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ORIGINAL ARTICLE

Facial mucosal level of single immediately placed implants with either immediate provisionalization or delayed restoration: An intermediate-term study

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Abstract

Background: Immediately placed single implants with either immediate provisionalization (test) or delayed restoration (control) were followed for up to 1 year in our previous randomized clinical trial. Peri-implant tissues continue to remodel after implants are in function. Therefore, the primary aim of this study was to evaluate the facial mucosal level changes in the intermediate term between the two groups and to study potential factors influencing the mucosal level change.

Methods: Patients who had already completed the previous clinical trial by receiving a single immediately placed implant were re-invited to this study. The facial mucosal level as well as the other peri-implant hard and soft tissue dimensions and conditions were measured clinically, radiographically and with ultrasound. These data were compared between the test and control implants. The mucosal level change as the function of the final crown contour, measured as the abutment-crown angle (ACA), was estimated with a linear regression model.

Results: Twenty-eight patients (n of test/control = 16/12) with a mean 30-month follow-up were recruited. The mean mucosal level change was -0.38 mm (control) and 0.06 mm (test), without statistical difference between the two groups. The other clinical, radiographic, and ultrasound parameters were not statistically different. ACA was statistically significant associated with the recession (P = 0.02). The estimate effect was 0.25 mm per 10° increase (adjusted R^2 = 0.18; 95% CI, 0.02 to 0.49 mm). After adjusting for vertical implant position, implant abutment angle and the group, the effect became borderline significant (P = 0.09).

Conclusions: Peri-implant tissues, including the mucosal level change of immediately placed implants with either immediate provisionalization or delayed restoration remained stable and did not differ between the groups in the intermediate term. The final crown angle, influenced by implant position and abutment angle, might be associated with mucosal margin level change.

KEYWORDS
cone-beam computed tomography, dental implants, esthetics, prostheses and implants, ultrasonography

1 | INTRODUCTION

The central goal of implant therapy has evolved from merely survival to functional and esthetic success. A widely applied method to evaluate implant esthetics is the White and Pink Esthetic Scores.[1] While the White Esthetic Score is pertinent to the shade, shape, and texture of the restoration, the Pink Esthetic Score assesses soft tissue harmony surrounding the examined implant(s). More specifically, the facial mucosal level, papillae height, mucosal color, contour, and texture in comparison with the adjacent tissues are evaluated. In the context of immediate implant placement (IIP), midfacial recession has been frequently observed as a potential esthetic complication.[2–7] It was summarized that IIP have a prevalence of mucosal recession for ≥1 mm between 8% and 40.5%.[2] Another systematic review showed advanced midfacial recession (≥1 mm) was described in up to 64% of the IIP cases.[8] In a recent study, IIP demonstrated inferior esthetic outcomes and a higher complication rate.[9] Nevertheless, IIP may be performed in strictly selected cases to shorten overall treatment time.

Although with various level of evidence, some case selection guidelines have been suggested for IIP to reduce soft tissue recession.[8] Patients with an intact facial bone wall and thick soft tissue phenotype may have a lower risk of advanced recession. Pre-existing facial bone dehiscence is commonly associated with recession.[2] Bone remodeling might be more unpredictable with partial loss of the facial plate at the time of IIP.[10,11] Thin soft tissue phenotype is more frequently correlated with recession, possibly due to its susceptibility to surgical trauma.[8] Therefore, soft tissue augmentation has been suggested as a means to reduce recession.[12]

Abutment and crown designs can also be a determinant to mucosal level stability and yet scarcely investigated. It was suggested that changing the level of the facial mucosal margin is possible through modifications in the facial contour of the implant abutment and crown, especially at the critical zone.[13] The abutment contour design might be based on facial-lingual implant position.[14] Depending on the implant location, the emergence angle may range from 15° in incisal position, 30° in cingulum position to 45° in palatal position.[15] The intricate relationships between the implant positioning and axis, abutment and crown contours, and the surrounding tissue characters determine the mucosal level and its stability overtime. In our previous study, we reported the 12-month mucosal margin change was not statistically different between the immediately placed implants immediately provisionalized, and those with delayed restoration.[16] Peri-implant tissues continue to remodel as the final crown is introduced and the implant starts to bear occlusal force. Therefore, the primary aim of this study was to compare the mucosal margin changes between the two cohorts in an intermediate term. The secondary aim was to compare the other clinical, radiographic, and ultrasound parameters between the two cohorts. The tertiary aim was to explore the association between the final crown contour and the mucosal margin level change.

2 | MATERIALS AND METHODS

This study was conducted at the Department of Periodontics and Oral Medicine, University of Michigan School of Dentistry, Ann Arbor, Michigan. The study was approved by the University of Michigan Institutional Review Board (IRB) under the number HUM00139630 and was conducted in accordance with the Helsinki Declaration of 1975, as revised in 2013. It was also registered with the National Institutes of Health US National Library of Medicine database for clinical trials (ClinicalTrials.gov) under the following identifier: NCT03558282. All participants signed a written consent form.

Figure 1 was a flowchart summarizing the study deign, sample size, and the measured parameters. The 38 participants were invited again for this study who completed a randomized clinical trial comparing the mucosal margin changes of single immediately placed implants between the immediate and delayed restoration groups.[16] To minimize selection and response bias, a random order was used to contact the patients. For details in the inclusion/exclusion criteria, please refer to the paper.

2.1 | Implant placement/restoration protocol

In the previously mentioned study, all patients received a single immediately placed implant.[*] These implants were

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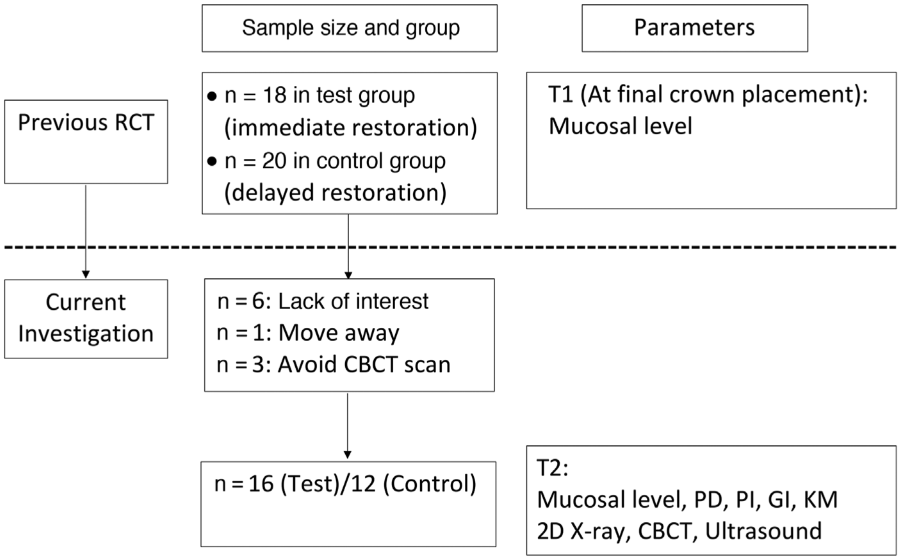

FIGURE 1 Flowchart summarizing the study design, sample size, and measured parameters

tapered, with an internal-connection, 0.5-mm smooth collar, length of 11.5 to 13 mm depending on the available ridge height, and diameter of 3.5, 4.0, or 4.5 mm determined according to the socket size and adjacent tooth location. All anterior and premolar implants were placed aiming at the cingulum position and central groove position, respectively. Vertically, implants were placed at ≈3 mm below the mucosal margin, and achieved primary stability of at least 30 N-cm. The gap between the implant and socket wall was filled with human cancellous particulate allograft.[†]¶

These implants were then assigned into one of the two groups: immediate temporization (test group) or temporary abutment (control group) with a simple randomization method. The test implants were restored immediately by a prosthodontist (FG) with a titanium temporary abutment and customized screw-retained provisional crown. For the control implants, an abutment with a size that is closest to the socket was placed, and a collagen dressing[‡] was used to cover the bone graft. An implant-level impression was performed in both groups at ≈4 months after the implant surgery by the same prosthodontist. The emergence profile of the provisional crowns on test implants was transferred, and the final ceramic crowns and titanium-based ceramic abutments were cemented. The abutment-crown margin was ≈1 mm apical to the mucosal margin.

2.2 | Dependent variable measurement

In the previous study,[16] the mucosal margin was measured clinically with 2.5× loupes by referencing to an imaginary line connecting the free gingival margins of the immediately adjacent teeth at the baseline final crown placement (T1) using a periodontal probe rounded to nearest 0.5-mm periodontal probe.[§] In this follow-up, one-visit study (T2), the mucosal margin was remeasured with the same method. The primary outcome was the amount of change between T1 and T2. A positive value meant apical migration of the mucosal margin and vice versa. Peri-implant probing depth (PD), gingival and plaque indices (GI and PI)[17] were measured at six sites at T2. Additionally, midfacial keratinized mucosa (KM) width (mm) was measured.[18] All parameters were rounded to nearest 0.5 mm using the same probe by the calibrated examiner (AB). A calibration method was performed to achieve consistent, unbiased clinical measurements between the examiner of the previous trial (HC) and the calibrated examiner of this study (AB). This was executed by initially having the two examiners (HC and AB) perform the clinical measurements until an agreement of 0.85 was achieved, after which a single examiner (AB) continued the measurements for the remaining patients.

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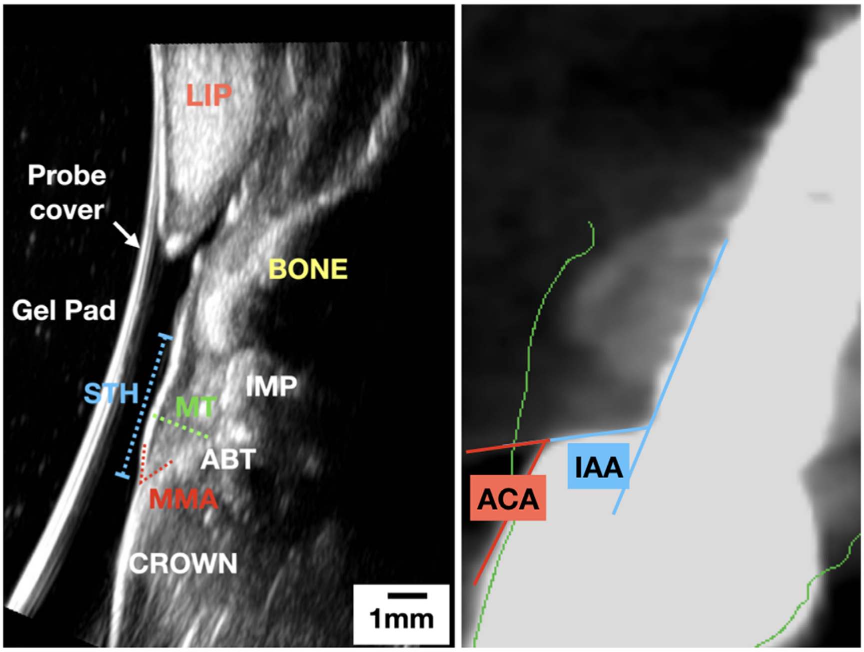

FIGURE 2 Two-dimensional, cross-sectional ultrasonographic image (right) corresponding to a cross-sectional CBCT and optical scan composite image (left) of a representative case. On the ultrasound image, mucosal thickness (MT) was measured at 2-mm apical to the mucosal margin. Soft tissue height (STH) was the vertical distance between the crestal bone and mucosal margin. On the composite image, the green line delineated the soft tissue and crown surface, derived from the optical scanning image. Abutment-crown angle (ACA) was the angle between the tangent line of the cervical 2 mm of the crown surface and the facial abutment surface line. Implant-abutment angle (IAA) was the angle between the surface lines of the implant and abutment. IMP, implant; ABT, abutment; MMA, mucosal marginal angle

2.3 | Peri-implant hard tissue assessment

A single CBCT scan was obtained at T2 with a scanner[**] with voxel size of 200 μm. Dental model scans were acquired using a laboratory optical scanner[††] and saved in in STL files. Subsequently, CBCT and optical scans were superimposed using automatic registration module on a commercially available software[‡‡] to improve visualization of the implant crown and soft tissue surface. A midfacial image across the long-axis of the studied implant was selected for the following measurements: the implant-abutment angle (IAA), abutment-crown angle (ACA), and crestal bone thickness (CBT). The IAA was defined as the outer angle (in degrees) corresponding to the junction between the surface of the implant and the abutment (Fig. 2). The ACA was defined as the outer angle (in degrees) corresponding to the junction between the surface of the abutment and the cervical 2 mm of the crown surface (Fig. 2). To evaluate the accuracy of CBCT on imaging ACA, the values derived from CBCT were compared with the known angles measured on the optical scans of seven temporary crowns from the enrolled patients who were in the test group in the previous clinical trial. The results showed CBCT was an acceptable method to measure ACA, with $R^2 = 0.83$ and a mean difference = 0.56 ± 3.72°. The CBT was measured in millimeters at the midfacial aspect of the implants 2.0-mm apical to the bone crest. In addition to 3D radiography, digital 2D radiographs using the parallel long-cone technique and the cone ring were obtained to evaluate mesial and distal marginal bone level. This level was defined as the vertical distance between the implant platform and the first implant–bone contact. The average mesial and distal interproximal marginal bone level was presented. The digitalized 2D and 3D radiographs of all patients were gathered in one database and were measured using commercially available software[§§] with a built-in, automatically calibrated caliper on a 27″ desktop monitor.

2.4 | Peri-implant soft tissue assessment

An ultrasound scan was taken at T2 for soft tissue evaluation. The US device comprised a custom-made ultrasound probe prototype[***] and an off-shelf scanner[†††] operating on the built-in software. A detailed description of the device was previously documented.[19–21] The implant, abutment, and crown surface were shown on ultrasound images as a bright white line, with hyperechoic shadows behind the line due to the reverberating effect. The shadows can be used as a functional feature for structure identification (Fig. 2). The resultant ultrasound scans were observed and interpreted via commercially available software[§§] on a 27″ desktop monitor. On representative ultrasound images, the following measures were made: 1) mucosal margin angle (MMA)—the angle between the external and

** 3D Accuitomo 170, J.Morita, Japan
†† 3-Shape, Warren, NJ
‡‡ Blue Sky Bio, Grayslake, IL
§§ Osirix MD, Pixmeo SARL, Bernex, Switzerland
*** L25-8, Mindray, Mountain View, CA
††† ZS-3, Mindray, Mountain View, CA

TABLE 1 Baseline (at the time of immediate implant placement) data related to patient information, facial socket features, and implant location

Category	Parameters (mean [SD])	Control	Test	*P*
Demographic data	Sample size (number)	7 M/5F	8 M/8 M	0.66
	Patient age (year)	66.17 (8.02)	63.07 (8.96)	0.35
	Implant location (number)	6A/6P	9A/7P	0.74
	Follow-up (month)	29.0 (4.0)	30.8 (4.6)	0.30
Facial socket features	Bone thickness (mm)	1.42 (0.86)	1.77 (1.93)	0.56
	Vertical bone dehiscence (mm)	0.58 (0.79)	1.00 (1.21)	0.31
	Bone dehiscence (No/Yes)	9/3	13/3	0.45
Implant location	Vertical implant location from the mucosal margin (mm)	3.38 (0.74)	2.69 (0.70)	0.02
	Vertical implant location from the midfacial bone (mm)	0.04 (1.21)	0.38 (1.26)	0.48
	Vertical implant location distribution (EC/SupC/SubC)	5/3/4	9/4/3	0.45
	Horizontal implant-facial plate gap (mm)	2.71 (0.40)	2.50 (0.75)	0.39

M, male; F, female; A, anterior; P, posterior; EC, equal crestal; SupC, supracrestal; SubC, subcrestal.
Most of the parameters were non-statistically significant, except for the vertical implant location.

sulcular wall of the mucosal margin; 2) mucosal thickness (MT) measured at 2 mm from the mucosal margin; and 3) soft tissue height (STH)—the vertical distance between the mucosal margin and the bone crest (Fig. 2).[22]

2.5 | Statistical analysis

2.5.1 | Sample size calculation

The analysis used the mucosal margin change (T2-T1) in millimeters as the outcome. To achieve 80% power and accept 0.05 type-1 error, to detect an effect size of 1 mm, 12 subjects in each group were required.[16]

Descriptive analysis, including the mean, SD, and range was used for the clinical, ultrasound, and radiographic measurements. These parameters were summarized for all patients and stratified by the study groups, that is, the test (immediate restoration) and the control (delayed restoration) groups. These parameters were compared between the two groups using the Mann-Whitney *U* test for continuous data and Chi-square test for non-continuous data. Since implant location, abutment angle, and crown angle might be correlated, a Spearman or Pearson correlation test was used, based on whether the parameters were normally distributed. A multiple regression model was estimated by treating the dependent variable, that is, mucosal margin change, as a continuous value. The independent variables included the group (immediate provisionalization and stock healing abutment placement), ACA (degrees), IAA (degrees), and vertical implant location (mm). The linear regression estimated beta coefficients and 95% CIs. Significance level used in analyses was set at 5% ($\alpha = 0.05$). Data analysis were performed by a masked biostatistician external to the primary investigators.

3 | RESULTS

3.1 | Demographic findings, extraction socket features, and implant location

Table 1 summarized the demographics and socket features at the time of IIP between the control and test groups. A total number of 28 patients (16 males and 12 females, mean age of 65.7 ± 8.5 years) were able to return. These included 16 test (8 males and 8 females) and 12 control (7 males and 5 females) patients. Ten patients declined the invitation due to lack of interest (n = 6), moving out of the state (n = 1), and avoidance of additional CBCT scan (n = 3). The mean follow-up time was 29.0 ± 4.0 and 30.8 ± 4.6 months for the control and test groups, respectively. The facial socket features, including the bone thickness, and the amount of dehiscence were not statistically different between the two groups. Regarding the vertical implant position, the control and test implants were placed at 3.38 ± 0.74 and 2.69 ± 0.7 mm, measured from the mucosal margin, with statistical difference between the two groups ($P = 0.02$). The distribution of implants placed equal-, supra-, and subcrestally between the control and test groups was not statistically different ($P = 0.45$). The mean horizontal implant-facial plate gap was 2.71 ± 0.4 and 2.50 ± 0.75 mm for the control and test implants ($P = 0.39$).

TABLE 2 Comparisons between the control (delayed restoration) and test (immediate restoration) groups

Category	Parameters (mean [SD])	Control	Test	*P*
Primary outcome	Mucosal margin change (mm)	−0.38 (0.64)	0.06 (1.18)	0.26
Restoration contours	Implant-abutment angle (IAA) (°)	44.66 (10.63)	51.92 (10.35)	0.10
	Abutment-crown angle (ACA) (°)	21.88 (8.72)	34.91 (8.69)	<0.01
Peri-implant hard tissue parameters	Interproximal marginal bone level from platform (mm)	1.09 (0.50)	1.26 (0.61)	0.42
	Midfacial bone level from platform (mm)	1.88 (0.61)	1.89 (1.02)	0.97
	Midfacial bone thickness (mm)	2.04 (0.92)	1.83 (1.04)	0.60
Peri-implant soft tissue parameters	MT (mm)	1.39 (0.38)	1.36 (0.70)	0.89
	STH (mm)	3.42 (0.64)	4.56 (2.22)	0.09
	MMA (°)	69.07 (21.75)	63.58 (26.44)	0.74
	PD (mm)	3.3 (0.7)	2.9 (0.4)	0.06
	GI	1.0 (0.6)	0.8 (0.4)	0.97
	PI	0.4 (0.4)	0.4 (0.6)	0.36
	KM (mm)	4.9 (1.0)	4.8 (1.2)	0.94

M, mucosal thickness; STH, soft tissue height; MMA, mucosal margin angle; PD, probing depth; GI, gingival index; PI, plaque index; KM, keratinized mucosa width.

Most parameters, including the mucosal margin change, were not statistically different between the two groups, except for the ACA.

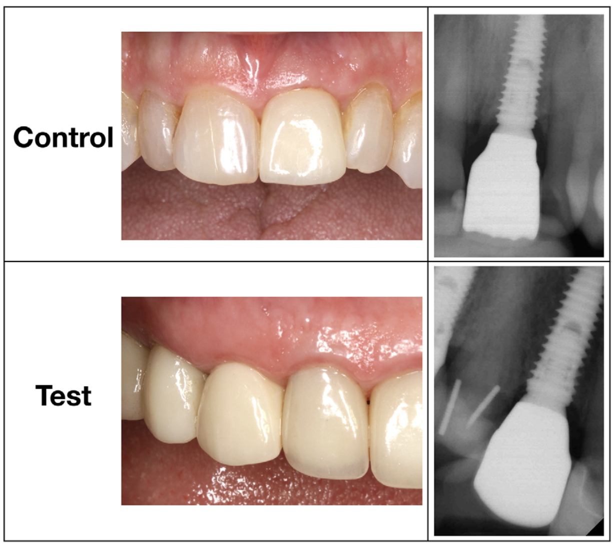

FIGURE 3 Two representative cases demonstrating clinical photos and radiographs. Peri-implant hard and soft tissues in both implants (#9 in the control and #6 in the test group) were stable

3.2 | Restoration and peri-implant hard- and soft-tissue characteristics

Table 2 summarized the restoration profiles and peri-implant tissue parameters. Figure 3 showed representative clinical photos in the control and test groups. The IAA was 44.66 ± 10.63° and 51.92 ± 10.35° for the control and test groups (*P* = 0.10); while the ACA was 21.88 ± 8.72° and 34.91 ± 8.69°, respectively with statistically significant difference between the two groups (*P* = 0.002). No correlation was found (r = 0.038, *P* = 0.86) between vertical implant location and ACA. Interproximal marginal bone level, midfacial bone level, and midfacial bone thickness were 1.09 ± 0.50, 1.88 ± 0.61, and 2.04 ± 0.92 mm in the control group. The respective data were 1.26 ± 0.61, 1.89 ± 1.02, and 1.83 ± 1.04 mm in the test group. These three peri-implant bone parameters were not statistically different between the two groups. Minimal mucosal margin change was noticed in the control (−0.38 ± 0.64 mm) and test (0.06 ± 1.18 mm) groups (*P* = 0.26). The mean MT was 1.39 ± 0.38 and 1.36 ± 0.70 mm for the control and test implants (*P* = 0.89). The mean STH was 3.42 ± 0.64 and 4.56 ± 2.22 mm, respectively (*P* = 0.09). The mean PD, PI, GI, and KM were also summarized in Table 2.

3.3 | Estimation of the mucosal margin change

The simple linear model showed ACA was statistically significant (*P* = 0.02), with the estimate effect of 0.025 mm (95% CI, 0.002 to 0.049 mm), accounting for 21% of the variation in mucosal recession amount. Each 10° increase in ACA estimated an additional 0.25 mm of recession. The model also showed ACA corresponding to an expected 0-mm recession was 28° (95% CI, 16.3° to 33.5°). However, after adjusting for IAA and implant vertical position, ACA became borderline significant (*P* = 0.09) (Table 3). A significant moderate correlation was found between ACA and IAA (r = 0.48, *P* = 0.015). Abutment angle statistically explained 23% of the variability in the crown angle.

JOURNAL OF Periodontology

TABLE 3 Results of the multiple regression for mucosal recession

Mucosal recession	B	95% CI for B LL	95% CI for B UL	SE B	β	R^2	$\triangle R^2$
Model						0.32	0.18
Constant	0.03	−1.91	1.98	0.93			
Group	0.05	−0.65	0.75	0.33	0.04		
ACA	0.03	−0.01	0.07	0.02	0.49		
Implant vertical position	−0.30	−0.74	0.14	0.21	−0.31		
IAA	−0.001	−0.03	0.03	0.01	−0.01		

B, unstandardized regression coefficient; CI, confidence interval; LL, lower limit; UL, upper limit; SE B, standard error of the coefficient; β, standardized coefficient; R^2, coefficient of determination; $\triangle R^2$, adjusted R^2.

4 | DISCUSSION

This observatory study primarily focused on mucosal margin changes of immediately placed implants either with immediate provisionalization or delayed restoration over a mean 30-month follow-up period. This mean change was -0.38 ± 0.64 mm and 0.06 ± 1.18 mm in the control and test implants, respectively without statistical difference (Table 2). As for the case distribution of the 28 cases, 12 patients had apical movement of the mucosal margin, of which four had ≥1 mm recession, equivalent to 14.29%. Three out of the four cases were in the test group. Due to small sample size, a correlation may not be drawn. On the other hand, eight patients had no change, and the other eight patients showed minor coronal movement of the mucosal margin. This intermediate-term outcome in general agreed with the literature.[4,23,24] The mean recession at 1 year was ≈0.3 mm in their strictly selected cohorts.[4,24] However, a systematic review showed a subset of patients developed clinically noticeable recession, resulting in esthetic complications that may require additional corrective procedures.[8] Another study[9] found an inferior esthetic outcome and higher complication incidence with the IIP group. Difference in surgical techniques (open flap and primary closure versus flapless and open wound healing) might have partially accounted for the contrasting outcomes. Since these procedures are technique sensitive, to optimize esthetic outcomes, recognition of risk factors and stringent case selection is extremely important.

The other peri-implant tissue parameters are not statistically different between the test and control implants, either. The interproximal bone level is ≈1 mm, measured from the implant platform; the facial bone level is ≈2 mm from the implant platform and the facial bone thickness is close to 2 mm for both groups (Table 2). These hard-tissue parameters largely agreed with the literature.[4,23,24] Midfacial soft tissue thickness is around 1.5 mm for both groups (Table 2). The mean midfacial STH is larger in the test group (4.56 versus 3.42 mm); however, this was because of the two implants with facial bone dehiscence in the test group (Table 2). Thin tissue phenotype has been indicated to have a strong predilection of mucosal recession.[3,7,8,24] However, this current study did not find a significant correlation between MT and the amount of recession ($P = 0.29$). It was possible this cohort already had relatively thick soft tissue (mean = 1.70 ± 0.78 mm with range 0.7 to 3.16 mm) (Table 2). Subsequent post-hoc analysis found the mean MT was <1 mm in patients with recession ≥1 mm (the recession group), compared with a mean of ≈2 mm in patients with <1 mm recession (non-recession group). The MMA was an alternative measure of soft tissue thickness. In the same post-hoc analysis, the mean angle of the recession group was almost one-half that of the non-recession group (38.78 ± 9.48° versus 72.01 ± 22.55). Clinically, additional connective tissue graft has been advocated along with IIP.[4,12,25] This procedure can increase tissue thickness, therefore, converting the thin tissue to more recession-resistant thick phenotype.

Two components in implant restoration that are essential in priming and manipulating peri-implant tissues, are the emergence profile of the abutment and cervical-third of the crown contour. It was suggested that a concave abutment enables superior soft tissue outcomes over a convex design because the former provides space for tissue ingrowth, which potentially increases tissue volume and stability.[14,15,26] Su and coworkers classified the implant abutment and crown contour into two zones that can be individually operated to condition and manipulate peri-implant soft tissue, namely the critical and subcritical contours.[13] While the subcritical zone provides the runway for soft tissue infiltration and maturation; the critical zone ultimately determines the soft tissue margin location. The angles of interest selected in our study were basically an amalgamation of both concepts. It is important to note both implant-abutment and abutment-crown angles are heavily influenced by the apico-coronal and facio-palatal implant position. Our preliminary results suggested the ACA was marginally associated with the amount of midfacial mucosa. Interestingly, ACA of the test group was statistically larger (34.91° ± 8.69° versus 21.88° ± 8.72°) (Table 2). It may reflect on the shallower placement in relationship to the mucosal margin in the test group (2.69 versus 3.38 mm). Shallower placement might have resulted in a larger ACA; however, when plotting the vertical implant location with ACA, no significant correlation was found. It is possible facio-lingual and axial positions may have a greater impact on ACA. The fact that ACA corresponding to an expected 0-mm recession was 24.9° indicated that recession is estimated to occur when ACA is more than ≈25°. Each 10° increase in ACA is estimated to increase recession by 0.25 mm. These preliminary results, if confirmed by studies with a larger sample size, may provide clinicians as well as dental laboratory technicians a reference to optimize the implant position and restoration designs so as to minimize the incidence of recession.

Limitations of this study include: 1) CBCT imaging artifacts that may interfere with the readings, 2) the small sample size, 3) intermediate-term follow-ups, and 4) single implant brand used. A recent study demonstrated the negative impact of CBCT imaging artifacts on peri-implant bone interpretation.[27] Optical scan images were superimposed with CBCT images to improve crown contour determination. Long-term follow-ups may reveal other risk factors, for example, bone remodeling/resorption that develops at a later stage. Some studies pointed to a prevalence of late esthetic complications.[4,23] Therefore, late-stage risks factors will be worth researching. Other implant designs may influence vertical implant position and the emergence profile, which in term might result in different outcomes.

5 | CONCLUSIONS

This study showed that the facial mucosal margin of immediately placement single implants was stable for a period of (mean) 30 months, whether or not with immediate provisionalization. The ACA of the final crowns significantly correlated with the amount of recession but became borderline significant after adjusting for IAA and vertical position. Because of smaller sample size and the exclusive use of one implant system under certain implant placement protocol, the results should be interpreted with caution.

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AUTHOR CONTRIBUTIONS

Dr. Ali Bushahri contributed to data analysis, data interpretation, article preparation, and final approval of the article. Dr. Oliver D. Kripfgans contributed to conception of the work, data interpretation, article preparation, and final approval of the article. Dr. Furat George contributed to data collection, data analysis, article preparation, and final approval of the article. Dr. I-Ching Wang contributed to data collection, data analysis, article preparation, and final approval of the article. Dr. Hom-Lay Wang contributed to data collection, article preparation, and final approval of the article. Dr. Hsun-Liang Chan contributed to conception of the work, data collection, analysis, interpretation, article preparation, and final approval of the article.

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