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Soft tissue phenotype modification impacts on peri-implant stability: a comparative cohort study

Cho-Ying Lin[1,2] · Pe-Yi Kuo[1] · Meng-Yao Chiu[1] · Zhao-Zhao Chen[3] · Hom-Lay Wang[3]

Abstract

Objectives Soft tissue phenotype modification (STPM) could be performed to maintain peri-implant health. Therefore, the aim of the study was to analyze tissue alteration around implants following soft tissue phenotype modification during implant uncovering surgery.

Materials and methods Patients who had STPM (either pouch roll or modified roll technique) during implant second-stage surgery with at least 12-month follow-up were included. Clinical and radiographic parameters including mucosal tissue thickness (MTT), recession (REC), keratinized mucosa width (KMW), probing pocket depth (PPD), marginal bone loss (MBL), emergence profile, and emergence angle were extracted from 2-week, 2-month, and 12-month visits after second-stage surgery.

Results Twenty-eight patients with 33 implants that fulfilled the inclusion criteria were included. After soft tissue phenotype modification, at 2 weeks, REC was negatively correlated to mean MTT at mid-buccal site ($r = -0.41$, $p = 0.018$) and borderline correlated at mid-lingual site ($r = -0.343$, $p = 0.051$). Stable KMW was maintained from 2 weeks to 12 months with minimal shrinkage rate (3 ~ 14%). MBL change was limited (0.24 ~ 0.47 mm) after STPM. All implants had shallow PPD (≤ 3 mm) with the absence of bleeding on probing. Emergence angle at the mesial side, however, was significantly correlated to surgical techniques, which indicated pouch roll technique would have 6.96 degrees more than modified roll technique ($p = 0.024$).

Conclusions Soft tissue phenotype modification, either pouch roll or modified roll technique, during uncovering surgery resulted in favorable clinical outcomes. Thin mucosal tissue thickness and pouch roll technique are the factors related to more recession at 2 weeks. Pouch roll technique could influence the restorative design by having a wide emergence angle at the mesial side.

Clinical relevance Modified and pouch roll techniques during uncovering surgery were viable methods to yield favorable peri-implant health, while the preciseness of pouch roll technique was required to avoid mucosal recession and inadequate restorative design.

Introduction

Soft tissue augmentation around implants has been centered in increasing width of keratinized mucosa (KMW) as well as mucosa tissue thickness [1–5]. It has been thought to not only maintain natural teeth health but also peri-implant health and stability [6]. However, with regard to the need of KMW to maintain dental implant health, the evidence remained to be limited [7]. Nevertheless, lack of adequate KMW has been associated with more plaque deposition, more inflammation, higher mucosal recession, and greater

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attachment loss [8], or even higher risks of peri-implant disease in erratic maintenance compliers [9].

So far, the use of autogenous graft–based techniques, especially free gingival graft placement, has been regarded as the gold standard to increase KMW as well as the vestibule depth [5, 10]. Likewise, the autologous connective tissue graft has been widely recommended for mucosal tissue thickness enhancement [5], due to its favorable thickness with minimal shrinkage in long-term follow-up when comparing to other soft tissue graft approaches [10, 11]. The necessity of augmenting mucosal tissue thickness might be attributed to prevent peri-implant bone loss and to enhance esthetic outcomes [3, 10, 12, 13]. The difference in the amount of bone remodeling could be attributed to the difference in mucosal tissue thickness, which has been believed to be the result of supracrestal tissue height (i.e., biological width) establishment [14–16]. Moreover, one cross-sectional study even suggested that thin mucosal tissue was more likely to have peri-implantitis [17]. Not surprisingly, thick mucosal tissue often has better esthetic outcomes because of its ability in achieving better tissue contour [18], masking effect from metal abutment [19, 20] and creating papilla after prosthesis fabrication [21].

Soft tissue phenotype modification around the implant could be performed at different time points without causing any significant reduction in both KMW and mucosal tissue thickness [22]. It is often recommended to perform soft tissue phenotype modification, either pouch roll [23], or modified roll technique [24], during implant uncovering surgery, since this procedure can be done simultaneously without the need of an additional surgery [25]. However, data on how both procedures influence the peri-implant clinical parameters have not been thoroughly investigated or compared. Therefore, the primary purpose of this retrospective cohort study was to analyze the soft tissue alteration during the early healing process and the change after loading, including initial mucosa tissue thickness, KMW, probing pocket depth (PPD), mucosal recession (REC), and radiographic bone level during the 12-month period. The secondary outcome of this study was to assess the correlation between all clinical parameters to the following two variables: surgical techniques and restorative designs of the crown.

Materials and methods

Patient selection and study design

The present retrospective cohort study included patients with at least one implant placement 4 to 6 months prior to stage 2 surgery, and all implant surgeries had been performed by the same surgeon (CYL) between 2019 January and 2020 June. All included patients had to meet the following inclusion criteria:

1. Patient treated with at least one bone leveled 3i implant[*]: 3.25, 4, and 5 mm in diameter and 8.5, 10, and 11.5 mm in length, and primary stability was obtained with insertion torque ≥ 20Ncm after placement.
2. Implant(s) is/are restored with fixed prosthesis (single crown and splinted crown, which excluded the ones with pontic(s)).
3. Informed consent had been obtained prior to implant uncovering.
4. Intact clinical and radiographic data was available, and the patient followed the recommended supportive post-implant treatment during the 12-month loading period of implants.
5. Implant was classified as score 0 of peri-implant bleeding index [26].

Patients were excluded from this study if they have one of the following criteria:

1. Uncontrolled systemic disease, such as hypertension, diabetes.
2. Untreated periodontitis.
3. Implant was placed immediately after extraction.
4. Guided bone regeneration was performed at the time of soft tissue phenotype modification.
5. Implant with ≥ 3 mm in KMW.
6. History of radiation therapy on head and neck regions.
7. Heavy smokers (more than 0.5 pack per day).
8. Patient with pregnancy.
9. Same surgical site with failed implant history.
10. Patient who did not comply to the recommended supportive treatment was regarded as erratic complier.

The study protocol was conducted according to revised version of Helsinki Declaration in 2013, and it was approved by institutional review board of Chang Gung memorial hospital (IRB: 202101533B0). Following STROBE statement, the cohort study was performed.

Clinical procedure

After local anesthesia, either modified roll technique [24] (Fig. 1A–H) or pouch roll technique [23] (Fig. 1I–P) was performed around implants with 4-mm or 6-mm healing abutment. In the pouch roll technique, part of the U-shaped flap above the implant was de-epithelized and rolled up then tugged in under the buccal flap. When modified roll technique was chosen, H-shaped incisions were performed, and part of the palatal/lingual flap was taken to enhance mucosa tissue thickness of buccal flap (Fig. 2). Rotation

Fig. 1 Modified roll technique (**A**, **B**) or pouch roll technique (**I–K**) was performed for pedicle soft tissue augmentation around implants, and 4-mm healing abutment was placed after flap preparation. All cases (modified roll (**C–H**); pouch roll (**L–P**)) were under supportive treatment at 2 weeks, and 2 and 12 months after surgery
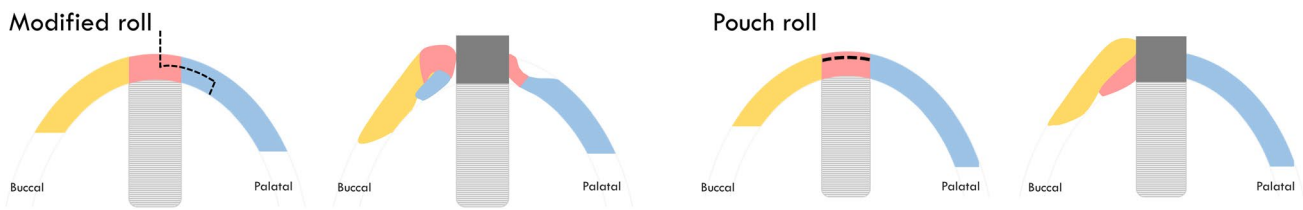

Fig. 2 The colored diagraph described different designs of roll flap around implant from cross-sectional view. Yellow: buccal flap; red: soft tissue above the implant; blue: lingual/ palatal flap

flap in both techniques were stabilized with 5–0 (PDS*II, Polydioxanone, ETHICON) or 6–0 (PROLENE, ETHICON) suture for wound closure. Post-operative instructions were instructed verbally, and the medications were prescribed (acetaminophen 500 mg, tid for 5 days) for pain control. Systematic antibiotics (amoxicillin 375 mg, tid for 5 days) were also given if symptom and signs of infection was noted during post-operative phase. Sutures were removed 2 weeks after surgery, and surgical wounds were followed 2 months afterwards. The implant prosthesis, including titanium patient-specific abutment, was then constructed by a board-certified prosthodontist, and the final data was collected 12 months after implant loading. All patients had been through tailored supportive post-implant treatment, and the interval was 3 months for the 12-month period. As for the regimen, routine coronal prophylaxis and mechanical debridement were performed with ultrasonic device and titanium curettes, and oral hygiene reinforcement was also applied at every visit with adequately designed interdental brush and superfloss for homecare maintenance.

Data collection and outcome measurement

Clinical parameters (mucosa tissue thickness, REC, KMW, PPD) were measured with periodontal probe (PCP-UNC 15 tip, HU-Friedy, Chicago, IL) with an accuracy of 0.5 mm before and after abutment connection procedure.

Other clinical and radiographic measurements were conducted as follows:

1. Mucosal tissue thickness around implant (MTT): Sounding technique was performed with periodontal probe above the implant with 3 points (mesial, central, distal) prior to surgery under local anesthesia.
2. Mucosal recession (REC): the distance from the top of the abutment to the margin of mucosa at 6 sites around implants (mesio-buccal, mid-buccal, disto-buccal, mesio-lingual, mid-lingual, and disto-lingual) at the visits of 2 weeks, 2 months after surgery, and 12 months after loading.
3. Keratinized mucosa width (KMW): Periodontal probe was used to measure KMW at 3 buccal sites (mesio-buccal, mid-buccal, disto-buccal) of the implant at the visits of 2 weeks, 2 months after surgery, and 12 months after loading.
4. Probing pocket depth (PPD): Periodontal probe was used to measure PPD at 6 spots around implants (mesio-buccal, mid-buccal, disto-buccal, mesio-lingual, mid-lingual, and disto-lingual) at the visits of 2 months after surgery and 12 months after loading.

Radiographic measurements were followed with paralleled taken peri-apical films by an independent calibrated examiner (MYC) (Fig. 3).

1. Marginal bone level (MBL): mesial and distal bone level was defined as the distance from the shoulder of the implant to the first bone-to-implant contact at proximal sites. The measurement accuracy was 0.1 mm, and the length of the implant was utilized as the reference for deformation correction. The alteration of proximal bone level was followed from baseline to 2 months and 12 months after surgery.
2. Emergence angle [27] and emergence profile [27]: the angle was measured in periapical film with digital caliper, and the profile type was categorized with straight, concave, and convex.

Statistical analysis

SPSS25 (IBM Corp. Released 2017. IBM SPSS Statistics for Mac, Version 25.0) statistics package program was used for statistical analysis. Descriptive statistics of mucosal tissue thickness, REC, KMW, PD, and MBL at different time points in 2 different techniques are reported as means ± standard deviations. Intergroup and intragroup comparisons were performed by means of the non-parametric Mann–Whitney U test and the Wilcoxon signed-rank test, respectively. The chi-square association test (χ^2) was used to compare EP distribution in 2 different techniques. The association between clinical parameters and EA was evaluated by Spearman's Rank correlation coefficient. Univariate linear regression methods were performed to investigate factors to EA and recession. $p < 0.05$ was accepted for the significance level of the tests.
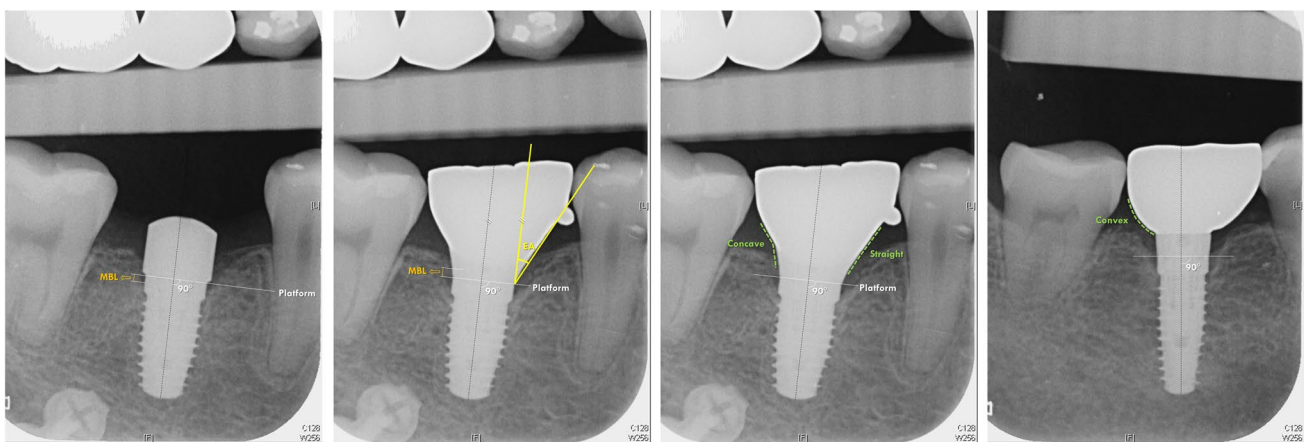

Fig. 3 Radiographic measurements were followed with paralleled taken peri-apical films. Abbreviation: Marginal bone loss (MBL), emergence profile (EP), and emergence angle (EA) were measured at mesial and distal sides of implants

Results

Study population

Twenty-eight patients with 33 implants that fulfilled the study criteria were included. Totally, 16 patients (18 implants) received modified roll technique, and 12 patients (15 implants) had pouch roll technique during uncovering surgery. However, four participants (one in pouch roll and 3 in modified roll group) missed the 4 months recall due to Covid-19 pandemic.

Demographic data and clinical and radiographic measurements

The demographic data and measurements are summarized in Table 1. The inter-examiner measurement agreement was 92% within 0.2 mm by repeating measurement 10 times. Interestingly, at baseline, the modified roll group possessed thicker mucosa tissue thickness than the pouch roll group (3.1 vs. 2.4 mm) with a significant difference. At the 2 weeks visit, mid-buccal REC was negatively correlating to mean mucosa tissue thickness mean ($r = -0.41$, $p = 0.018$), and mid-lingual REC was borderline correlated as well ($r = -0.343$, $p = 0.051$) after adjusting the difference noted in the baseline. The statistical difference disappeared at 2 months recall. For REC change (2 weeks–2 months), both mid-buccal/mid-lingual RECs were positively borderline correlated with mean mucosa tissue thickness ($r = 0.333$, $p = 0.058$; $r = 0.338$, $p = 0.054$).

Regarding REC at different time points, mean REC at 6 sites presented a small but insignificant change from 2 weeks to 2 months, while the lingual side of REC showed different tendency lines when compared to buccal sites except for the mesio-lingual site (Fig. 4).

For KMW, modified roll technique preserved significantly more KMW than the pouch roll group at 2 months ($p = 0.048$). However, the statistical differences between groups disappeared 2 months after surgery (Table 1).

PPD and MBL were stable in both groups without any differences at all time points. PPD was not correlated to REC and MBL from baseline to 2 months except for the mid-lingual site of implants. Furthermore, the regression of analysis indicated that an increase of 1 mm mid-L REC would have 0.3 mm less PPD at 2 months follow-up ($p = 0.026$). The MBL change was $0.24 \sim 0.28$ mm from baseline to 2 months, and the alteration was $0.1 \sim 0.16$ mm after abutment connection from 2 to 12 months (Table 1) (Fig. 5a, b). Both soft tissue phenotype modification groups presented limited MBL from implant placement to 12 months follow-up. However, the calculated MBL

change at mesial site achieved significance after loading ($2 \sim 12$ months) in pouch roll group ($p = 0.006$). Neither PPD nor REC was correlated to MBL at all time points.

Correlation between implant restorative design and other factors

Generally, the pouch roll group resulted in more REC than modified roll group at all time points. For example, in mid-B REC at 2 weeks, pouch roll group had 1.02 mm more recession than modified roll group with statistical significance ($p = 0.025$, $B = 1.017$). Focusing on the change of REC from 2 weeks to 2 months, the intragroup difference with statistical significance could only be found in the modified roll group at mid-buccal site ($p = 0.031$), while the intergroup difference did not exist between two surgical approaches at either site of implants (Fig. 6a, b).

Based on the change of KMW (2 weeks–2 months), the shrinkage of graft was 0.43 mm (5%) in modified roll group and 0.71 mm (14%) in pouch roll group (Table 1). Despite the lack of significant difference between groups, the statistical change could be observed in the pouch roll group ($p = 0.011$). From 2 to 12 months, the alteration of KMW was minimal without intergroup difference ($p = 0.238$), while the intragroup difference could be noted in modified roll group ($p = 0.033$) (Fig. 7).

The correlation between the restorative design of the implant and clinical data was assessed (Table 2). Intergroup difference was not noted in terms of emergence profile distribution. REC 2 weeks at disto-lingual, mesio-lingual areas were positively correlated to emergence angle at distal side ($r = 0.389$, $p = 0.025$) and at mesial side ($r = 0.366$, $p = 0.036$). However, the positive correlation remained at only mesio-lingual site during the 2-month period ($r = 0.392$, $p = 0.024$). No correlation could be found between MBL change and emergence angle at mesial side among all examination visits (2 months ~ baseline, 12 months ~ 2 months). Additionally, emergence angle at mesial side was significantly correlated to surgical techniques, which indicated the pouch roll technique would cause 6.96° wider than the modified roll technique ($p = 0.024$) (Table 2).

Discussion

Surgical approaches of soft tissue phenotype modification could be performed at various time points [2, 3, 22, 25, 28], and the application with concomitant uncovering surgery was efficient to achieve soft tissue enhancement with abutment connection at the same time [28]. Results obtained from this study confirmed that soft tissue phenotype modification, either pouch roll or modified roll technique, could

Table 1 The demographic data and measurements

Surgical approach	Mod		Pouch	
Demographic data				
Patient/implant (N)	16/18		12/15	
Gender (female; male) (N) (patient level)	7; 9		6; 6	
Tooth site (N) (implant level)	Upper: Incisor(1)/canine(1)/ premolar(1)/molar(8) Lower: Premolar(1); molar(6)		Upper: Incisor(0)/canine(0)/ premolar(2)/molar(5) Lower: Premolar(0); molar(8)	
Restorative design (implant level)	Single crown: 13 Splinted crown: 5		Single crown: 10 Splinted crown: 5	
Measurements	Mean ± SD	Min–Max	Mean ± SD	Min–Max
MTT mean*	**3.13 ± 0.56**	**2.33**	**2.42 ± 0.41**	**2–3.33**
REC 2 weeks				
Disto-buccal*	**0.47 ± 1.1**	**−2–2**	**1.4 ± 1.24**	**−1–3**
Mid-buccal*	**0.25 ± 1.05**	**−2–2**	**1.27 ± 1.44**	**−2–3**
Disto-buccal	0.69 ± 1.24	−2–2	1.1 ± 1.23	−1–3
Disto-lingual	1.28 ± 1.02	−1–3	1.6 ± 1.06	−1–3
Mid-lingual	1.25 ± 1.05	−1–3	1.73 ± 1.32	−2–3
Mesio-lingual	0.42 ± 1.41	−2–3	1.27 ± 1.16	−1–3
REC 2 months				
Disto-buccal	0.72 ± 0.99	−1–2.5	0.93 ± 1.18	−1–3
Mid-buccal	0.72 ± 0.83	−1–2	0.77 ± 1.56	−2–3
Disto-buccal	0.61 ± 0.88	−1–2	0.6 ± 1.44	−2–3
Disto-lingual	1.14 ± 0.76	0–2.5	1.73 ± 0.96	0–3
Mid-lingual	1.39 ± 1.13	0–3	2 ± 1.18	0–3
Mesio-lingual	0.56 ± 1.44	−2–2.5	1.37 ± 0.97	0–2.5
REC change 2 months–2 weeks				
Disto-buccal	0.25 ± 0.73	−1–1.5	−0.47 ± 1.47	−3–2
Mid-buccal	0.47 ± 0.74	−1–2	−0.5 ± 2.24	−5–3.5
Disto-buccal	−0.08 ± 1.02	−2.5–2	−0.5 ± 1.7	−5–2
Disto-lingual	−0.14 ± 0.74	−1.5–1	0.13 ± 1.25	−2–3
Mid-lingual	0.14 ± 0.7	−1–1	0.27 ± 1.53	−2–4
Mesio-lingual	0.14 ± 0.38	−0.5–1	0.1 ± 0.89	−1–2
REC 12 months				
Disto-buccal	−0.07 ± 0.26	−1–0	0	0
Mid-buccal	−0.07 ± 0.26	−1–0	0	0
Disto-buccal	−0.07 ± 0.26	−1–0	0.04 ± 0.13	0–0.5
Disto-lingual	0	0	0.07 ± 0.27	0–1
Mid-lingual	0.27 ± 0.46	0–1.5	0.11 ± 0.29	0–1
Mesio-lingual	−0.03 ± 0.3	−1–0.5	0.07 ± 0.27	0–1
REC change 12 months–2 weeks				
Disto-buccal	−0.9 ± 0.83	−2.5–0	−0.89 ± 1.21	−3–1
Mid-buccal	−0.77 ± 0.75	−2–0	−0.71 ± 1.6	−3–2
Disto-buccal	−0.7 ± 0.82	−2–1	−0.5 ± 1.41	−3–2
Disto-lingual	−1.13 ± 0.79	−2.5–0	−1.64 ± 1.01	−3–0
Mid-lingual	−1.2 ± 1.22	−3–1.5	−1.89 ± 1.26	−3–0.5
Mesio-lingual	−0.73 ± 1.19	−2.5–2	−1.29 ± 0.99	−2.5–0
KMW				
2 weeks	5.57 ± 1.5	4–9.33	5 ± 1.82	2.33–9
2 months*	**5.15 ± 1.3**	**3.67–9**	**4.29 ± 1.88**	**1.67–9**
2 months–2 weeks	−0.43 ± 0.86	−1.67–1	−0.71 ± 0.82	−2–0.33

Table 1 (continued)

Surgical approach	Mod		Pouch	
2 months–2 weeks shrinkage (%)	−0.05±0.16	−0.24–0.25	−0.14±0.18	−0.45–0.17
12 months	4.44±1.25	3–6.67	4.12±2.05	2–9.33
12 months–2 months	−0.56±0.85	−0.2–0.67	−0.29±1.04	−1.67–1.33
12 months–2 months shrinkage (%)	−0.11±0.17	−0.35–0.13	−0.03±0.26	−0.44–0.33
PPD 2 months				
Disto-buccal	2.44±0.51	2–3	2.4±0.74	1–4
Mid-buccal	2.61±0.61	2–4	2.53±0.74	2–4
Disto-buccal	2.67±0.69	1–4	2.67±0.82	1–4
Disto-lingual	2.89±0.68	2–5	2.53±0.74	1–4
Mid-lingual	2.56±0.92	1–5	2.6±0.91	1–4
Mesio-lingual	2.61±0.61	2–4	2.47±0.74	1–4
PPD 12 months				
Disto-buccal	3±0	3	2.64±1.15	1–5
Mid-buccal	2.67±0.82	1–4	2.64±1.01	1–4
Disto-buccal	2.93±0.96	2–5	2.71±0.99	1–5
Disto-lingual	2.67±0.62	2–4	2.86±1.03	1–5
Mid-lingual	2.8±0.77	2–4	2.71±0.83	2–5
Mesio-lingual	2.87±0.74	2–4	2.86±0.95	1–5
PD change 12 months–2 months				
Disto-buccal	0.53±0.52	0–1	0.21±1.19	−1–2
Mid-buccal	0.07±1.1	−2–2	0.14±0.95	−1–2
Disto-buccal	0.33±1.11	−2–2	0±1.3	−2–2
Disto-lingual	−0.27±0.88	−2–1	0.21±0.89	−1–2
Mid-lingual	0.13±0.92	−1–2	0±0.88	−2–1
Mesio-lingual	0.27±0.88	−1–2	0.29±0.83	−1–2
MBL baseline				
Mesial	−0.03±0.71	−2.1–0.86	0.09±0.31	−0.47–077
Distal	0.05±0.51	−1.1–0.87	0.1±0.19	−0.38–0.43
MBL 2 months				
Mesial	0.26±0.67	−2.13–1.3	0.24±0.21	−0.24–0.67
Distal	0.24±0.52	−1.2–1.32	0.28±0.17	0–0.64
MBL change (2 months–baseline)				
Mesial	0.3±0.67	−0.74–1.94	0.14±0.32	−0.53–0.74
Distal	0.19±0.47	−0.44–1.25	0.18±0.26	−0.24–0.64
MBL 12 months				
Mesial	0.41±0.31	−0.3–1.05	0.37±0.19	0.17–0.82
Distal	0.34±0.35	−0.3–1.13	0.33±0.15	0–0.53
MBL change (12–2 months)				
Mesial	0.16±0.79	−0.67–2.93	0.13±0.15	−0.14–0.46
Distal	0.1±0.47	−0.9–0.96	0.15±0.24	−0.48–0.42
MBL change (12 months–baseline)				
Mesial	0.47±0.85	−0.61–2.9	0.27±0.38	−0.6–0.93
Distal	0.34±0.58	−0.51–1.67	0.24±0.26	−0.43–0.53

*Statistically significant differences ($p < 0.05$) (Mann–Whitney U test)

Mod modified roll technique; *pouch* pouch roll technique; *MTT* mucosal tissue thickness; *REC* recession, the distance from the top of abutment to margin of mucosa; *KMW* keratinized mucosal thickness; *PD* pocket depth; *MBL* marginal bone loss; *SD* standard deviation
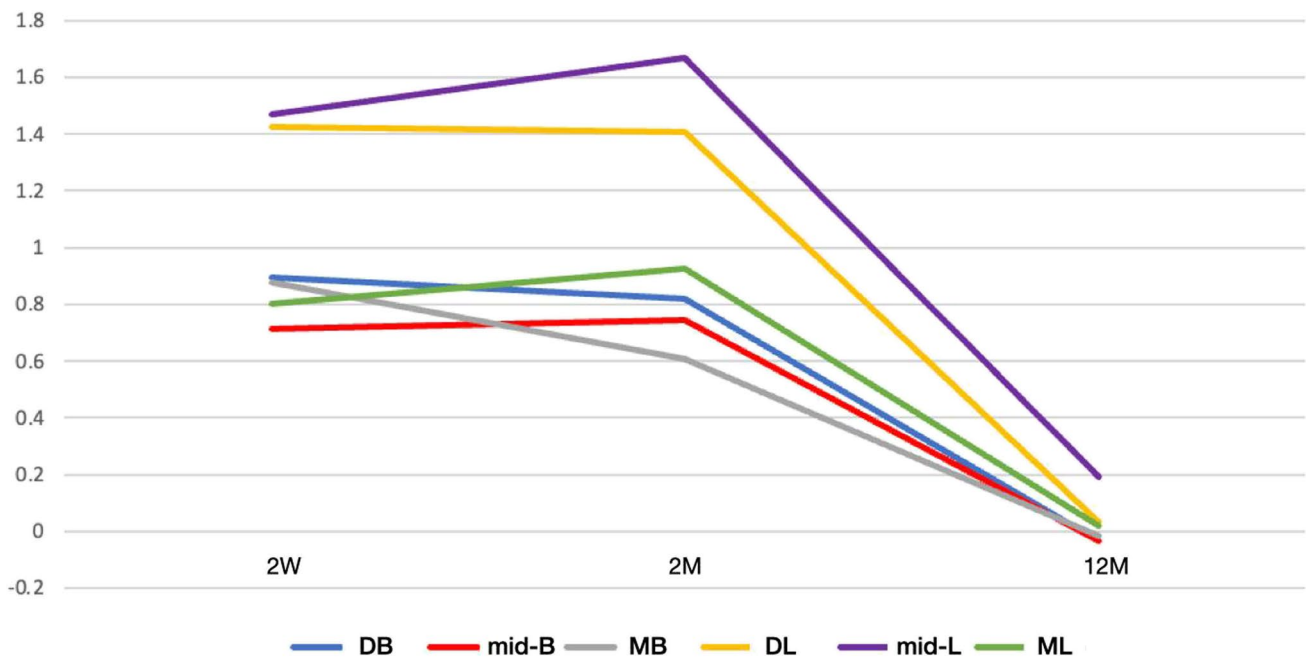
Fig. 4 From 2 weeks to 2 months after surgery, marginal mucosa at 6 points presented gentle alteration without significant difference. Abbreviation: REC, recession; DB, disto-buccal; mid-B, mid-buccal; MB, mesio-buccal; DL, distolingual; mid-L, mid-lingual; ML, mesio-lingual
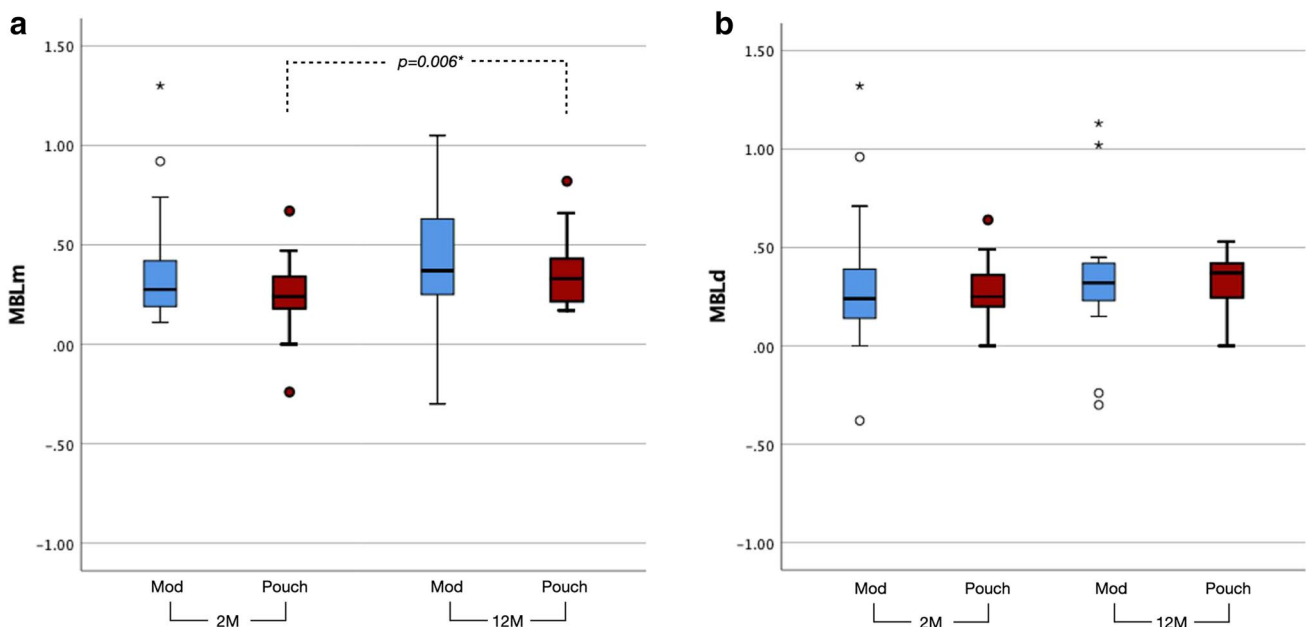

Fig. 5 The change of marginal bone level at **a** mesial and **b** distal sides in different surgical approaches from 2 to 12 months after surgery. Abbreviation: MBL, marginal bone loss; m, mesial; d, distal; Mod, modified roll technique; Pouch, pouch roll technique

gain mucosal tissue thickness and KMW as well as to achieve required supracrestal tissue height and nice tissue contour around implants for implant long-term stability and esthetics. This is in line with literature that showed soft tissue phenotype modification was aimed to improve mucosal thickness and keratinized mucosal width, maintain stable MBL, reduce

PPD, decrease plaque index, and prevent soft tissue dehiscence [4, 10, 13], thus promoting peri-implant health and stability. Result from this study indicated that soft tissue phenotype modification can effectively increase buccal KMW (all had ≥ 2 mm) with minimal shrinkage (3 ~ 14%) from 2 weeks to 12 months regardless of which surgical procedures were
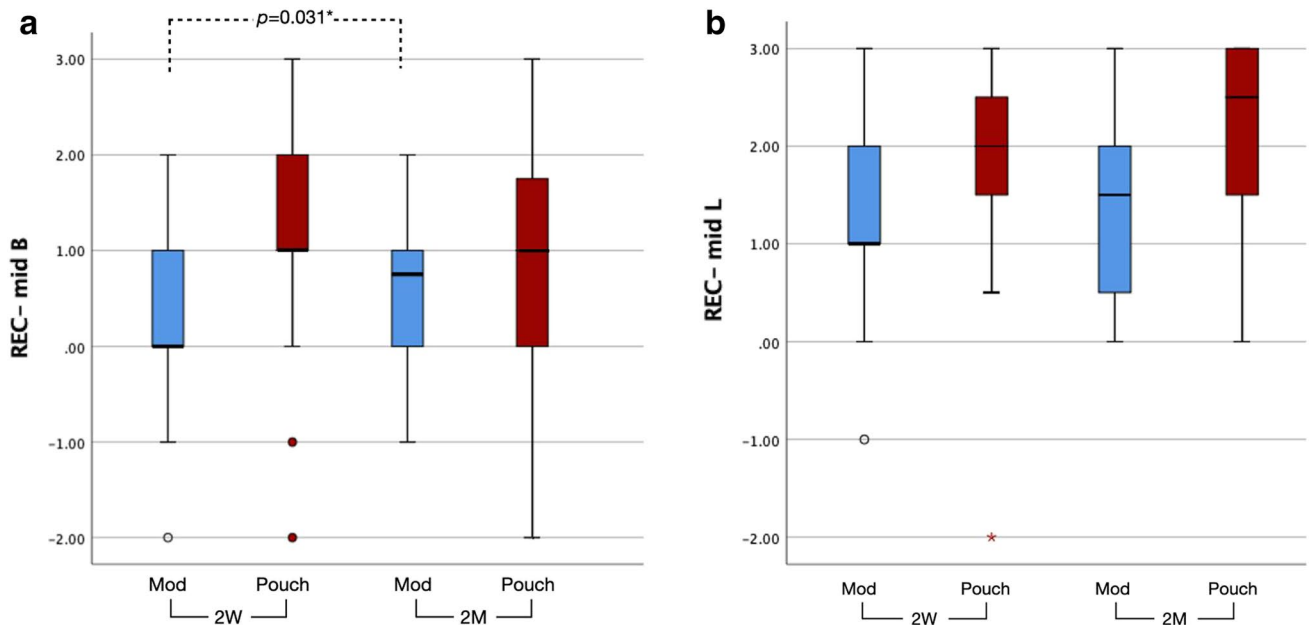
Fig. 6 The change of marginal mucosa at **a** mid-buccal and **b** mid-lingual sides in different surgical approaches from 2 weeks (W) to 12 months (M) after surgery. Abbreviation: REC, recession; Mod, modified roll technique; Pouch, pouch roll technique

Fig. 7 The change of keratinized mucosa at in different surgical approaches from initial to 12 months (M) after surgery. Abbreviation: KMW, keratinized mucosa width; Mod, modified roll technique; Pouch, pouch roll technique
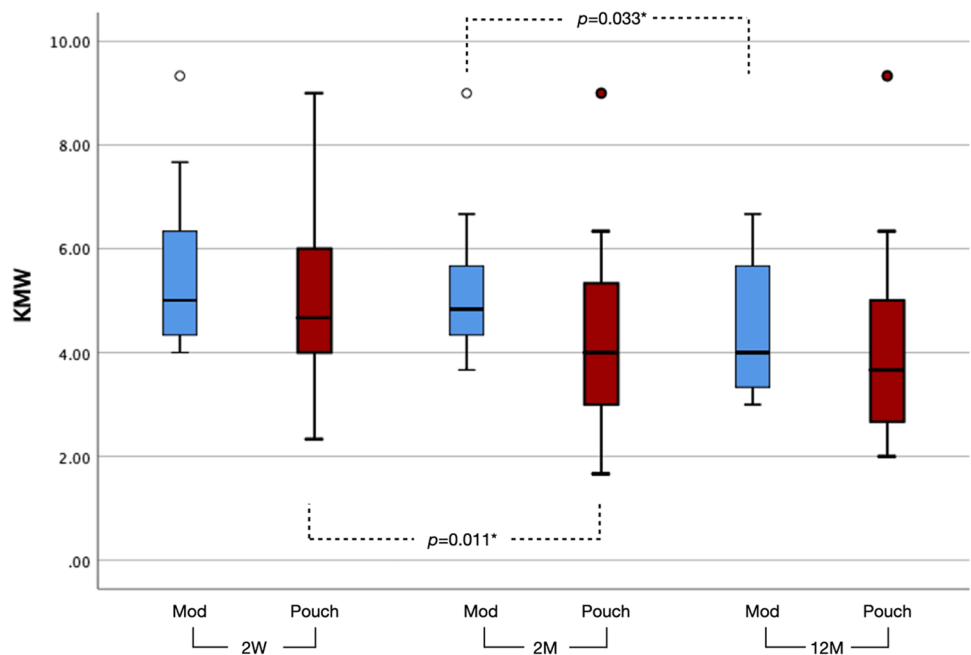
performed. This implied that soft tissue phenotype modification is beneficial for implant stability, which was in agreement with literature that demonstrated KMW ≥ 2 mm is an adequate amount needed to maintain long-term peri-implant health [8, 9, 29]. Furthermore, the amount of shrinkage was less than free autograft and substitute materials in related studies [30–33], which indicated both pouch roll and modified pouch roll techniques are good soft tissue phenotype modification procedures in terms of their tissue stability.

Our data also showed that factors that influence the outcomes of soft tissue phenotype modification are baseline REC and tissue phenotype (thin versus thick). Interestingly, our study found thicker mucosa tissue thickness had wider fluctuation of REC from 2 weeks to 2 months after surgery. Hence, it may imply that for implant prosthesis fabrication especially in esthetic demanding area, it should not be performed before 2 months to avoid potential soft tissue alterations. Besides, the correlations between REC

Table 2 The restorative design of implant in different surgical techniques

Restorative design	Modified roll technique	Pouch roll technique
Emergence profile: concave (m/day) (N)	5/3	7/5
Straight (m/day) (N)	7/8	5/5
Convex (m/day) (N)	6/7	3/5
Emergence angle mesial (°) (mean/SD)	20.44 (9.5)	**26.47 (7.51) ***
Emergence angle distal (°) (mean/SD)	11.58 (3.8)	22.85 (9.52)

*Statistically significant differences ($p < 0.05$) (Mann–Whitney U test)

N sample size, EP emergence profile, EA emergence angle, m mesial, d distal

2 weeks at disto-lingual, mesio-lingual areas were positively correlated to emergence angle at proximal sides (distal: $r = 0.389$, $p = 0.025$; mesial: $r = 0.366$, $p = 0.036$). The r value implied that initial REC prior to restoration could be one of the indicators but not the determinant factor, and several other factors could have impacts on emergence angle, such as the depth of implant placement, discrepancy from platform to crest of adjacent tooth, and the mucosal tunnel around implants [34]. In addition, the emergence angle in current study was evaluated from 2-dimensional images, which might genuinely weaken the impact of lingual flap to restoration design. Even though both soft tissue phenotype modification approaches could achieve similar outcomes, pouch roll technique might cause more REC because of the gap between the incision and actual implant position. Therefore, pouch roll technique probably was more suitable in single-implant cases since it can have less REC so a better restorative design can be fabricated.

Data obtained from this study showed that after soft tissue phenotype modification treatment, all implants had less than 3-mm PPD with absence of bleeding on probing, and this outcome further supports the benefit of this modification treatment. Furthermore, only limited (0.14 ~ 0.3 mm) MBL change was observed from baseline to 2 months suggesting soft tissue phenotype modification can minimize the amount of initial bone remodeling, by establishing the required supracrestal tissue height. It was not surprising to find bone level becomes stable from 2 to 12 months (with prosthesis in function) in this study. This phenomenon confirms that once the required supracrestal tissue height was formed, stable bone level could be anticipated overtime as long as patient complied with the recommended supportive peri-implant care.

Results from this study found that the intergroup difference did not exist beyond 2 months after surgery which illustrated that both treatment procedures are equally effective. According to Bassetti's article, soft tissue phenotype modification via various roll envelope flaps could enhance both KMW and mucosa tissue thickness [28]; however, in this specific review, no direct comparison was made among different roll techniques. It was worth noting that REC at mesio-lingual was positively correlated to emergence angle at mesial side, and pouch roll technique had almost 7° wider emergence angle at mesial side than the modified roll technique. The emergence angle around implants has been shown to influence the prosthesis contour design and potential MBL [27, 35, 36].

Several limitations do exist in this current study. Because of the nature of retrospective cohort study, it could inevitably weaken the quality of the evidence. Despite the fact that all included implants were with the same design from the same company (BIOMET 3i, Implant Innovations Inc., Palm Beach Gardens, FL, USA), a larger sample size with a longer follow-up is often desirable. Hence, continued documentation of the current study is also ongoing so the longer term of data will be available at a later time. Nonetheless, this was the first study investigating tissue alteration after different soft tissue phenotype modifications during early healing process, which shall provide a valuable information to the clinical practice. Furthermore, the reference of peri-implant mucosa was somehow altered following prosthesis placement, which could also have impacts on the values of PPD and REC. Therefore, future study with a volumetric analysis might minimize this concern by eliminating the drawback with superimposition images. Moreover, despite the debate of repetitive radiation exposure, 3-dimensional radiographic analysis might be essential to depict the panoramic view of peri-implant bone level change and restorative design. To eliminate the bias above, a prospective well-design randomized clinical trial with adequate subject number and long-term observations was required for further investigation.

Conclusions

With the limitations of this study, soft tissue phenotype modification at the time of implant uncovering surgery resulted in favorable clinical outcomes. Among all factors, thin mucosal tissue thickness and pouch roll technique are the factors related to more recession. Pouch roll technique could influence the restorative design by having a wide emergence angle at the mesial side.

Author contribution Cho-Ying Lin: concept/design, data collection/analysis/interpretation, drafting article, editing articles.

Pei-Yi Kuo: Data analysis/interpretation, statistics, drafting article.

Meng-Yao Chiu: data collection and analysis, drafting article.
Zhao-Zhao Chen: data analysis/interpretation, drafting article.
Hom-Lay Wang: data interpretation, drafting article, editing articles.

Declarations

Ethics approval and consent to participate This study was reviewed and approved by Chang Gung Medical Foundation Institutional Review Board (IRB No.: 202101533B0, 2021–08-27).

Informed consent Inform consent was approved and obtained from all participants in present study.

Conflict of interest The authors declare no competing interests.

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