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Labial soft tissue contour dynamics following immediate implants and immediate provisionalization of single maxillary incisors: A 1-year prospective study

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Abstract

Background: Soft tissue dynamics in the esthetic zone are gaining increasing attention in recent years. Emerging intraoral scanning technology allows easier capture of soft tissue contours.

Purpose: To quantitatively assess the time-dependent contour alterations of labial soft tissue following single immediate implants and immediate provisionalization (IIPP) in maxillary incisors via intraoral scanning.

Materials and Methods: This was a prospective cohort study. Thirty eligible consecutive patients were included and received immediate replacement of a failure maxillary single incisor. A screw-retained immediate restoration was delivered for each patient. Subsequently, the anterior maxillary region was scanned by an intraoral scanning system at four time points: preoperation (baseline, BL), 3 months (3 m), 6 months (6 m), and 12 months (12 m). The Standard Tessellation Language files were exported to a dedicated software and superimposed for visual analysis. At 3, 6, and 12 months, the mid-facial mucosa level (ML) was assessed, and the precise three-dimensional (3D) configuration of the altered volume was calculated and reconstructed for visual analysis. Furthermore, quantitative analysis of the reconstructed morphology was performed using the following parameters: mean change in thickness ($\triangle d$), mesio-distal width (w), coronal-apical height (h), and horizontal and vertical position of the thickest point represented by coordinates (x, z).

Result: Twenty-seven of thirty enrolled patients were finally available for analysis at the 1-year follow-up. In general, the frontal view of the reconstructed volume exhibited a crescent shape. The mid-facial ML change at 3, 6, and 12 months was −0.05 ± 0.36 mm, −0.03 ± 0.32 mm, and −0.24 ± 0.37 mm, respectively (P = .012). The mean change in thickness at 3 months ($\triangle d_{3m}$), 6 months ($\triangle d_{6m}$), and 12 months ($\triangle d_{12m}$) was 0.50 ± 0.19 mm, 0.59 ± 0.21 mm, and 0.62 ± 0.22 mm, respectively (P <.001). At 12 months, nine patients had a $\triangle d$ less than 0.5 mm. The mean $\triangle d_{3\,m}/\triangle d_{12\,m}$ and $\triangle d_{6\,m}/\triangle d_{12\,m}$ was 0.81 ± 0.17 and 0.96 ± 0.13. The w, h, x, and z results showed no significant differences during the 1-year observation (P = .126, P = .324,

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P = .635, P = .263). At 12 months, w, h, x, and z were 11.57 ± 1.77 mm, 6.46 ± 2.01 mm, 0.03 ± 1.43 mm, and 2.16 ± 0.65 mm, respectively.

Conclusion: During the 1-year observation following single IIPP treatment in maxillary incisors, the labial soft tissue contour showed a continuous alteration resulting in a mean change in thickness of 0.62 mm that occurred mainly in the first 3 months and tended to be relatively stable after 6 months, while the crescent-like shape, width, height, and thickest point position of the alteration volume remained stable after 3 months. No advanced mid-facial recession was observed.

KEYWORDS

esthetic zone, immediate implant, immediate provisionalization, intraoral scan, single tooth, soft tissue alteration, volumetric evaluation

1 | INTRODUCTION

Immediate implant placement and provisionalization (IIPP) at the postextraction site in the esthetic zone has been shown to be a reliable therapy for patients and offers a reduced treatment time, high implant survival rate,[1,2] and long-term stability of marginal bone.[3-5] The esthetic outcome of IIPP is dependent on the soft tissue contour.[6-9] Although many surgical and prosthetic techniques have been proposed to reduce the alteration of the facial soft tissue contour,[4,10,11] it cannot be avoided completely,[3,12] causing the potential risk of suboptimal esthetic outcomes.[14] Therefore, it would be of significant clinical benefit to acquire a three-dimensional (3D) perspective of the soft tissue contour, as well as to provide insights regarding the dynamic change mode of the soft tissue contour at different time points following IIPP.

Until now, to the best of our knowledge, only two studies conducted by the same research group have provided time-dependent evidence of soft tissue contour alterations following IIPP.[6,8] The Pink Esthetic Scores (PES) results indicated a continuous soft tissue contour change from the healing period to years of functional loading. Nevertheless, due to the accuracy and objectivity limitations of the evaluation method,[15] the 3D alteration mode has remained unknown. Emerging intraoral scanning technology allows easier and noninvasive capture of 3D data for the soft tissue contour free of radiation and model casting.[16] Additionally, dedicated 3D analysis software provides an overall perspective and enables volumetric assessment of the data.

The objective of this study was to compare soft tissue alterations among follow-ups after single IIPP in the maxillary incisor by reconstructing the 3D configuration of the altered soft tissue contour captured by intraoral scan.

2 | MATERIALS AND METHODS

2.1 | Patients enrollment protocol

This was a prospective study conducted from January 2016 to June 2018 at Peking University School and Hospital of Stomatology, Department of Implantology. Thirty consecutive patients diagnosed with a single failure maxillary incisor were screened. The inclusion and exclusion criteria were as follows:

Inclusion criteria:

- At least 18 years of age;
- Single tooth failure of a maxillary anterior incisor (12-22) with neighboring teeth present and healthy periodontal conditions;
- Intact buccal bone wall at the time of tooth extraction;
- Adequate bone height apical to the alveolus of the failing tooth (≥5 mm) to ensure an insertion torque of at least 35 N·cm;
- Good treatment compliance.

Exclusion criteria:

- Systemic diseases;
- Gestation period;
- Poor local conditions (parafunctional habits: bruxism, clenching, smoking, poor oral hygiene);
- Presence of active infection (pus, fistula) around the failing tooth;
- A thin-scalloped gingival biotype (determined by the transparency of the periodontal probe through the gingival margin while probing the buccal sulcus of the upper central incisors[17]);
- Undergoing orthodontic treatment.

The study was conducted in accordance with the Helsinki declaration of 1975 as revised in 2000. The study protocol was approved by the local ethical committee (Institutional Review Board of Peking University School and Hospital of Stomatology, Approval Number: PKUSSIRB-201416075). Informed consent was signed after a comprehensive consultation.

2.2 | Surgical and prosthetic procedures

Stringent surgical and prosthetic protocols were followed. The surgical procedures were performed by two experienced surgeons (Lin and Jiang). All implant surgeries were preceded by prophylactic antibiotic therapy (cefuroxime 0.25 g, 1 hour before surgery) and oral disinfection (0.2% chlorhexidine solution for 1 minute). After administration of a local infiltration anesthesia with Primacaine Arenaline (1.7 mL, Produits Dentaires Pierre Rolland, Acteon Pharma Division, Merignac, France), atraumatic flapless tooth extraction was performed Figure 1A-C. The socket was thoroughly debrided and irrigated with sterile saline. The integrity of the buccal bone wall was checked meticulously by intrasocket probing. An osteotomy was made with a palatal bias for placement of the implant. Immediate implant placement (Nobel Active, Nobel Biocare, Göteborg, Sweden; CAMLOG SCREW-LINE, Camlog Biotechnologies AG, Basel, Switzerland) was performed according to the individual anatomical conditions Figure 1D. The implant shoulder was placed 3 mm apical to the cement-enamel junction of the adjacent teeth with an insertion torque ≥35 N·cm. An appropriate healing abutment was applied. Deproteinized bovine bone particles (Bio-Oss 0.25-1 mm, Geistlish Biomaterials, Wolhusen, Switzerland) were inserted to fill the gap between the implant and the buccal bone wall. The gap above the implant shoulder was filled with collagenous bone substitute (Bio-Oss Collagen, Geistlish Biomaterials). Patients were placed on postsurgical antibiotic therapy, and an analgesic as needed.

Screw-retained provisional restorations were fabricated either digitally or manually in the dental laboratory by one experienced technician and installed ~3 hours later Figure 1E-F. All patients underwent oral hygiene instruction afterward. The definitive restoration was delivered 6 months thereafter. The prosthetic procedures were performed by two experienced prosthodontists who were not involved in the study. All immediate and permanent restorations were fabricated by the same technician.

2.3 | Reconstruction of the altered volume of the facial soft tissue contour

2.3.1 | Intraoral scan

An experienced operator used an intraoral scanner (3Shape Trios, 3Shape, Denmark; software version: 2014-1) to obtain a digital impression at the preoperation (baseline, BL), 3 months (3 m), 6 months (6 m, before delivery of the definitive restoration), and 12 months (12 m, with the definitive restoration), following the same scanning strategy Figure 1G-L. To ensure accuracy, the scan region was restricted to a relatively short span in the anterior maxillary region (from canine to canine; Figure 2A,B).

2.3.2 | Digital model alignment

The Standard Tessellation Language (STL) files were exported to image analysis software (Geomagic Qualify 12; 3D Systems, Rock Hill, South Carolina). For each patient, STL data at 3, 6, and 12 months were superimposed with the respective baseline STL data. To achieve an adequate superimposition of two selected digital models, similar areas of the adjacent teeth were marked manually, as commonly used in a previous report as the reference surface according to the "best-fit alignment" algorithm[18] (Figure 2C,D).

2.3.3 | Coordinate system construction

After superimposition of four digital models, the coordinate system was constructed in the software (Figure 3A,B). The facial gingiva zenith of the implant site at baseline was identified as the origin of the coordinates (Point O). In the 12-month model, the horizontal line passed along the tangential line of the outermost incisal edge (Point A and B) of the two maxillary central incisors. The *x*-axis was parallel to the horizontal line at point O, from mesial to distal. The most coronal point of the papilla between the two maxillary central incisors, in other words, the papilla tip in the 12-month model, was marked as Point C. The frontal plane was identified by the *x*-axis and Point C. In the frontal plane, the *z*-axis was identified perpendicular to the *x*-axis at the origin, from coronal to apical. The *y*-axis was determined perpendicular to the frontal plane at Point O, from labial to palatal. Thus, the *x*-*y*-*z* coordinate system was constructed, and the *x*-*y*, *y*-*z*, and *x*-*z* planes represented the horizontal, sagittal and frontal planes, respectively.

2.3.4 | Reconstruction of the 3D morphology of facial contour alterations

Step 1: Perform a 3D comparison of the postoperation model and baseline model pairwise (Figure 2E). To specify the highest positive and negative deviation, the *Minimal Nominal Value* and *Maximal Nominal Value* (two options in the software) were set as −150 μm and +150 μm, respectively, indicating that a difference within ±150 μm would be displayed as green in the colored spectrum.

Step 2: Superimpose the spectrum of the 3D comparison result with two aligned models, respectively. The nongreen altered surface was marginated manually according to the spectrum, erasing the green part, frenum, and mucosa near the vestibular groove (Figure 2F,G).

Step 3: Enclosure the space between the two aimed surfaces by filling the marginal gap (Figure 2H-J). Thus, the altered volume was constructed.

2.4 | 3D analysis of soft tissue alterations

2.4.1 | Measurement at the mid-facial mucosal level

At implant sites, the baseline mid-facial mucosal level (ML_0) was identified by the *z* coordinate value (z_{i0}) of the gingival zenith minus the *z* coordinate (z_{t0}) of the gingival zenith of the contralateral tooth (Figure 3). In the same way, the mid-facial mucosa level (ML) at 3 months ($ML_{3\,m}$), 6 months ($ML_{6\,m}$), and 12 months ($ML_{12\,m}$) was calculated. A positive value of ML represented a gingival level of the implant site that was apical to the contralateral tooth. When ML was equal to zero, good symmetry of the midfacial ML was achieved.

$ML_0 = z_{i0} - z_{t0}$, $ML_{3m} = z_{i3m} - z_{t3m}$, $ML_{6m} = z_{i6m} - z_{t6m}$, $ML_{12\,m} = z_{i12m} - z_{t12m}$

The mid-facial mucosal level alteration was represented by $\triangle ML$ based on ML_0. A positive value of $\triangle ML$ represented the occurrence of mid-facial recession. In contrast, a negative value of $\triangle ML$ represented an overgrowth or hyperplasia of the midfacial gingiva.

$\triangle ML_{3m} = ML_{3m} - ML_0$, $\triangle ML_{6m} = ML_{6m} - ML_0$, $\triangle ML_{12m} = ML_{12m} - ML_0$ (Figure 3D)

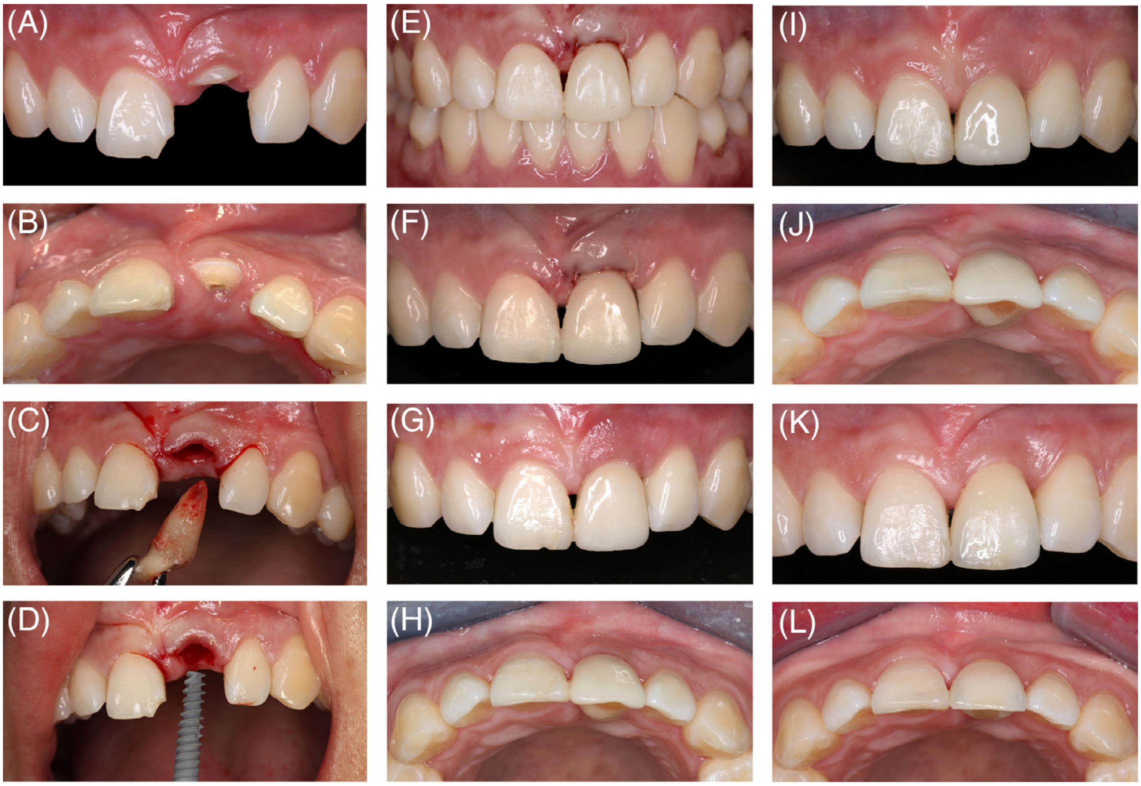

FIGURE 1 Surgical and prosthetic protocol. (A,B) Facial and occlusal view of a failure central incisor. (C,D) Atraumatic tooth extraction and immediate implant placement. (E,F) Immediate provisionalization with a screw-retained restoration. Facial and occlusal view at 3 months (G,H), 6 months (I,J), and 12 months (K,L)

In addition, the mid-facial mucosal level alteration from BL to 12 months at contralateral tooth ($\triangle ML_t$) was also measured.

2.4.2 | Visual analysis of facial contour alterations

Visual analysis was performed. The morphology of the reconstructed volumes was observed with the documented common characteristics.

2.4.3 | Quantitative 3D analysis of facial contour alterations

For each patient, the reconstructed volume ($\triangle V$) was calculated, and the mean areas of the two surfaces were also calculated ($\triangle S$). To allow a direct comparison of different sites at different time points, a variable, $\triangle d$, was calculated, which represented the mean thickness of the reconstructed volume.[19]

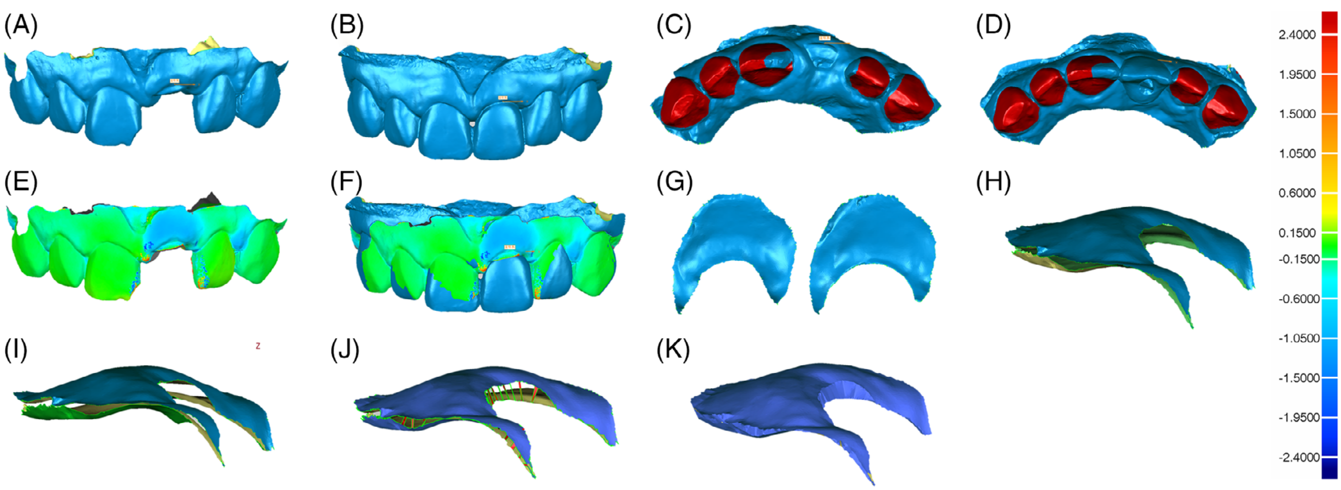

FIGURE 2 Illustration showing the reconstruction of the 3D morphology of the altered volume. A, Baseline digital model. B, digital model at follow-ups. C–D, manual selection of similar surfaces (reddish part) of the teeth to align the two models. E, spectrum showing the 3D comparison results for the two models. F, superimposition of the spectrum and the two aligned models. G, trim of the models according to the 3D comparison result. H–J, enclosure the space between the two aimed surfaces by filling the marginal gap

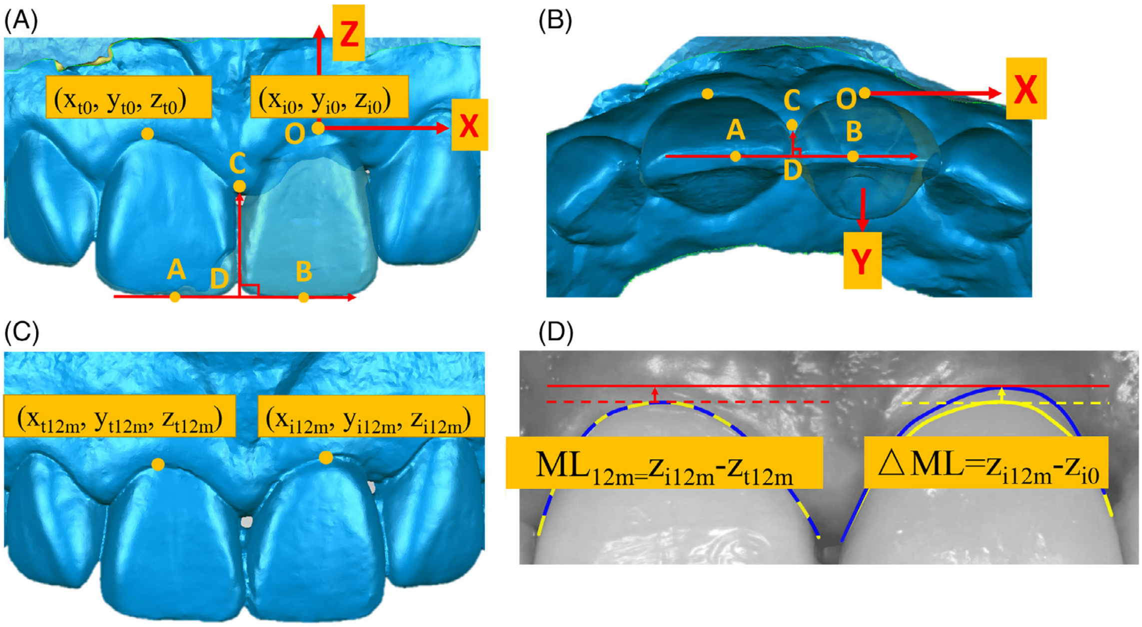

FIGURE 3 Coordinate system building. (A,B) O: the origin of the coordinates, facial gingival zenith of the implant site at preoperation; Point A and B: the outermost incisal edge of the two maxillary central incisors in the 12-month model; *x*-axis parallel to line AB, from mesial to distal; Point C, the most coronal point of the papilla in the 12-month model between the two maxillary central incisors; *z*-axis, perpendicular to the *x*-axis at the origin in the frontal plane, from coronal to apical; *y*-axis, perpendicular to the frontal plane at point O, from labial to palatal, (C) at each follow-up model, the gingival zenith of the implant site and contralateral tooth were marked with their calculated coordinates for the (D) mid-facial mucosal level at each follow-up

$\triangle d$ (mm) = $\triangle V$ (mm^3)/$\triangle S$ (mm^2)

The $\triangle d_{3\,m}/\triangle d_{12\,m}$ and $\triangle d_{6\,m}/\triangle d_{12\,m}$ ratio were calculated. Furthermore, frequency statistics of $\triangle d$ were performed using three scales: 0-0.5 mm, 0.5-1 mm, and >1 mm.

In addition, four dimensional parameters were measured: *w*, *h*, *x*, and *z*, at 3, 6, and 12 months. *w*, the width of the altered volume, was the maximal mesio-distal distance projected in the frontal plane. *h*, the height of the reconstructed volume, was identified by the vertical distance from the gingival zenith to its apical boundary projected in the frontal plane. The thickest point was also noted as point P in the spectrum, and its coordinate was read as (x_P, z_P). The absolute value of *x* and *z* represented the horizontal and vertical distance from the thickest point to the gingival zenith.

2.5 | Clinical assessment

2.5.1 | Periodontal health

At 3, 6, and 12 months, the plaque scores of the implant restoration and its adjacent tooth were documented. A dichotomous score was given (0 = no visible plaque at the soft tissue margin; 1 = visible plaque at the soft tissue margin) at four sites (mesial, midfacial, distal, and palatal).

At 12 months, the peri-implant health of the implant restoration was evaluated by the probing depth (PD) and bleeding on probing (BOP) at mesial, midfacial, distal, and palatal sites using a manual probe (CP 15 UNC, Hu-Friedy, Chicago, Illinois). PD was measured to the nearest 0.5 mm, and BOP was measured by a dichotomous score (0 for no bleeding; 1 for bleeding)

2.5.2 | Implant survival and complications

At 3, 6, and 12 months, implant survival and complications of patients were recorded. The latter included biologic (abscess and fistula) technical (loosening of the screw and fracture of components) aspects.

2.6 | Statistical analysis

Straightforward descriptive statistics were used to present the soft tissue contour changes at 3, 6, and 12 months. Parameters that changed over time were evaluated by the Friedman test. Parameters that showed significant time effects were subsequently analyzed using Wilcoxon signed-rank tests to compare time points in a pairwise manner. The significance level with no corrections was set at .05.

3 | RESULTS

3.1 | Patients and implants

Details regarding patient characteristics at baseline are shown in Table 1. Overall, three patients were excluded. One implant in one patient was excluded for early infection around the apex of the implant without loosening of the implant 2 weeks after the surgery, and abscess incision and drainage were performed. Another patient was

TABLE 1 Characteristics of patients and implants at baseline

Male/female ratio	Age in years Mean ± SD (range)	Implant site location I_1/I_2	Types of implants NA/C
14/16	34.6 ± 12.0 (20, 66)	27/3	18/12

Abbreviations: C, Camlog; I_1, central incisor; I_2, lateral incisor; NA, noble active.

excluded for orthodontic treatment during the treatment that made it impossible to superimpose the model. The other one patient dropped out at 6 months due to unwillingness to return. Thus, 27 implants in 27 patients (14 females and 13 males) with a mean age of 34.6 years (range from 20 to 66 years) were available for the final analysis.

3.2 | 3D analysis results

The results for the measured parameters at each follow-up are displayed in Table 2 and Figure 5.

3.2.1 | Mid-facial mucosal level

The ML_0 was −0.26 ± 0.41(−0.88, 0.54) mm. A significant difference was found among $ML_{3\ m}$, $ML_{6\ m}$ and $ML_{12\ m}$ (P = .012). The post hoc

TABLE 2 3D measurements of the reconstructed volume at each follow-up and patient distribution of $\triangle d$

Parameters	3 months	6 months	12 months	*P* value
ML (mm)	0.05 ± 0.36 (−0.45, 0.51)[a]	0.02 ± 0.32 (−0.36, 0.54)	0.24 ± 0.37 (−0.25, 0.72)	.012
△ML (mm)	0.31 ± 0.43 (−0.26, 0.85)	0.30 ± 0.41 (−0.15, 0.90)	0.51 ± 0.45 (−0.10, 1.23)	.019
△*d* (mm)	0.50 ± 0.19 (0.15, 0.92)	0.59 ± 0.21 (0.34, 1.21)	0.62 ± 0.22 (0.40, 1.20)	<.001
△*d* ≤ 0.5 mm	15 (55.6%)[b]	10 (37.0%)	9 (33.3%)	–
0.5 mm < △*d* ≤ 1 mm	12 (44.4%)	15 (55.6%)	15 (55.6%)	–
△*d* > 1 mm	0	2 (7.41%)	3 (11.1%)	–
w (mm)	11.38 ± 1.84 (8.41, 14.83)	11.60 ± 1.82 (8.5, 14.83)	11.57 ± 1.77 (8.52, 14.81)	.126
h (mm)	6.42 ± 2.05 (3.62, 8.72)	6.45 ± 2.01 (3.61, 8,72)	6.46 ± 2.01 (3.65, 8.74)	.324
x (mm)	0.03 ± 1.42 (−2.03, 2.62)	0.03 ± 1.43 (−2.04, 2,62)	0.03 ± 1.43 (−2.04, 2.62)	.635
z (mm)	2.28 ± 0.69 (1.09, 3.74)	2.29 ± 0.68 (1.09, 3.72)	2.29 ± 0.69 (1.09, 3.72)	.263

[a]Mean ± standard deviation (minimum, maximum).
[b]Patient number: N (proportion %).

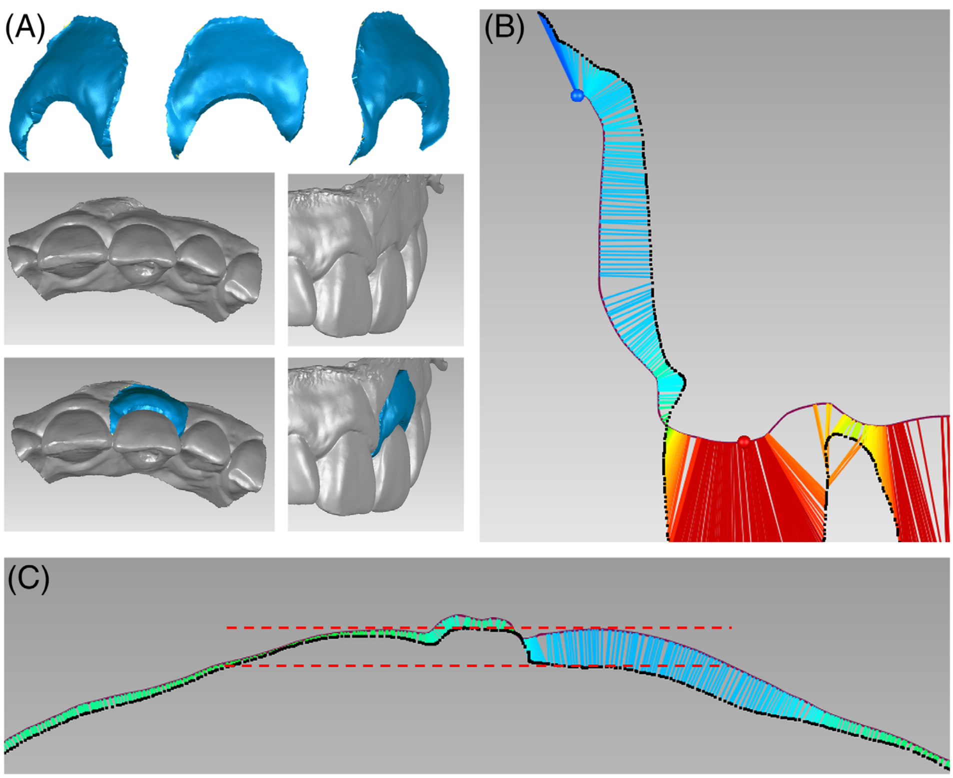

FIGURE 4 A, 3D morphology of the reconstructed volume. B, sagittal view. C, horizontal view 2 mm above the gingival zenith

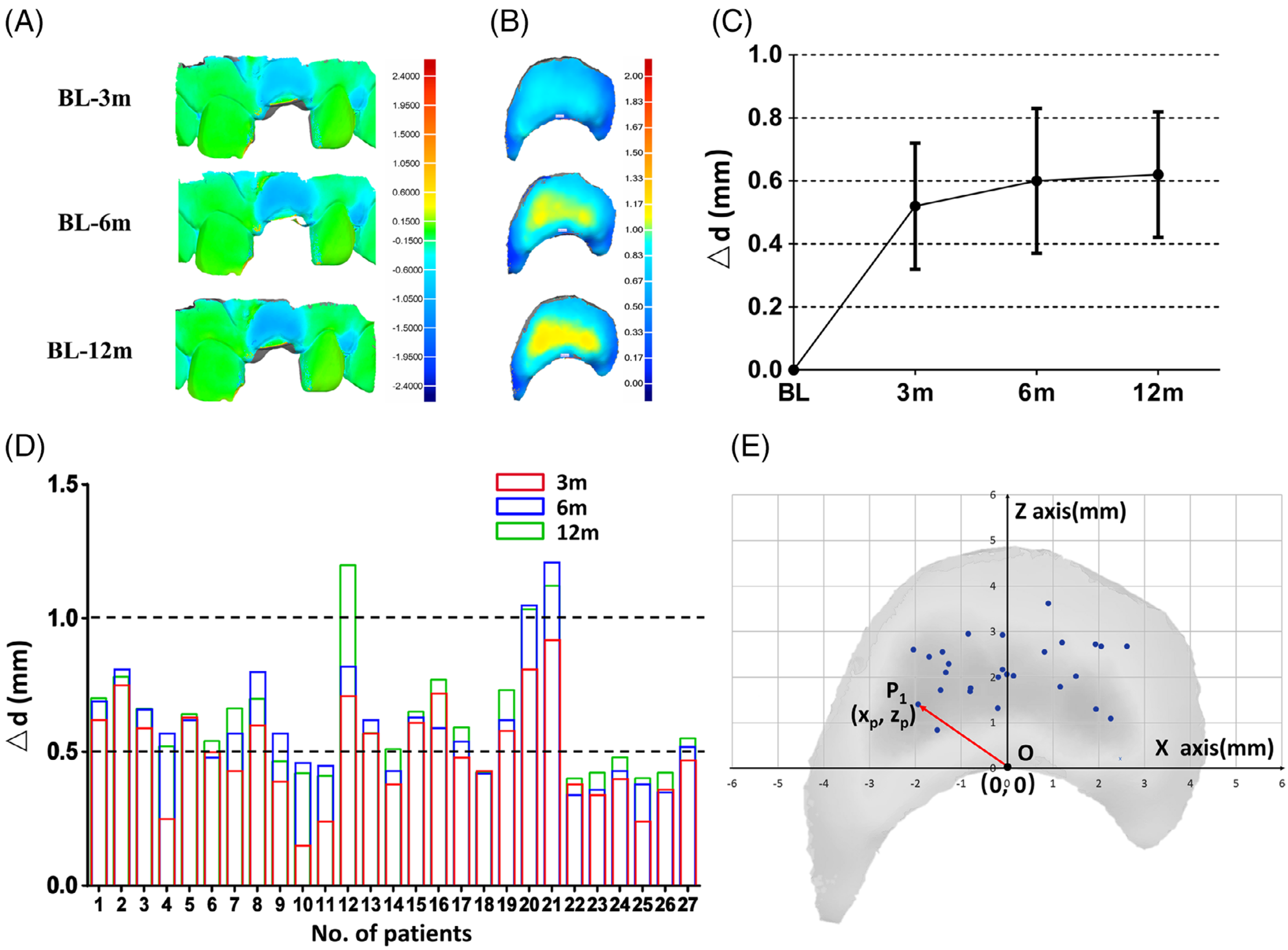

FIGURE 5 A, Illustration showing the 3D comparison results of the contour change at 3, 6, and 12 months. B, 3D measurements of the reconstructed volume at 3, 6, and 12 months. The color ranging from blue to yellow represents different sizes of volume decrease. A continuous contour change was observed in the central area over 12 months, while the peripheral area remained relatively stable after 3 months. C, Mean $\triangle d$ from baseline to 12 months. D, The $\triangle d$ for each patient at different time points. Histograms were superimposed to intuitively compare the contour change over time. E, Annotation of the thickest points (Point P) for all 27 patients at 12 months. As an example, point P1 represents the point of the greatest change in one patient

test showed a significant difference between $ML_{3\,m}$ and $ML_{12\,m}$ (P = .003), as well as between $ML_{6\,m}$ and $ML_{12\,m}$ (P = .003), while $ML_{3\,m}$ and $ML_{6\,m}$ did not differ significantly (P = .663).

$\triangle ML_{3\,m}$, $\triangle ML_{6\,m}$, and $\triangle ML_{12\,m}$ showed a significant difference (P = .019). The posthoc test showed a significant difference between $\triangle ML_{3\,m}$ and $\triangle ML_{12\,m}$ (P = .005), as well as between $ML_{6\,m}$ and $ML_{12\,m}$ (P = .005), while $\triangle ML_{3\,m}$ and $\triangle ML_{6\,m}$ had no significant difference (P = 0.674). The $\triangle ML_t$ was 0.02 ± 0.05 (−0.05, 0.12) mm.

3.2.2 | Visual analysis of the reconstructed volume

A mild collapse in facial soft tissue contour was observed in all patients during the 12-month follow-up. In general, the reconstructed volume exhibited a crescent-like shape (Figure 4A), and the thickness was not uniform in both mesio-distal and coronal-apical directions. It was thicker in the center than the periphery (Figure 4B,C).

3.2.3 | Time-dependent contour alterations

The values of $\triangle d_{3\,m}$, $\triangle d_{6\,m}$, and $\triangle d_{12\,m}$ showed statistically significant differences (P<.001). Subsequently, $\triangle d_{3\,m}$ and $\triangle d_{12\,m}$, $\triangle d_{3\,m}$ and $\triangle d_{6\,m}$ showed statistically significant differences (P < .001), while $\triangle d_{6\,m}$ and $\triangle d_{12\,m}$ showed no statistically significant difference (P = .166). The values of $\triangle d_{3\,m}/\triangle d_{12\,m}$ and $\triangle d_{6\,m}/\triangle d_{12\,m}$ were 0.81 ± 0.16 and 0.96 ± 0.13, respectively. w, h, x, and z showed no statistically significant difference among follow-ups (P = .124, P = .324, P = .635, and P = .263, respectively).

3.3 | Clinical assessment

3.3.1 | Implant survival rate and complications

During the follow-up period, the overall implant survival rate was 100%. Screw loosening occurred in 6 patients and was easily resolved by repeated tightening without further consequences. No other

TABLE 3 Peri-implant health results

Parameters	3 months	6 months	12 months	*P* value
Plaque score at implant site	0.18 ± 0.13[a]	0.17 ± 0.13	0.17 ± 0.13	.627
Plaque score at adjacent teeth	0.17 ± 0.13	0.16 ± 0.11	0.17 ± 0.12	.619
BOP	/	/	0.26 ± 0.19	/
PD (mm)	/	/	3.10 ± 1.12	/

[a]Mean ± standard deviation.

complications occurred. One patient refused delivery of the definitive restoration at 6 months because he was quite satisfied with the provisional crown.

3.3.2 | Periodontal health

For implants and adjacent teeth, the mean plaque levels showed no statistically significant differences (*P* = .627, *P* = .619; Table 3).

4 | DISCUSSION

Intraoral scanning is now becoming a preferable method to directly obtain 3D data for the peri-implant soft tissue. The accuracy has been reported to be adequate to perform dimensional analysis.[16,20-22] In the present study, labial soft tissue dynamics following IIPP treatment were documented and investigated for the first time via intraoral scanning and subsequent 3D analysis. The results contribute to clarification of the merit of immediate implant placement and provisionalization of the maxillary single incisor. The most important finding was that the labial soft tissue contour and the mid-facial ML showed a continuous change within a 1-year period, while the shape, width, height, and thickest point of the alteration volume remained relatively stable after 3 months.

After immediate implant placement, structural changes of the soft tissue contour are ongoing and cannot be completely avoided.[12,13,23] The reasons are manifold, but chief among them may be physiological resorption of the underlying facial bundle bone wall in the healing period after extraction.[24,25] Regarding the use of immediate implant alone, two randomized clinical trials reported outcomes for crestal bone and showed a horizontal width loss of −1.10 mm (CI = −1.28 to −0.92)[26] and −1.10 mm (CI = −1.30 to −0.90),[13] respectively. However, several treatment modalities have been proposed to ameliorate such resorption. First, it has been well validated that bone grafting in the jumping gap considerably limits the amount of horizontal soft tissue alterations compared with leaving it untreated. Cardaropoli et al[27] reported a horizontal contour change of 0.69 ± 0.68 mm at 12 months after immediate implants combined with bone substitute plus a collagen membrane, in comparison to 1.92 ± 1.02 mm without grafting. Arora and Ivanovski also reported a horizontal contour change of 0.56 ± 0.48 mm at 12 months using a similar surgical protocol.[28] In addition, the flapless approach and immediate provisionalization have also been recommended to minimize the amount of ridge contour change.[10] It is noteworthy that most of the previous studies included canines and first premolars, but the present study focused on maxillary incisors (24/27 were central incisors), which tend to be more susceptible to contour change than other areas.[29] Our results for the horizontal dimensional changes in the soft tissue (0.62 ± 0.22 mm) are concurrent with or even slightly superior to those reported in previous studies. The possible reason for this difference might be the stringent treatment protocol of the present study utilizing flapless tooth extraction with bone substitute in the jumping gap plus immediate provisionalization, benefiting the preservation of the peri-implant tissue.

The soft tissue contour alterations over time are shown in Table 2. Based on our results, the soft tissue contour yielded major alterations in the first 3 months ($\triangle d_{3\ m}/\triangle d_{12\ m}$ was 81%, on average) and tended to be relatively stable after 6 months ($\triangle d_{6\ m}/\triangle d_{12\ m}$ was 96%, on average). Several studies of type 1 implant placement have also reported that the greatest dimensional change of soft tissue occurs within the first 3 months of surgery.[30-32] In contrast, Cosyn et al reported that the mid-facial contour and alveolar process deficiency deteriorated after 1 year.[6] A continuous remodeling of peri-implant tissues has been reported, requiring long-term monitoring.[33] Longer follow-up periods are needed to confirm the findings of our study, and we are monitoring the patient pool to record and publish measurements over the years.

No soft tissue grafting was performed in any of the included patients in the present study. As the authors know, the requirement for systematic soft tissue grafting procedures in IIPP treatment has been controversial until now.[10,34] A recent randomized controlled trial conducted by van Nimwegen et al[35] revealed that a systematic connective tissue graft (CTG) at implant placement did not result in less volume loss after 12 months. In the present study, one-third of the patients (9/27) had a mean change in thickness less than 0.5 mm after 12 months (Table 2 and Figure 5D). Whether to perform CTG at implant placement should be carefully reconsidered in terms of increased morbidity due to a second surgical site, especially given the potential risk of the same amount of final volume loss. Three out of 27 patients showed a $\triangle d$ higher than 1 mm at 12 months, without advanced mid-facial recession, which might indicate a possible need to perform CTG from the perspective of long-term aesthetic results. Moreover, the time-dependent results indicated that resorption at 3 months could serve as an early predictor of soft tissue contour alterations for the selection of CTG treatment. Decision-making based on the soft tissue condition at 6 and 12 months was comparably reliable. Therefore, selected CTG at 6 months for a small portion of patients after IIPP seemed to be reasonable from a patient-centered perspective. Interestingly, a minor contour increase was noticed from 6 to 12 months in some patients. This recovery might be related to the delivery of the definitive restoration and the regaining of volume in the papilla region.

Regarding the mid-facial mucosal level compared with the contralateral tooth, a slight recession was observed at 12 months, without advanced mid-facial recession (>1 mm). Similar findings have been reported by Cardaropoli et al,[7] Raes et al,[5] and Morimoto et al,[36] while some other studies have also reported advanced recession (>1 mm) in a limited number of patients.[6,26] Possible explanations for our data may be a stricter selection of patients with an intact buccal bone at implant placement, a thick gingival biotype, and a stringent surgical procedure. Palatal placement of the implants, immediate provisional restoration, and a bone graft in the socket ensured sufficient healing space for bone and soft tissue,[37] which may play an important role in preventing the risk of mid-facial recession.

An interesting finding was that at baseline, the mid-facial gingival level of the failure tooth could be coronal instead of apical to the contralateral tooth (ML_0: −0.26 ± 0.41 mm). The failing tooth at baseline was sometimes unable to support a healthy and ideal shape of the gingival margin. Mild edema of the gingival margin was frequently observed to cause a coronal position of the gingival margin. Thus, an obvious higher recession value compared with baseline (△ML) was measured. This phenomenon has also been reported by Aoral et al[38] Gingival recession can sometimes be induced purposefully by the prosthodontist to create harmony with the soft tissue level on the contralateral tooth, which may be deemed to have experienced "advanced" recession. Little research is available in terms of the initial gingival level of the failure tooth compared with the contralateral tooth with regard to difficulties in building a proper 3D coordinate to determine the horizontal line. Therefore, misleading within the aforementioned "advanced" recessions in those patients might be possible. Obviously, a harmonious gingival relationship with the surrounding teeth instead of the gingival level stability of the implant site alone was of uttermost importance for optimal aesthetics.

It is noteworthy that via 3D visual analysis, w, h, x_p, and z_p showed no statistically significant differences among follow-ups, namely, width, height, and the thickest point position of the alteration volume remained stable after 3 months. The soft tissue contour alteration occurred within a restricted crescent-like-shaped area, prominently at the center and slightly in the periphery. The greatest soft tissue contour alteration was mainly situated 2 to 3 mm apical to the gingival zenith, with a discrete distribution 0–2 mm mesial/distal to the gingival zenith horizontally. In particular, the thickest point position remained unchanged for each patient. These findings are in accordance with the available evidence for wound healing. The most likely explanation was that active alterations of the soft tissue contour were driven by bone healing.[39] From an anatomical perspective, the thickest point was close to the peak of the underlying facial bone plate, lacking in blood supply after tooth extraction. Different resorption patterns between bundle bone and the surrounding bone have been elucidated and confirmed in several CBCT studies.[12] The buccal plate of the socket showed predominantly higher resorption, while the surrounding bone was relatively more stable against resorption.[24,36] Further scientific proof combining CBCT and digital impression data may clarify the exact role of facial bone remodeling in soft tissue contour alterations.

Moreover, the digitally reconstructed volume of the soft tissue contour alterations in the study provided a rationale for clinicians to individually design the shape, size, and thickness of the soft tissue graft if connect tissue grating is planned. Not only the crescent-like shape, but also the thickness of the grafted tissue on CTG outcomes should be taken into consideration to prevent resorption.

There are still some limitations of the present study. First, the observation period was relatively short. Second, the implant system might influence the contour change; however, the effect was not the research focus in this study.

5 | CONCLUSIONS

During the 1-year observation period following a single IIPP treatment in maxillary incisors, the following conclusions were drawn within the limitations of this study:

1. The labial soft tissue contour showed a continuous alteration that resulted in a mean change in thickness of 0.62 ± 0.22 mm at 12 months, which was quite clinically acceptable.
2. The major alteration took place in the first 3 months and tended to be relatively stable after 6 months.
3. The crescent-like shape, width, height, and the position of the thickest point of the alteration volume remained stable after 3 months.
4. No advanced mid-facial recession was observed.

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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