, evidence-based dentistry

Within the past 3 decades, our understanding and evolution in implant dentistry has shifted our attention to the soft-tissue interface. Several studies[1–3] have looked at this structure throughout the years and found several similarities between teeth and implant. Adjacent to the implant, oral epithelium has the same keratinization characteristic that merges into nonkeratinized sulcular epithelium (SE).[4] Apical to the SE, junctional epithelium (JE) adheres to titanium through hemidesmosomes. The JE along with the connective tissue apical to it forms a biologic width around the implant similar to the tooth.[4] However, when looking at the connective tissue component, the fibers that insert in cementum in a perpendicular fashion are missing around implants. Instead, these fibers run in parallel and circumferential directions to the implant body.[4] The inner zone of this connective tissue compartment contains less fibroblasts and blood vessels and is densely packed with collagen fibers. A display is more similar to scar tissue. When looking at JE around implants, evidence[1] has shown that the microstructural components of the internal basement membrane may also be different than teeth. The JE is longer in implants compared with teeth.[1] The soft-tissue interface around implants completely lacks the blood supply from periodontal ligaments. Finally, in implants, the biologic width is established apical to the crest of adjacent bone in specific clinical situations where, in teeth, this structure is always supracrestal. Although these differences seem minor, their clinical implications influencing patient-centered outcomes can be immense.

Several soft-tissue parameters, that is, tissue phenotype and amount of keratinized mucosa, have been examined in the literatures to warrant the periimplant tissue health. Thin soft-tissue phenotype can be more prone to recession and black triangle defects.[5] Adequate keratinized mucosa has been proposed to be important in control of periimplant soft-tissue health.[6] Insufficient keratinized mucosa is associated with higher plaque index and gingival index scores, as well as higher levels of

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recession and attachment loss around implants. In addition, the mucosal height between the bone crest and the periimplant soft-tissue margin has been associated with the periimplant health and marginal bone loss.[7] This is important during the early healing stage since the establishment of biologic width around implant could take place in the expense of marginal bone level. Therefore, to provide a comprehensive understanding of periimplant soft-tissue considerations, the purpose of this article is to summarize the currently available literature related to soft-tissue parameters associated with periimplant mucositis and periimplantitis.

MATERIALS AND METHODS

Patient, Intervention, Comparison, Outcome (PICO) Question

- **P**: Healthy patient with dental implant placement
- **I**: Implant placement with an assessment of soft-tissue parameters
- **C**: The difference (influence) of soft-tissue conditions on implant outcomes
- **O**: The risk of developing periimplant mucositis and periimplantitis

Screening Process

An electronic and manual search in dental literature up to March 2018 were performed by 2 independent reviewers (I.M.M. and G.-H.L.) in 4 databases, including PubMed, EMBASE, Web of Science, and Cochrane Central Register of Controlled Trials. The search terms used were a combination of keywords, including but not limited to "dental implants," "periimplant," "mucosa," and "gingiva." The screening in such databases were limited to "clinical studies" AND "humans." In addition, a search for references in the review articles was performed. Finally, a hand search (January 2018–March 2018) was performed in implant-related peer-reviewed journals.

Eligibility Criteria and Data Analyses

Articles were reviewed and summarized (Table 1) if the following criteria were met: published evidence with recommendations on soft-tissue conditions around dental implants. A descriptive review was performed because of the heterogeneity of the study designs. An illustration to define the investigated soft-tissue parameters around dental implants is presented as Figure 1.

RESULTS

Periimplant Tissue Complexity

The periimplant attachment apparatus has some important distinctions from that at teeth. Similar to teeth, the epithelial "attachment" consists of hemidesmosomes; however, since there are no Sharpey's fibers and cementum, connective tissue fibers run parallel to the implant surface, rather than a direct fibrous insertion as with teeth. This lack of a physical barrier could render implants more susceptible to pathogenic challenge and ultimately result in periimplantitis. Because of this weak seal, periimplant tissues show slightly greater probe penetration at all disease states than periodontal tissues, particularly in periimplantitis when the probe can reach as close as 0.25 mm to bone.[8] This could contribute to spontaneous continuous progression of bone loss in periimplantitis cases without a "self-limiting" protective process seen in periodontitis.[9] Recent evidence has shown that certain implant surfaces might elicit a biologic response to inhibit down-growth of epithelium and induce a true connective tissue attachment to the implant surface[10]; however, more evidence is needed to warrant this concept.

Ideal Implant Position

A malpositioned implant incurs periimplant hard- and soft-tissue loss, resulting in tissue inflammation, esthetic failure, or even implant loss. Therefore, it is crucial to place an implant in an ideal 3-dimensional position to minimize future biologic or mechanical complications. It has been suggested that an implant should be placed 3 mm apical to the planned gingival zenith.[11] An implant placed too deep away from crestal bone will result in large amount of bone remodeling and increase the difficulty for maintenance. On the contrary, an implant placed too shallow will trigger crestal bone remodeling to establish periimplant biologic width, resulting in bone loss and tissue recession. In the labiopalatal or buccolingual dimension, the implant/abutment interface should be placed within the bony housing with at least 2-mm buccal plate present[11] to withstand the physiologic bone remodeling. An implant placed not within bony housing may result in bone and/or soft-tissue dehiscence, periimplant pockets, tissue inflammation, exudates, and esthetic complications. In addition, the implant-tooth distance and the interimplant distance should be at least 1.5 and 3.0 mm away, respectively, to retain the bone crest level[12] and access for hygiene. These guidelines for implant placement should be followed to establish healthy periimplant soft-tissue framework; otherwise, the occurrence of complications is inevitable.

Need of Nonmobile Keratinized Mucosa

The significance of a wide band of nonmobile keratinized tissue around dental implants has been widely investigated. At least 7 systematic reviews[6,13–18] were published in scientific journals in the last decade. Although an inconsistency is seen among the published reviews, most of the reviews[6,13–15,17] (5 of 7) concluded that an adequate zone of keratinized mucosa is associated with less plaque accumulation, tissue inflammation, recession, and loss of attachment. Therefore, a lack of nonmobile keratinized mucosa might be directly linked to a poor condition of periimplant soft-tissue health and the development of periimplant mucositis. However, research investigating the relationship between periimplant bone level changes and the amount of keratinized mucosa is scarce. Future studies are still needed to warrant the risk of periimplantitis development if insufficient keratinized mucosa is present around dental implants.

Need of Mucosal Height

A connective tissue cuff and a JE attachment consist the periimplant seal coronal to bone crest. The biologic width around a dental implant is approximately 3 mm.[2,3] If the periimplant mucosal height is insufficient to establish this physiologic dimension, bone resorption will occur to allow for formation of a stable soft-tissue

Table 1. Current Evidence of Periimplant Soft-Tissue Conditions on Implant Outcomes

Parameter	Authors/Year	Type of Study	Meta-analysis	Conclusion
Nonmobile keratinized mucosa	Wennstrom and Derks,[18] 2012	Review	No	If proper plaque control is performed, the presence of keratinized mucosa around implants may not be of importance.
	Lin et al,[6] 2013	Review	Yes	A lack of adequate keratinized mucosa around dental implants is associated with more plaque accumulation, tissue inflammation, recession, and attachment loss.
	Brito et al,[13] 2014	Review	No	The presence of keratinized mucosa results in less mucosal inflammation, less plaque accumulation, increased stability of the periimplant area, and prevention of mucosal recession.
	Chiu et al,[14] 2015	Review	No	Conflicting results were identified in the current literature. Individual consideration of treatment strategies for the patient with minimal keratinized mucosa is recommended.
	Pranskunas et al,[17] 2016	Review	No	The presence of an appropriate amount of keratinized mucosa is required due to an effect of decreasing gingival index, plaque index, pocket depth, and bleeding on probing.
	Gobbato et al,[15] 2017	Review	Yes	Lack of keratinized mucosa is statistically significantly associated with increased plaque index and bleeding index.
	Moraschini et al,[16] 2017	Review	No	Current systematic reviews and meta-analyses have structural and methodological variability and none obtain the maximum score on quality analyses. A potentially positive association between keratinized mucosal width and periimplant health exists.
Mucosal height	Suarez Lopez del Amo et al,[7] 2016	Review	Yes	Implants placed in sites with mucosal height of less than 2 mm have significantly more marginal bone loss compared with sites with mucosal height of 2 mm or more during the first 12 months of healing.
	Akcali et al,[19] 2017	Review	No	Currently there is insufficient evidence to warrant the clinical outcome in terms of bone-level changes between implants placed in sites with initial mucosal height <2 mm and those with ≥ 2 mm.
Tissue phenotype	Fu et al,[22] 2010	Cadaver study	Not applicable	A correlation exists between soft-tissue phenotype and labial bone thickness in cadavers' anterior maxillary region.
	Cook et al,[20] 2011	Human clinical study	Not applicable	Thick soft-tissue phenotype in maxillary anterior region of human subjects shows thicker labial bone thickness apical to the cementoenamel junction.
	Frost et al,[21] 2015	Human clinical study	Not applicable	There is a trend that thin phenotype is associated with thin labial plate. However, this trend does not reach statistical significance.

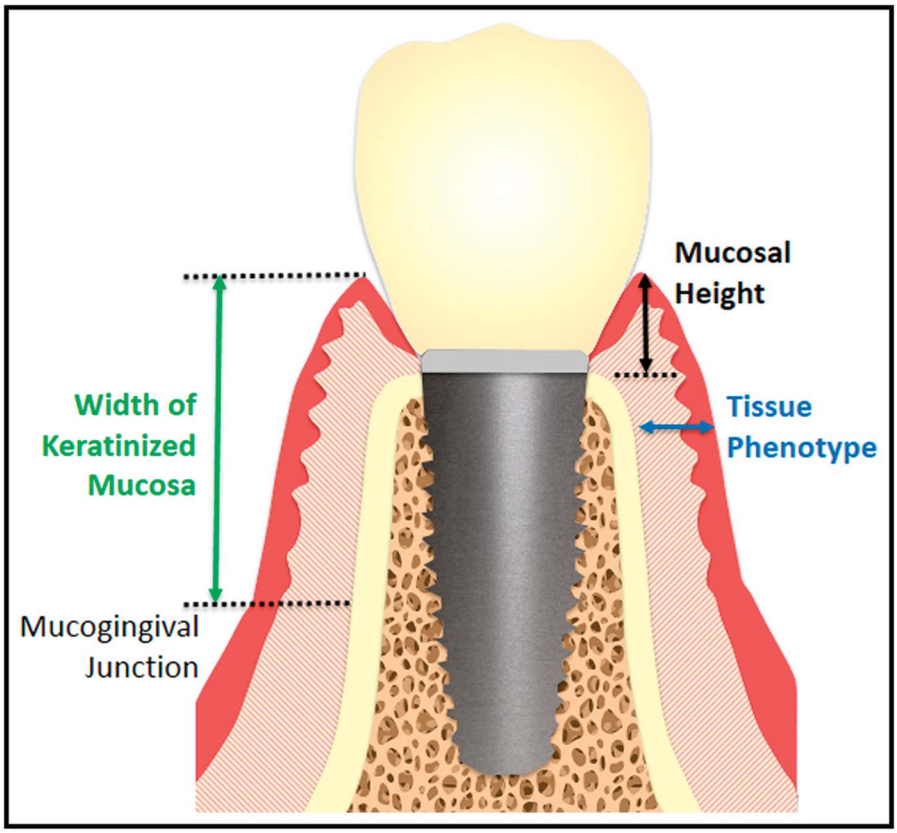

Fig. 1. An illustration to define the width of keratinized mucosa (from periimplant tissue margin to mucogingival junction), mucosal height (from tissue margin to alveolar bone crest), and tissue phenotype around dental implants. Figure 1 was created by G. -H. Lin.

attachment.[2] It has been shown that reducing the connective tissue height around dental implants resulted in crestal bone loss.[2] Two systematic reviews[7,19] were identified analyzing the need of mucosal height. Interestingly, one[7] concluded that implants placed with a larger periimplant mucosal height have less radiographic bone loss; however, the other one[19] concluded that insufficient evidence is present to warrant the need of mucosal height. This difference could be explained by various type of implants used (bone level vs soft-tissue level), surgical techniques, prosthetic designs, and patients' systemic conditions.[19] Therefore, the need of mucosal height remains controversial, and it is suggested to place implants based on the manufacturer's recommendations to establish the ideal periimplant soft-tissue framework.

Periimplant Tissue Phenotype

Although no systematic review was identified, 3 human studies[20–22] analyzed the correlation between tissue phenotype and buccal bone thickness. All 3 articles reported that a thicker labial tissue phenotype is associated with a thicker buccal plate. This finding provides clinicians an alert that a thin buccal plate might be present when a patient is with thin gingival phenotype at the treatment plan phase. Further surgical procedures, that is, bone augmentation, before or during implant placement might be necessary to create sufficient bone quality and quantity.

Midfacial Tissue Level

The periimplant midfacial tissue level is greatly influenced by the implant shoulder location.[23] A buccally positioned implant will increase the chance of esthetic failure due to unpredictable bone and soft-tissue remodeling. In addition, a thin tissue phenotype and a bony dehiscence might further predispose an implant to facial tissue recession. When the rough surface of the implant is exposed to the oral cavity, the risk for bacterial adhesion increases. Therefore, clinicians should evaluate these risk indicators before surgical execution to minimize the risk of tissue recession. Soft-tissue graft or bone augmentation is often performed to compensate the limited amount of tissue quantity and/or quality during the treatment phase.

Papillary Fill

Although interproximal papillary fill is not associated with periimplantitis, it still dictates a successful treatment outcome since esthetics can be compromised without papillary fill. The papillary fill is determined by the vertical distance between the contact point of the crowns to the interproximal bone crest.[24] This vertical distance has to be within 5 mm between 2 natural teeth, within 4.5 mm between an implant and a natural tooth, and within 3.5 mm between 2 adjacent implants, to warrant a predictable papillary fill.[24] It has been reported that delayed restoration resulted in more initial papillary loss than immediate restoration; however, this difference is not statistically significant, and a comparable height of papillary fill is seen after 1 year of treatment.[25]

Critical and Subcritical Contours for Soft-Tissue Compensation

Critical and subcritical contours are subgingival zones of an implant restoration. Periimplant tissue support could be facilitated with an ideal design of these zones based on the implant position.[26] The critical contour is defined as an area extending from the periimplant tissue margin to 1.0- to 1.5-mm subgingival level. The subcritical contour is an area located immediately coronal to the implant platform and extends to the critical contour of a restoration. Because the critical contour represents the emergence profile of a restoration, it should mimic the contour of a natural tooth and provides support for a final esthetic outcome. The subcritical contour serves as a "running room" between the platform and the emergence profile. It should be biologically acceptable without impinging on the osseous crest to prevent future tissue recession or loss of papillary height.

COMMENTS

Although poor soft-tissue conditions could result from periimplantitis due to bacterial challenge and recurrent inflammation, there is a limited amount of evidence to insure the causal effect between soft-tissue parameters and periimplant bone level. The need of keratinized mucosa is the parameter investigated the most. Although currently available evidence is controversial, a trend favors a need of a wide band of nonmobile keratinized mucosa is seen with the benefit of less incidence of periimplant mucositis. However, if a patient could demonstrate adequate oral hygiene, a lack of keratinized mucosa does not result in the development of mucositis.

The importance of the mucosal height between the marginal tissue and crestal bone is controversial. Currently, there is a lack of evidence to warrant the correlation between an inadequate mucosal height and the development of periimplantitis. Theoretically, an adequate amount of mucosal height will insure the establishment of biologic width around a dental implant, and further minimize the incidence of bone loss during remodeling. However, an absolute value for the mucosal height is still inconclusive. Future clinical trials are needed to investigate the influence of this parameter with various implant designs.

Although tissue phenotype is not yet proven to be associated with the occurrence of periimplantitis, the evidence shows a thick tissue phenotype is correlated with a thick buccal plate. This finding is of great clinical significance since clinicians might foresee a potential tissue deficiency and further set up the treatment plan to avoid future complications. However, state-of-the-art diagnostic imaging, that is, cone beam computed tomography, is still considered the standard of care to analyze bone architecture and identify tissue deficiency.

Other soft-tissue parameters, including papillary fill and midfacial tissue level, are associated with surgical techniques and implant location. Although these parameters are not yet proven to be related to periimplantitis, they play a crucial role to achieve successful esthetics. Clinicians should consider ideal three-dimensional implant positioning whenever possible to ensure long-term favorable treatment outcomes. In addition, prosthetic modifications, including platform switching abutment and adjustment of critical/subcritical contours, should also be considered to achieve this goal.

CONCLUSION

A limited amount of evidence was identified to correlate periimplant soft-tissue parameters with periimplantitis. However, a wide band of nonmobile keratinized mucosa, an adequate periimplant mucosal height, and a thick tissue phenotype might reduce the incidence of soft-tissue inflammation and future complications. In addition, an understanding of factors associated with mucosal recession and papillary fill can further help clinicians to plan treatment and achieve favorable esthetic outcomes.

DISCLOSURE

The authors claim to have no financial interest, either directly or indirectly, in the products or information listed in the article.

ROLES/CONTRIBUTIONS BY AUTHORS

G. -H. Lin: contributed to the article search, manuscript preparation, review of the content, and creation of Figure 1. I. M. Madi: contributed to the manuscript preparation and review of the content.

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