Single Immediate Implant Placement into Anterior Maxillary Sockets with Facial Bone Defects: A 5-Year Retrospective Study

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Purpose: To evaluate the long-term functional and esthetic effects of immediate implantation combined with guided bone regeneration in patients with labial bone plate defects. ***Materials and Methods:*** A total of 46 implants were immediately placed into anterior maxillary fresh sockets with buccal bone defects. Jumping space and the outer side of buccal defects were densely filled with hydroxyapatite bioceramics and covered with biomembrane. CBCT was performed immediately after surgery (T1), 6 months later (T2), and after 5 years (T3). Radiographs were taken at 1 month after surgery (RT1), definitive crown delivery (RT2), and once a year after prosthetic loading (RT3 to RT7) for 5 years. Pink esthetic score (PES) was evaluated at the time of definitive crown delivery (PT1) and at follow-up visits 1, 3, and 5 years (PT2 to PT4) after crown fixation. ***Results:*** No implants were lost during the observational period. The labial bone was radiographically reconstructed to acceptable volumes, with an average 2.86-mm horizontal bone and 2.2-mm vertical bone. Significant marginal bone loss occurred within 1 year after delivery of the definitive prosthesis. PES scores did not reveal inferior results at the 5-year follow-up. ***Conclusion:*** When other conditions are met for immediate implant placement, small labial plate defects (≤ 5 mm) will not affect the long-term esthetic effect. *Int J Oral Maxillofac Implants 2023;38:374–380. doi: 10.11607/jomi.10160*

Keywords: esthetic zone, facial bone defects, guided bone regeneration, immediate implant

Dentition defects in the esthetic area cause adverse effects on esthetics and pronunciation. According to a systematic review by Esposito et al,[1] patients prefer short treatment protocols over a conventional delayed approach. Therefore, short-term treatment may be more attractive to patients with missing teeth in the esthetic zone.

Immediate implant placement into fresh extraction sockets has been considered a predictable treatment. It has many advantages[2–7] and has also been documented as having a similar survival rate to a delayed approach.[1,8,9] However, it should be clarified that the success rate rather than the survival rate is the key assessment index of implant performance. A successful implant in the esthetic zone means long-term and steady function with esthetic effect without any biologic, esthetic, or technical complications.

Achieving and maintaining optimal pink esthetics of anterior maxillary implants is a demanding task.[10] However, experimental[11–13] and clinical[14–16] studies have confirmed that immediate implantation does not prevent the absorption of labial alveolar bone caused by bone remodeling, especially the buccal bone crest, leading to bony dehiscence and subsequently to gingival recession.[17–20] Despite the high survival rate achieved with implant osseointegration, the incidence of gingival recession of single anterior implants is up to 16%,[21] which has a negative impact on esthetics.

Intact socket walls are one of the indications for immediate implantation that were proposed at the Fifth International Team for Implantology (ITI) consensus in 2013. The presence of a facial bone defect is a risk factor for future facial gingival recession, and the condition of the labial bone plate should be evaluated for any preexisting defects prior to starting immediate implant placement.[22–26] Clinical research from Chen et al showed that 6 months after immediate implant placement, horizontal resorption of facial bone was significantly greater in the presence of a dehiscence defect compared to cases with intact facial bone, while there was no significant difference in vertical bone loss between the groups.[27]

In postextraction sites, loss of one or more socket walls is a common observation.[28] If cases are screened strictly for indications proposed in the ITI guidelines, < 10% are eligible for immediate implantation. Since 2014, various studies have reported on the expansion of specific indications and techniques for immediate implant placement in the esthetic zone. When a labial osseous dehiscence/defect is detected, it is clear that the decision to perform an immediate implant should

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be made weighing the potential benefits and the drawbacks, such as the magnitude of gingival recession risk. In conclusion, the extent, shape, and location of the defect should be evaluated to determine the predictability of immediate implantation.[29]

Regeneration techniques are important to achieve adequate bony contours around implants. Immediate implant placement in conjunction with guided bone regeneration (GBR) procedures can achieve the desired effect in cases with some types of labial bone defects. Many scholars believed that defects located at least 5 mm apical to the intact facial marginal bone are usually inconsequential to immediate implant placement. A V-shaped defect that is confined to only the midfacial portion of the labial bone plate responds favorably to immediate implantation combined with GBR.[22] However, this needs to be further confirmed by clinical studies.

The aim of this study was to evaluate the long-term functional and esthetic effects of immediate implantation combined with GBR in patients with labial bone plate defects.

MATERIALS AND METHODS

Patient Recruitment

This study was approved by the ethical committee of the Affiliated Hospital of Qingdao University in accordance with STROBE guidelines (QYFY WZLL 27177). The study included patients treated consecutively at the Department of Oral Implantology, Affiliated Hospital of Qingdao University, between 2017 and 2018. The inclusion criteria were: *(1)* maxillary anterior single tooth (from central incisors to premolars) indicated for extraction due to tooth fracture, periapical lesions, etc; *(2)* labial osseous dehiscence/defect at the apical or crest site, ranging in size from 1 to 5 mm, without damage of the adjacent alveolar ridge; *(3)* sufficient apical and palatal bone to allow for immediate implant engagement in a proper position; and *(4)* patient available for follow-ups and available complete CBCT scans, radiographs, and clinical records. Exclusion criteria before enrollment were: *(1)* patients with general contraindications to implant surgery; *(2)* acute infection in the site intended for implant insertion; *(3)* heavy smokers (> 10 cigarettes per day); *(4)* pregnant women; and *(5)* presence of buccal soft tissue recession. After the eligibility and exclusion criteria were applied, a total of 46 patients were enrolled in this study.

Surgical Procedure

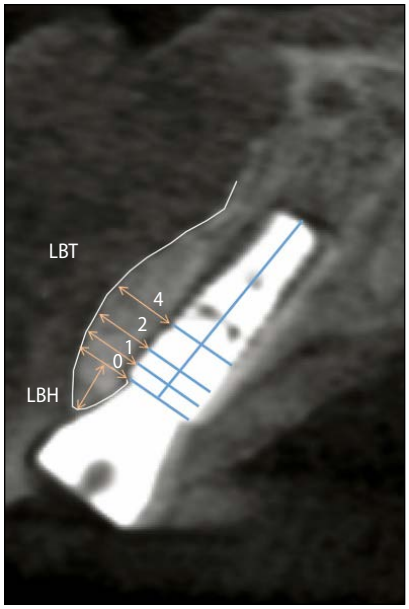
All surgical procedures were performed by an experienced surgeon (B.Z.). Cefdinir 100 mg dispersible tablets and paracetamol dihydrocodeine 0.51 g (lugec) were administered 30 minutes before surgery. Under local anesthesia, an incision was made and a flap procedure was performed to expose the tooth and labial bony plate. The tooth was extracted with a minimally invasive approach without damaging the labial bony plate. Fresh sockets were then thoroughly curetted to remove any visible apical/periodontal granulation tissue. Internal-connection implants (Straumann; Nobel Biocare; WeiGao), 3.3 to 3.8 mm in diameter and 10 to 12 mm in length, were immediately inserted palatally. High primary stability was achieved by engaging in palatal and apical bones. The insertion torque ranged from 25 to 40 Ncm in all implants. Following implant insertion, jumping space around the implants and the outer side of buccal dehiscence defects were densely filled with hydroxyapatite bioceramics (TianBo) and covered with biomembrane (Haiao). A healing abutment with a diameter close to that of the fresh socket was placed to facilitate primary wound closure. Gingiva were sutured without tension. All implants were nonsubmerged during healing. Postoperative antibiotics (cefdinir dispersible tablets [100 mg thrice daily] and ornidazole tablets [0.5 g twice daily]) were administered to every patient for 5 to 7 days.

Prosthetic Procedure

After a healing period of 6 months, the prosthetic treatment started with the final implant impression without gingival induction using a provisional crown. In the lab, a definitive restorative abutment was selected according to the gingival contour of the implantation site, and its shoulder was located 0.5 to 1 mm subgingivally. A zirconia porcelain crown was manufactured following the principle that 2 mm of the crown edge mimicked the gingival emergence profile of the contralateral homonymous tooth, and the adjacent contact point was 2 mm above the current papilla for future gingival growth. In the clinic, the abutment was tightened onto the implant using the manufacturer's recommended amount of torque. Subsequently, the crown was cemented on the abutment. The shape and position of the gingival margin were ensured by the gingival emergence profile of the definitive crown. The fit of the crown with the abutment and the abutment with the implant was verified with a periapical radiograph. Follow-up appointments with patients were made at 1, 3, 6, and 12 months, and annually thereafter, to ascertain the functional and esthetic outcomes.

Radiographic Evaluation

Cone beam computed tomography (CBCT; Carestream) was performed immediately after surgery (T1), 6 months later (T2), and after 5 years (T3). As seen in Fig 1, the midsagittal cut of each implant was identified. A line along the central axis of the implant length direction was determined. Parallel lines to the implant



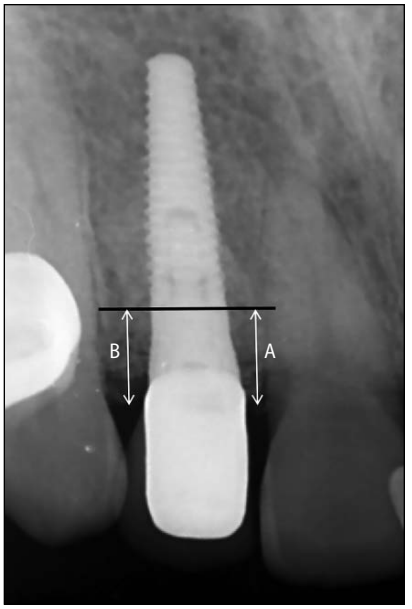


Fig 1 *(Left)* CBCT illustration of LBT at different levels and LBH.

Fig 2 *(Right)* Radiographs illustrating the measurement of marginal bone at the *(a)* mesial and *(b)* distal surfaces.

platform (horizontal implant lines) were set at 0, 1, 2, and 4 mm apically to the implant platform. Labial bone thickness (LBT) at each level was measured on the line extending from the surface of the implant to the outer border of the labial bone. Labial bone height (LBH) was considered as the perpendicular distance from the implant platform to the top of the labial bone crest. When the most coronal point of the facial bone was located coronally to the implant platform, values were designated positive; otherwise, they were designated negative. These measurements were calculated in millimeters.

Periapical standard radiographs were obtained with a paralleling device at 1 month after surgery (RT1), definitive crown delivery (RT2), and once a year after prosthetic loading (RT3 to RT7). The implant shoulder was used as a reference point. Vertical distances from the most coronal level of bone-to-implant contact to the reference point at both mesial and distal sites were measured (Fig 2). Changes of the mesial and distal bone level were analyzed in reference to the 1-month postoperative radiograph as the baseline in annual follow-ups. The bone level above and below the implant shoulder were recorded as positive and negative values, respectively. Distortion of periapical radiographs was considered.

Actual distance = value of distance in periapical × (the true value of implant length/the value of implant length in periapical radiograph).

All measurements were done by the same researcher (X.L). The assessments were performed twice, and an interobserver agreement estimated as > 0.92 was considered as the indicator of excellent intraexaminer reliability.

Esthetic Evaluation

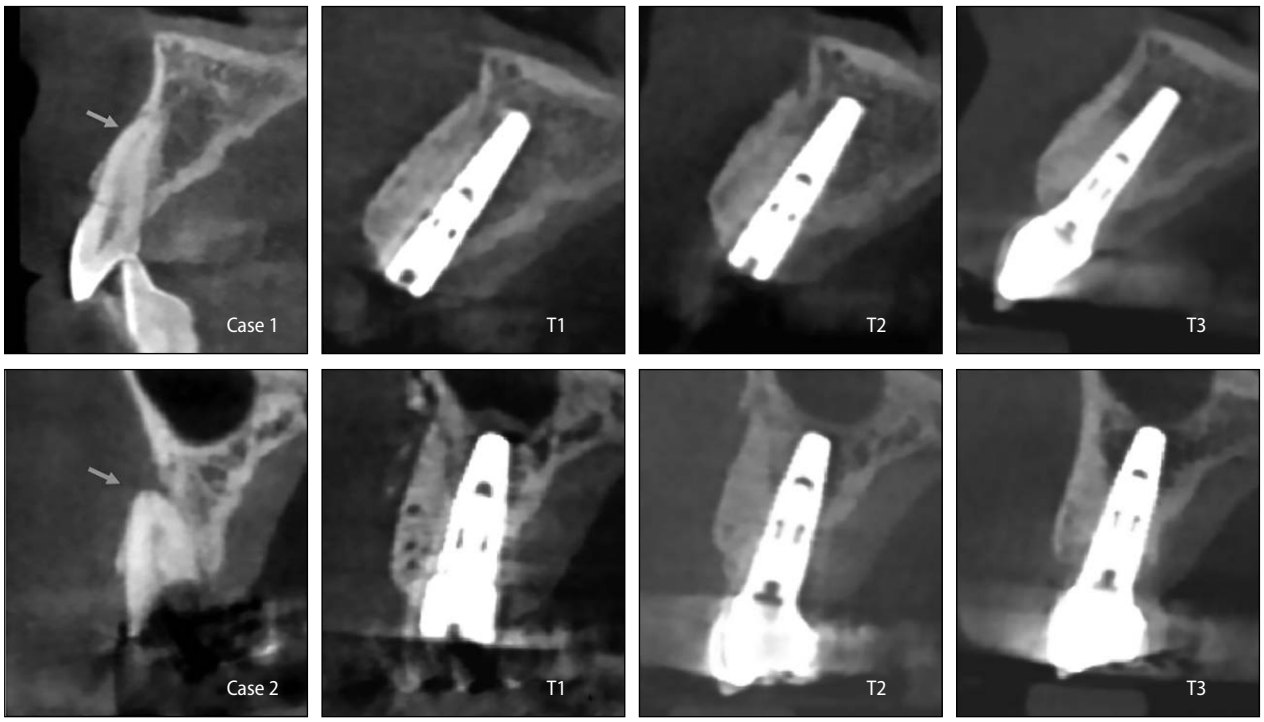
Intraoral photographs were taken under standardized conditions for esthetic evaluation at the time of definitive crown delivery (PT1) and during follow-up visits 1, 3, and 5 years (PT2 to PT4) after crown fixation, using a Canon EOS 60D equipped with Macro Lens EF 100 mm and Macro Ring Lite. Esthetic evaluation of gingival tissue around the implant was expressed as pink esthetic score (PES),[30] and the following parameters were recorded: *(1)* mesial papilla; *(2)* distal papilla; *(3)* level of soft tissue margin; *(4)* soft tissue contour; *(5)* alveolar process; *(6)* color; and *(7)* texture of soft tissue. For items 1 and 2, the scores applied were "absence = 0," "incompleteness = 1," and "completeness = 2," whereas items 3, 4, 5, 6, and 7 were assessed by comparison with a reference tooth, ie, the corresponding tooth (anterior region) or a neighboring tooth (premolar region); the scores used were "obvious difference = 0," "moderate difference = 1," and "no difference = 2." In addition to PES ratings, labial gingival level was dynamically observed based on crown delivery. Evaluation was performed by an independent dentist (W.W.).

Statistical Analysis

Statistical analysis was performed using SPSS software version 26. Descriptive analysis of radiographic and clinical parameters was described as mean ± SD. Values at different observation times at each measurement level were compared using one-way ANOVA. Student-Newman-Keuls was used to compare values measured at two adjacent time periods. $P < .05$ was considered significant.

Table 1 Baseline Characteristics. Population, Sex, and Implant System Distribution at Different Implant Sites

	Central incisors	Lateral incisors	First premolars
Sex			
Male	8	9	3
Female	14	8	4
Implant systems			
NobelReplace	8	6	2
Straumann	8	8	2
WeiGao	6	3	3



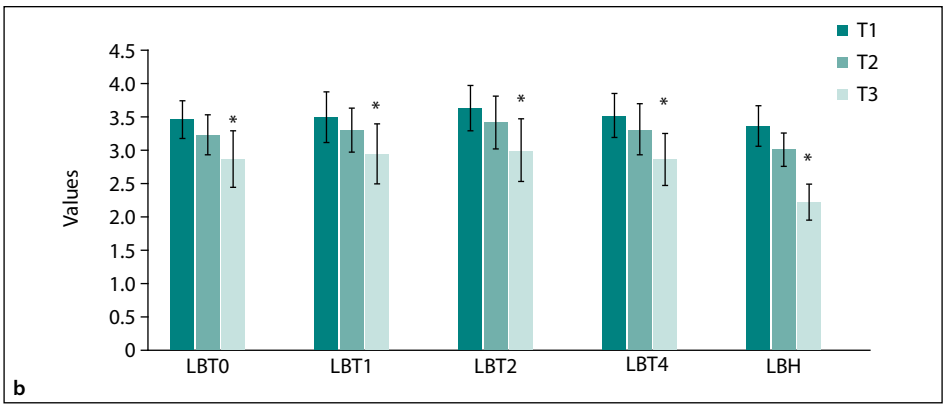


Fig 3 Facial bone dimensions at different observations and different levels. *(a)* Imaging changes of facial bone dimensions in CBCT. The gray arrows show the bone defects. *(b)* Histogram of LBT and LBH values at T1, T2, and T3. *$P < .05$ compared to T1 and T2.

RESULTS

A total of 46 immediate single-tooth implants from 26 female and 20 male patients (mean age: 37.8 ± 16.2 years) were evaluated. Three systems of implants were placed in 22 central incisors, 17 lateral incisors, and 7 first premolars (Table 1).

Labial Bone Thickness and Height

As the implantation followed the principle of 3A2B,[31] bone thickness at the labial site of the implant of LBT0 was > 2 mm, with an average of 3.45 mm, and bone height above the implant platform was 3.36 mm on average. At T2, the LBH and LBT were slightly reduced, possibly due to lip pressure, but there was no

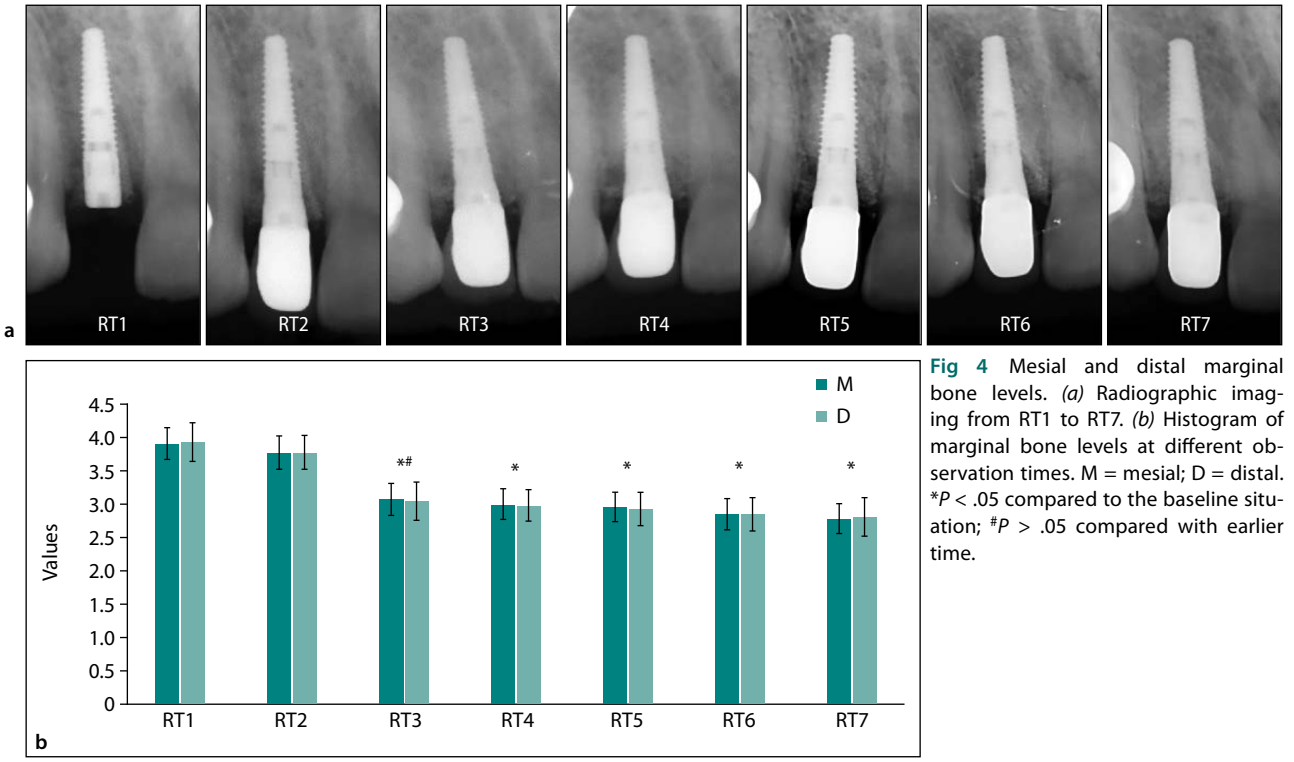


Fig 4 Mesial and distal marginal bone levels. *(a)* Radiographic imaging from RT1 to RT7. *(b)* Histogram of marginal bone levels at different observation times. M = mesial; D = distal. *$P < .05$ compared to the baseline situation; #$P > .05$ compared with earlier time.

significant difference when compared to immediately after the operation. By 5 years after the operation (T3), bone was further absorbed and remodeled, and LBT and LBH were significantly shrunk compared to those at T1. However, the grafting bone was reconstructed to maturity with continuous cortical bone observed at the lateral edge. The average bone height was 2.2 mm, while the average bone thickness was 2.86 mm. Means and SDs of LBT and LBH at different time intervals and measurement levels are presented in Fig 3.

Marginal Bone Levels

As shown in Fig 4, most of the marginal bone loss often occurred within 1 year after the definitive prosthesis, and statistically significant differences could be observed compared with the baselines (PT1 and PT2). After implant loading, bone loss tended to increase slightly. The mean marginal bone loss was 0.71 ± 0.11 mm and 0.73 ± 0.13 mm at the mesial and distal sites, respectively, at PT3. Minimal bone loss was detected after 1 year and gradually became stabilized.

PES Ratings

Between the time of definitive crown delivery and 1-year follow-up, PES increased significantly from 10.83 ± 1.12 to 11.98 ± 0.91 ($P < .01$) and then remained fairly stable up to the fifth year. Among the seven PES variables, the filling of gingival papilla, level of soft tissue margin, and soft tissue contour demonstrated significant changes over the observational period. Significant improvement was seen for the variables of distal and mesial papilla up to the 1-year follow-up. During the extension of observational time, the papilla gradually filled the gingival space, and the black triangle gradually decreased, while soft tissue contour deteriorated for labial bone resorption, which was in accordance with the CBCT measurements. As one of the most common complications of immediate implantation, gingival recession calls for great concern. Taking the level of labial gingival margin at the time of crown delivery for reference, moderate gingival recession could be observed at the 1-year follow-up. Nevertheless, it had no adverse esthetic effect. After 1 year, the level of gingival margin was gradually stable, and there were no significant differences between that in the first year and the fifth year after crown delivery. The intraoral photographs and PES ratings at the time of definitive crown delivery and follow-up visits are presented in Table 2.

DISCUSSION

The placement of implants into fresh extraction sockets has proven to be an effective procedure. Nevertheless, this approach is associated with partial resorption of the buccal bone wall[11,13] and soft tissue recession,[32] leading to a compromising esthetic outcome.[33] A compromised labial bone plate and a thin periodontal biotype are considered risk factors for future gingival recession after immediate implantation.[34] Also, the size

Table 2 PES Ratings at Immediate Crown Delivery and 1-, 3-, and 5-Year Follow-ups

	PT1	PT2	PT3	PT4
Mesial papilla	1.02 ± 0.36	1.52 ± 0.41#*	1.79 ± 0.39#*	1.80 ± 0.38#
Distal papilla	1.04 ± 0.53	1.48 ± 0.28#*	1.81 ± 0.43#*	1.82 ± 0.53#
Level of soft tissue margin	1.62 ± 0.32	1.70 ± 0.14	1.59 ± 0.37#*	1.52 ± 0.24#
Soft tissue contour	1.55 ± 0.28	1.51 ± 0.27	1.39 ± 0.62#*	1.12 ± 0.61#
Alveolar process	1.78 ± 0.23	1.77 ± 0.28	1.61 ± 0.23	1.42 ± 0.36#*
Color	1.82 ± 0.12	2 ± 0	1.91 ± 0.03	1.85 ± 0.12
Texture	2 ± 0	2 ± 0	1.88 ± 0.15	1.81 ± 0.17
Sum total (max 14)	10.83 ± 1.12	11.98 ± 0.91#*	11.98 ± 1.23#	11.34 ± 2.13#

*$P < .05$ compared to the earlier period; # $P < .05$ compared to the baseline situation.

and shape of facial bone defects determines the degree and probability of gingival recession.[22] If a thin and compromised labial bone plate is detected through a presurgical CBCT, other parameters must be evaluated for immediate implantation, such as facial bone defect classification, the residual alveolar morphology and mass, and the condition of soft tissue.

An elaborate presurgical diagnostic phase includes evaluation of the sagittal root position,[34] morphology of the alveolar process,[35] integrity of the labial bone plate of the extraction site, and the periodontal biotype.[36] The presurgical diagnostic phase is followed by surgical planning to provide a guide for implant placement,[36] to manage the peri-implant gap,[37] and to apply appropriate bone augmentation techniques.[22] In the present study, it is proven that immediate implantation in cases with labial bone plate defects ≤ 5 mm can still achieve acceptable esthetic outcomes through reasonable preoperative evaluation and correct surgical and restorative operation. Labial osseous defects confined to 5 mm that do not damage the adjacent alveolar ridge could be treated with GBR. The results of follow-up evaluation demonstrated that GBR around immediate implants with favorable buccal dehiscence could prompt an ideal bone augmentation effect.

Buccal flaps are frequently raised to allow for primary closure of GBR sites. However, some scholars believe that flap operation increases the risk of gingival recession. A meta-analysis by Lin et al[38] compared the implant survival rate and the marginal bone loss between flapless and flapped approaches, and no statistically significant difference was found between them. They concluded that whether the approach should be flapped or flapless depends on the need for access and bone augmentation, patient comfort, and the experience level of the surgeon. In the present study, flap operations were performed for GBR, and significant gingival recession and marginal bone loss only occurred within 1 year after loading, without deteriorated esthetic outcomes, indicating that proper selection of flap design and standard flap operation does not bring adverse esthetic outcomes in immediate implantation.

Adequate bone mass in the palatal and root sides of the extraction socket is another important assessment factor because it guarantees adequate primary stability and correct implant position. Primary stability of the implant is a prerequisite for immediate implantation, especially for the cases in this study that required simultaneous bone grafting. Primary stability is usually achieved by engaging the palatal wall and apical bone 4 to 5 mm beyond the extraction socket. Bone resorption following tooth extraction cannot be prevented by immediate implant placement per se; however, the apicocoronal and buccopalatal position of the implant could affect bone resorption[35] and is critical to the final position of the facial gingival margin.[39] The more labial or apical the position of the implant, the more it will lead to increased bone resorption, resulting in lower marginal bone levels and thus lower facial gingival margin. Research showed that implants with a labially positioned shoulder exhibited facial gingival recession that was three times higher than implants with a palatally positioned shoulder, concluding that there is a strong association between increased recession and a buccal position of the implant.[40] To obtain an ideal implant position, sufficient bone is key, as well as the experience of the surgeon. The use of a surgical guide can aid the surgeon in maintaining the correct implant position without migrating facially during insertion.

Kan et al[41] observed that papillae may have the capacity to regrow over time following implant restoration, which seems to be independent of gingival biotype. In this study, although the degree of papillae was poor (score 1) immediately after the definitive crown delivery, it continued to grow over time. The increase of papillae filling was more pronounced during the first 3 years; approximately 50% of the gaps were completely filled with soft tissue, and approximately 65% of the cases received a score of 2. This phenomenon is consistent with previous studies about papilla growth potential.

Even though results are promising, the present study has some limitations, such as the control group with intact labial bone plate not being set and the small sample size. Prospective case-control studies with longer observation periods and larger sample sizes are needed.

CONCLUSIONS

When other conditions are met for immediate implant placement, small labial plate defects (≤ 5 mm) will not affect the long-term esthetic effect. Presurgical CBCT evaluation and proper planning of the case is mandatory; placing the implant in an ideal position combined with GBR is essential.

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