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Assessment of Peri-implant Soft Tissue Phenotype Change: A Prospective Pilot Study

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Assessment of Peri-implant Soft Tissue Phenotype Change: A Prospective Pilot Study

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Assessment of Peri-implant Soft Tissue Phenotype Change:

A Prospective Pilot Study

Trung Nguyen

Abstract

Recently, dental implants have become a popular treatment to replace missing dentition. Peri-implant hard tissue, such as bone dimensional changes, has been widely investigated. New research regarding peri-implant soft tissue has emerged in the recent years focusing on the association between peri-implant soft tissue phenotype and implant health. Current evidence shows that thin gingival phenotype and a lack of adequate keratinized mucosa around dental implants are associated with recession and peri-implant diseases. However, there is still a lack of evidence evaluating the remodeling process of peri-implant soft tissue during implant treatment. This prospective pilot study aimed to investigate the change of peri-implant soft tissue phenotype and keratinized tissue width at three specific timepoints during implant treatment. Gingival thickness at 2, 4, and 6 mm from the free gingival margin and keratinized tissue width were measured in six patients receiving single implant placement in the maxillary esthetic zone at the time of tooth extraction and ridge preservation, implant placement, and implant restoration. Data analysis showed no statistically significant differences in peri-implant soft tissue measurements among the three timepoints during implant treatment. The present pilot study did not find significant changes in gingival thickness or keratinized tissue width in sites receiving dental implants throughout the different treatment timepoints.

Table of Contents

List of Figures

List of Tables

1. Introduction

The management of edentulism with endosseous dental implants have become an increasingly popular treatment to replace missing dentition. The prevalence of dental implants in the United States has been recorded to be 0.7% in 1999-2000 and projected to rise to 23% in 2026.[1] Research on dental implants and their surrounding tissues have also broadened as more clinicians begin to understand the hard and soft tissue changes following dental implant treatment. While bone dimensional changes after tooth extraction and dental implant placements have been widely evaluated,[2,3,4,5] the dimensional changes in soft tissue is not well understood. Recent research suggests that the threshold for peri-implant soft tissue complications is based on the peri-implant soft tissue phenotype. The soft tissue dimensions, defined as thin and thick soft tissue phenotype, can be non-invasively determined using clinical assessment of whether a periodontal probe can be visualized through the marginal tissue.[6,7] It has been found that thin periodontal tissue thickness influences the development and progression of gingival recession.[8] In recent years, a limited amount of evidence has shown a correlation between peri-implant soft tissue parameters with peri-implantitis.[9] Thin buccal peri-implant soft tissues are to be associated with an increased risk of recession.[10,11]

Though strategies such as platform switching may help with a thick phenotype, thin peri-implant tissue phenotype, especially with the overlying mucosal tissue, appears to be susceptible to recession as well as crestal bone loss.[12] Conversely, the presence of at least 2 mm of keratinized mucosa was shown to decrease the incidence of peri-implant inflammation.[13,14,15] A lack of adequate keratinized mucosa around dental implants has

been found to be associated with increased plaque accumulation, tissue inflammation, mucosal recession, attachment loss, and peri-implant diseases.[16,17] Currently, there is still a lack of evidence regarding the remodeling process of peri-implant soft tissue parameters before, during, and after dental implant treatment.

The aim of this prospective pilot study is to investigate the change of peri-implant soft tissue phenotype and keratinized tissue width at three specific timepoints throughout the duration of dental implant treatment.

2. Materials & Methods

2.1 Patient Population and Selection

The patient population consisted of 13 participants that received dental implant placements in the maxillary anterior esthetic zone. These patients were recruited for this study from the Periodontology Clinic at the University of California, San Francisco (UCSF) School of Dentistry.

Inclusion criteria for all patients consisted of (i) male or female age 18 or older, (ii) controlled periodontal condition, (iii) no active/history of intraoral or systemic diseases, (iv) teeth in the maxillary esthetic zone to be extracted with ridge preservation and delayed implant placement without soft tissue graft, horizontal ridge augmentation, or buccal bone graft at the time of extraction or implant placement, (v) non-smokers, (vi) no current anticoagulant or antiplatelet medications, and (vii) no allergy to local anesthetics. No segregation was performed based on thin versus thick phenotype.

Exclusion criteria were as follows: (i) male or female age 17 or younger, (ii) active or untreated periodontal disease, (iii) uncontrolled systemic conditions (ASA III or higher), (iv) sites that required soft tissue graft, horizontal ridge augmentation, or buccal bone

graft at the time of tooth extraction or implant placement, (v) sites outside the maxillary esthetic zone, (vi) current smokers, (vii) patients currently on anticoagulant or antiplatelet medications, (viii) patients with history of radiation therapy, bisphosphonates, and selective serotonin reuptake inhibitors, (ix) patients with allergy to local anesthetics, and (x) pregnant female patients.

Informed consents were obtained from all participants that explained the aim, study timeline, and potential benefits and risks of the study. The medical history (medical conditions, medications, and drug allergies) was reviewed using the electronic health record system of the UCSF School of Dentistry. Eligibility screening was performed, which included an evaluation of systemic and intraoral criteria. Clinical photographs were obtained for the site of interest. Alginate impressions were taken, and diagnostic casts were used to fabricate stents for the data collection process.

2.2 Data Collection

The three specific timepoints to be investigated in this study were the following: time of tooth extraction and ridge preservation (T1), time of implant placement (T2), and time of implant restoration (T3). Timepoint T1 and T2 data collection were completed in the UCSF Periodontics Clinic. Timepoint T3 data were collected in the UCSF General Dentistry Faculty Practice and Prosthodontics Clinic. All data collection were completed by two calibrated investigators, TN and GHL.

Stents were fabricated using diagnostic casts to reproducibly obtain clinical measurements at the same sites throughout the study just prior to extraction. For each timepoint, the pre-extraction stent was used. For each timepoint data collection, patients were anesthetized with 2% Lidocaine with 1:100K epinephrine local anesthetic at the

Figure 1. Calibrated digital caliper

site of interest. To eliminate any local anesthesia-induced transient increase of gingival volume, the clinical measurements were not performed until at least 20 minutes after local anesthesia injection. Clinical measurements were obtained by transgingival probing with a standard endodontic file (FLEXOFILE, length: 21 mm, size: 040, Denstply Maillerfer, USA) mounted with silicone stopper into the soft tissue until reaching resistance. The distance between the tip of the endodontic file and the silicone stopper was measured using a calibrated digital caliper (**Figure 1**) (NEIKO, China).

The clinical measurements collected at timepoint T1, T2, and T3 in this study were soft tissue thickness measured at 2 mm, 4 mm, and 6 mm away from the free gingival margin prior to extraction (**Figure 2**), as well as keratinized tissue width, measured as the distance between the free gingival margin and the mucogingival junction. For each patient, the stent fitted accurately with the adjacent teeth across all three timepoints.

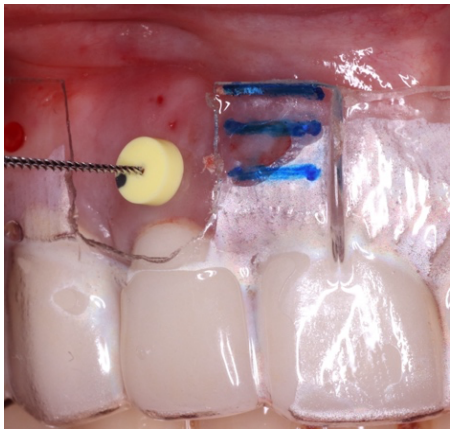

Figure 2. Measurement with stent. Stent in place with endodontic file measuring soft tissue thickness at 2, 4, and 6 mm from free gingival margin

2.3 Statistical Analyses

The mean values and standard deviations for all clinical measurements were calculated for each of the three study timepoints. The Student's t-test was used to assess the statistical significance of the peri-implant soft tissue changes. The differences of clinical measurements at three different timepoints were analyzed using the repeated measure of analysis of variance.

3. Results

Six patients (six implant sites) were included in the final data analysis of the study. Of the initial 13 patients recruited into the study, seven patients did not finish the study and were excluded from the final data analysis. Of the seven patients excluded, two patients required horizontal ridge augmentation prior to implant placement and three required buccal bone graft at the time of implant placement. Hence, these patients did not meet the inclusion criteria. The other two patients had to postpone treatment due to financial hardship. The implant sites included in the final data analysis comprised of three lateral incisors, one canine, and two second premolars. The initial measurement sites at T1 were used for measuring the same soft tissue thickness at T2 and T3. The soft tissue height and the change in gingival crest were not recorded.

For the clinical measurements of timepoint T1, the mean gingival thickness was 2.20 ± 0.44 mm, 1.90 ± 0.32 mm, and 1.74 ± 0.46 mm at 2 mm, 4 mm and 6 mm from the free gingival margin, respectively. For timepoint T2, the mean gingival thickness was 1.94 ± 0.37 mm, 1.62 ± 0.43 mm, and 1.78 ± 0.82 mm at 2 mm, 4 mm and 6 mm from the free gingival margin, respectively. For timepoint T3, the mean gingival thickness was 1.81 ± 0.28 mm, 1.76 ± 0.42 mm, and 1.80 ± 0.24 mm at 2 mm, 4 mm and 6 mm from the free

gingival margin, respectively. With regards to keratinized tissue width, the mean clinical measurements were 5.0 ± 0.45 mm, 4.92 ± 0.38 mm, and 4.92 ± 0.92 mm for timepoint T1, T2, and T3, respectively. This data is summarized in Table 1.

Table 1. Mean Values of Different Timepoints

Timepoint	GT @ 2 mm	GT @ 4 mm	GT @ 6 mm	KTW
T1	2.20 ± 0.44 mm	1.90 ± 0.32 mm	1.74 ± 0.46	5.0 ± 0.45 mm
T2	1.94 ± 0.37 mm	1.62 ± 0.43 mm	1.78 ± 0.82	4.92 ± 0.38 mm
T3	1.81 ± 0.28 mm	1.76 ± 0.42 mm	1.80 ± 0.24 mm	4.92 ± 0.92 mm

GT = gingival thickness, KTW = keratinized tissue width
T1 = time of tooth extraction and ridge preservation, T2 = time of implant placement, T3 = time of implant restoration

For timepoint T1, the Student's t-test comparison of the mean values of gingival thickness at 2 mm vs. 4 mm and 4 mm vs. 6 mm from the free gingival margin did not yield any statistically significant difference. However, the comparison of the mean values of gingival thickness at 2 mm vs. 6 mm resulted in a statistically significant difference (p-value = 0.03). For timepoint T2, the data analysis showed a statistically significant difference (p-value = 0.02) for gingival thickness at 2 mm vs. 4 mm. However, there were no significant differences for gingival thickness at 4 mm vs. 6 mm and 2 mm vs 6 mm. For timepoint T3, there were no statistically significant differences overall. This data is summarized in Table 2.

Table 2. Comparison of Mean Values Between Measurement Markings (p-values)

Timepoint	GT @ 2 vs. 4 mm	GT @ 4 vs. 6 mm	GT @ 2 vs. 6 mm
T1	0.10	0.27	0.03*
T2	0.02*	0.57	0.58
T3	0.82	0.84	0.97

GT = gingival thickness
T1 = time of tooth extraction and ridge preservation, T2 = time of implant placement, T3 = time of implant restoration
* = statistically significant difference

When comparing the mean differences between timepoints, the data analysis from the Student's t-test did not yield any statistically significant results for any of the timepoints with regards to gingival thickness or keratinized tissue width. There were no significant changes in gingival thickness at 2 mm, 4 mm, 6 mm from the free gingival margin and keratinized tissue width when comparing the mean differences of T2-T1 vs. T3-T2, T2-T1 vs. T3-T1, or T3-T2 vs. T3-T1. This data is summarized in Table 3.

Table 3. Comparison of Mean Differences Between Timepoints (p-values)

Timepoint Comparison	GT @ 2 mm	GT @ 4 mm	GT @ 6 mm	KTW
T2-T1 vs. T3-T2	0.70	0.46	0.98	0.79
T2-T1 vs. T3-T1	0.57	0.62	0.95	1.0
T3-T2 vs. T3-T1	0.23	0.33	0.91	0.36

GT = gingival thickness, KTW = keratinized tissue width
T1 = time of tooth extraction and ridge preservation, T2 = time of implant placement, T3 = time of implant restoration

4. Discussion

This prospective pilot study evaluated the peri-implant soft tissue phenotype change at three specific timepoints throughout the duration of dental implant treatment: time of tooth extraction and ridge preservation (T1), time of implant placement (T2), and time of implant restoration (T3). By comparing the changes from soft tissue remodeling at different stages of dental implant treatment, it may be possible to understand the direction of change in gingival thickness and keratinized tissue width, anticipate potential soft tissue graft procedures in conjunction with implant treatment, and educate and inform patients on their long-term implant health.

Over the years, many methods have been proposed to evaluate soft tissue thickness or gingival phenotype. Methods such as direct visual assessment,[18,19] assessment utilizing a periodontal probe,[20,21] direct measurement using a caliper,[22] ultrasonic devices[23] and cone-beam computerized tomography (CBCT)[24] are all available clinical tools for evaluating gingival phenotype. De Rouck et al. originally proposed the presence or absence of periodontal probe transparency through the buccal sulcus to indicate thin versus thick gingiva.[6] Later, Kan et al. determined that gingival phenotype identified by visual assessment with a periodontal probe is not statistically significantly different from direct measurement with a caliper and serves as a reliable method in evaluating gingival thickness.[7] The results from this study showed that the tissue phenotype was always thin when the gingival thickness was 0.6 mm and always thick when the gingival thickness was more than 1.2 mm.[7] Furthermore, visual assessment of gingival phenotype alone should not serve as a sufficient predictor for proper diagnosis.[7]

In natural dentition, several factors were found to influence the surrounding soft tissue phenotype. It has been suggested that long-tapered teeth have a thin-scalloped periodontium, whereas wide-squared teeth have a thick-flat periodontium.[18] Long-narrow teeth are also thought to be more susceptible to gingival recession than short-wide teeth because of the congenitally thinner tissue phenotype.[25]

With regards to dental implants, soft tissue phenotype has been shown to have impacts on peri-implant outcomes. Initial gingival thickness of more than 2 mm at the alveolar crest may play a significant role on marginal bone stability around implants.[26] Implant sites with insufficient initial gingival thickness were observed to have signs of early bone remodeling.[27] Moreover, these sites may present more peri-implant bone loss after the re-establishment of the supracrestal tissue attachment when implants were placed at the crestal level.[26] Recently, a systematic review and meta-analysis by Suarez-Lopez del Amo et al. evaluated the influence of gingival phenotype on early marginal bone loss around dental implants. The study concluded that implants placed in sites with an initial thicker soft tissue present with less radiographic marginal bone loss in the short term.[28]

Our study found the mean differences of soft tissue thickness at 2, 4, and 6 mm from the free gingival margin across all three different timepoints throughout the implant treatment process did not reveal any statistically significant changes. This suggests that if a patient's soft tissue phenotype at the site of future implant is initially thin or thick, it will remain unchanged through the implant treatment process. Understanding this trend may aid in the discussion of phenotype modification therapy (PhMT) as part of the initial implant therapy in helping to improve the future long-term peri-implant soft tissue stability and health. A recent systematic review and meta-analysis by Lin et al. in 2018

explored the influence of the timing of PhMT during implant treatment on peri-implant soft tissue stability. The study specifically evaluated autogenous soft tissue graft procedures that were completed either in conjunction with or after implant surgery. The results showed no difference between simultaneous or delayed soft tissue augmentation and both procedures significantly enhanced soft tissue thickness.[29] When assessing keratinized tissue width around dental implants, many studies have concluded that a lack of adequate keratinized mucosa is associated with increased plaque accumulation, tissue inflammation, mucosal recession, attachment loss, and peri-implant diseases.[16,17] A widely accepted measurement of at least 2 mm of keratinized mucosa was shown to decrease incidence of peri-implant inflammation.[13,14,15] A more recent systematic review by Iorio-Siciliano et al. in 2020 evaluated the stability of soft tissues around implants by comparing mucosal recessions in patients with and without keratinized mucosa. Their findings showed that after a follow-up time of at least 5 years, the presence of keratinized mucosa may lead to less mucosal recession around implants.[30] Similar to soft tissue thickness, our study did not find the mean differences of keratinized tissue width across the three different timepoints of the implant treatment process to exhibit any statistically significant changes. Hence, an implant site with an initial keratinized tissue width of less than 2 mm will most likely remain the same, which may predispose the site to future peri-implant diseases. Lin et al. also found that PhMT significantly increases keratinized tissue width irrespective of the timing of the soft tissue augmentation.[29] A systematic review and network meta-analysis assessed different surgical techniques to gain keratinized tissue width. The findings revealed that apically positioned flap combined

with free gingival graft, connective tissue graft, collagen matrix, and acellular dermal matrix all provided significant gain in keratinized tissue width compared to non-augmented sites.[31] However, apically positioned flap in combination with free gingival graft was the most effective.[31]

Contrary to the aforementioned studies regarding soft tissue thickness having an impact on peri-implant gingival recession, a randomized controlled trial conducted by Zuiderveld et al. did not find gingival phenotype to be a predisposing factor for change in mid-buccal mucosal level.[32] Rather, implant positioning plays a more important role in determining the final esthetic outcome.[32] Implants that were placed too far to the buccal of the edentulous ridge have been associated with a higher incidence of gingival recession of the mid-buccal mucosa.[33,34]

The results of our present study did not reveal statistically significant changes in peri-implant soft tissue phenotype and keratinized tissue width throughout the three different timepoints of the dental implant treatment process. Our findings suggest that whether a patient initially has a thin or thick tissue phenotype, and an adequate or lack of keratinized mucosa, these parameters will most likely remain unchanged throughout implant treatment. Based on the current evidence, a thin tissue phenotype and lack of adequate keratinized mucosa may predispose patients to an increased risk of mucosal recession and peri-implant diseases.[10,11,16,17] As a mean to inform and educate patients with thin tissue phenotype and lack of adequate keratinized mucosa, PhMT should be discussed as part of the initial implant therapy. Although Lin et al. found no difference between soft tissue augmentation at time of implant placement or with delayed

approach[29], PhMT could be considered even prior to the time of tooth extraction since soft tissue phenotype would not be changed thereafter.

There are several limitations identified for this pilot study. First, a limited number of participants was recruited. A larger sample size would be required to increase the power of the study that could potentially produce a more statistically significant result. Second, the initial experimental pool should have been segregated into thin versus thick phenotype based on the probe transparency test. The changes in keratinized tissue width should be monitored using the initial incisive edge to horizontal soft tissue crest, as well as monitoring that there is no change in the mucogingival junction. The latter two data collection would better permit the evaluation of keratinized tissue width during treatment phases. As discussed, it is anticipated that the information above would provide information as to how keratinized tissue width changes with extraction, implant placement, and implant restoration. This information may be critical in that it may provide the 2 mm of attached gingiva that is putatively necessary to maintain implant health. Lastly, another limitation to the study is the possible inconsistency of the data collection process that was completed by investigator TN and GHL. Even though both investigators were calibrated, the element of human errors cannot always be eliminated.

5. Conclusion

Within its limitations, this prospective pilot study did not find any statistically significant changes in soft tissue thickness as measured at the time of tooth extraction and ridge preservation, time of implant placement, and time of implant restoration. Future studies with larger sample size with segregation of thin versus thick phenotype are required to further explore peri-implant soft tissue phenotype changes throughout the duration of dental implant treatment.

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