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Use of reactive soft tissue for primary wound closure during immediate implant placement: a two-year retrospective study

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Abstract. Sockets with both hard and soft tissue defects present a challenge for immediate implant placement. A modified technique harnessing the reactive soft tissue in the extraction socket for primary closure has been reported to contribute to hard and soft tissue augmentation after immediate implantation. The aim of this study was to evaluate the effects of this novel technique on the hard and soft tissues of sockets with both buccal bone and soft tissue defects (group B) and to compare the outcomes with those obtained for sockets with intact soft tissue but buccal bone dehiscence (group A). Thirty-two implants placed in the posterior region were included: 17 in group A, 15 in group B. The implants were inserted immediately utilizing reactive soft tissue from the socket for primary closure in both groups. The changes in buccal bone dimensions after 6 months were generally comparable between the two groups. A keratinized mucosa reduction of 0.56 mm in group A and keratinized mucosa gain of 0.67 mm in group B were observed at 6 months (P = 0.009). The bone and soft tissue levels were well maintained in both groups after 2 years. This technique may be a potential treatment method for tissue augmentation during immediate implantation in posterior sockets, even when a buccal bony defect and mucogingival recession need to be repaired at the same time.

Key words: dental implants; wound healing; granulation tissue; cone-beam computed tomography; wound closure techniques.

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Immediate implant placement in fresh sockets is a well-documented treatment modality with apparent advantages, including a reduced treatment duration, fewer surgical interventions, and higher patient acceptance compared with those of delayed implants[1,2]. However, buccal defects of the extraction socket, often as a consequence of chronic lesions, have become a challenge during implant treatment, since they may impair the aesthetic outcome and long-term stability of the implant[3].

To address this issue systematically, Elian et al.[4] proposed criteria to classify extraction sockets, helping to establish corresponding clinical protocols for implant restoration. Type I sockets are those with intact buccal soft tissue and buccal bone plate. To diminish collapse of the buccal bone, biomaterials are used in the horizontal gap between the implant and

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buccal bone wall during immediate implantation. Related studies have reported a lower resorption of buccal bone with this protocol[5–7]. Some researchers have also used a buccal segment of root as a shield to preserve the periodontal ligament and bundle bone[8,9]. Type II sockets are those with intact buccal soft tissue but partially absent buccal bone walls. In these cases, bone grafts with barrier membranes are usually recommended for immediate implantation[3,10]. Several studies have also reported acceptable outcomes for type II sockets treated with a flapless technique, immediate implant placement, and bone grafts without membranes[11,12]. Type III sockets are those with combined hard and soft tissue defects. These cases represent the most demanding situation in immediate implant placement. Only a few studies have reported successful immediate implantation, in combination with a connective tissue graft, coronally positioned flap, provisional restoration, or guided bone regeneration for defect augmentation[13–17]. However, these approaches are technique-sensitive and may lead to extra trauma at the donor sites.

Recently, a modified technique called the hood technique was introduced by the current authors' team, in which the reactive soft tissue in posterior compromised sockets is used for primary wound closure during immediate implant placement. A prospective cohort study was designed to evaluate the clinical outcomes with and without the use of reactive soft tissue for wound closure[18]. Posterior extraction sockets with intact soft tissue but varying degrees of dehiscence in the buccal bone walls (mainly type II sockets) were included. The reactive soft tissue was utilized during immediate implant placement. In the experimental group, the reactive soft tissue was raised as the primary wound closure for the implant. In the control group, the reactive soft tissue was also elevated but failed to cover the sites, due to the intrinsic discontinuity or small size of the reactive soft tissue. Interestingly, the reactive soft tissue, which is composed of granulation tissue and long junctional epithelium, eventually transforms to keratinized gingiva. The clinical outcomes of the two groups were compared and it was found that buccal soft tissue recession and bone resorption were reduced in cases treated with the hood technique (experimental group) when compared to those handled by routine 'curettage technique' (control group), indicating the potential of reactive soft tissue to facilitate hard and soft tissue augmentation during immediate implantation in type II sockets. Accordingly, a further attempt was proposed to explore the application of this novel technique in sockets with both bone defects and soft tissue recession on the buccal side (type III sockets).

The objective of this study was to evaluate the effects of the hood technique on the hard and soft tissues in type III sockets during immediate implant placement in the posterior area. To meet the single variable principle, sockets with intact soft tissue but a partially reduced buccal plate (type II sockets), for which the clinical outcomes after applying the hood technique were validated in the previous study, were chosen as the control group.

Materials and methods

Patient recruitment

This was a retrospective cohort study. All procedures were conducted with the approval of the Ethics Committee of the West China Hospital of Stomatology (WCHSIRB-D-2017-033-R1) and in accordance with the principles of the Declaration of Helsinki. Consecutive patients treated in the Department of Oral Implantology, West China Hospital of Stomatology, Sichuan University from 2018 to 2019 were included. The inclusion criteria were age ≥18 years, one or more hopeless teeth that needed to be extracted, the presence of at least 4 mm of bone beyond the root apex, the presence of a hypodense shadow around the tooth on preoperative cone beam computed tomography (CBCT), and the presence of an osseous defect on the buccal side of the extraction site (loss of buccal soft tissue could also occur at the same time). The exclusion criteria were uncontrolled systemic disease, pregnancy or breast-feeding, heavy smoker (over 10 cigarettes per day) or alcohol/drug abuser, and poor oral hygiene. Patients with acute inflammation around the tooth or insufficient reactive soft tissue for primary closure during surgery were also excluded.

The sample size was calculated based on the preliminary data, with $\alpha = 0.05$ and power $(1 - \beta) = 80\%$. The enrolment of 28 cases was required to detect a two-sided difference of 1.51 mm in keratinized mucosa alteration between the two groups, and a standard deviation (SD) of 1.38 mm. Considering a potential dropout rate of 10%, the total number of required cases was set at 32.

The included patients were assigned to two groups according to the existing socket conditions: group A if there was a partial bony defect without gingiva recession on the buccal side (type II sockets); group B if there was both a bony defect and gingiva recession on the buccal side (type III sockets).

Surgical procedure

The detailed surgical procedures have been described previously[18]. Briefly, tooth extraction was performed gently and the socket was irrigated thoroughly with sterile saline solution. A small incision was made on the lingual side of the socket. The reactive soft tissue was gently separated from the bony wall with a dental curette and the pedicle was kept on the buccal gingiva, leaving the soft tissue outside the socket for subsequent processes. After implant bed preparation, a Straumann or NobelActive implant (Institut Straumann AG, Basel, Switzerland; Nobel Biocare, Göteborg, Sweden) of the appropriate size was placed immediately, with the platform located 0–2 mm below the lingual bone crest. A deproteinized bovine bone mineral (DBBM) bone substitute (Bio-Oss; Geistlich Pharma, Wolhusen, Switzerland) was used to fill the osseous defect around the implant. A healing abutment was connected to the implant. The pedicled reactive soft tissue was sutured to the opposite mucosa over the graft materials and healing abutment for primary closure (Fig. 1).

Six months after implant placement, the secondary procedure was performed. Implant impressions were made and all patients received their definitive restorations.

The patients were scheduled for follow-up at 6 months and 2 years after surgery. The time before tooth extraction was set as T0, the time immediately after the operation as T1, the follow-up at 6 months after surgery as T2, and the follow-up at 2 years after surgery as T3.

Radiographic measurements

The implant sites were assessed radiographically by CBCT (3D Accuitomo 170; J. Morita Mfg. Corp., Kyoto, Japan) at T0, T1, T2, and T3 (Fig. 2A–D). Five parameters were measured by the same researcher for all sites[19]. To evaluate vertical bone dimensional changes, the distance between the implant platform and the top of the bone crest was measured on both the buccal (buccal P–C) and lingual sides (lingual P–C). For the horizontal bone dimensional evaluation, the buccal bone width was measured at 0, 3, and 5 mm below the implant platform level;

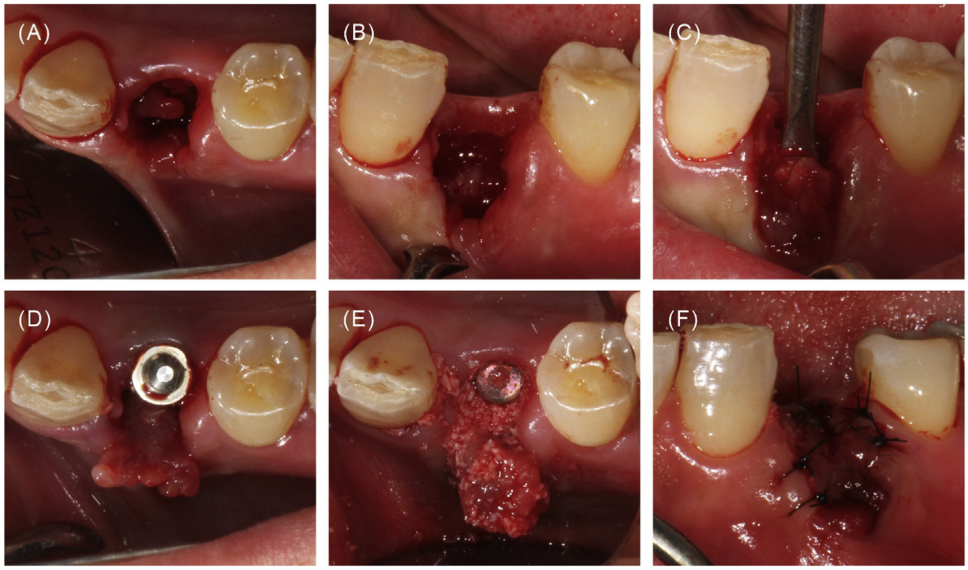

Fig. 1. Surgical procedure of the hood technique. (A) (B) A compromised mandibular first premolar was extracted gently. (C) A small incision was made on the lingual side of the socket to separate the reactive soft tissue from the bone wall, with the pedicle on the buccal gingiva. (D) An implant was inserted immediately. (E) Deproteinized bovine bone mineral (DBBM) was used to fill the osseous defect around the implant. (F) Reactive soft tissue was used to cover the implant as primary socket closure.

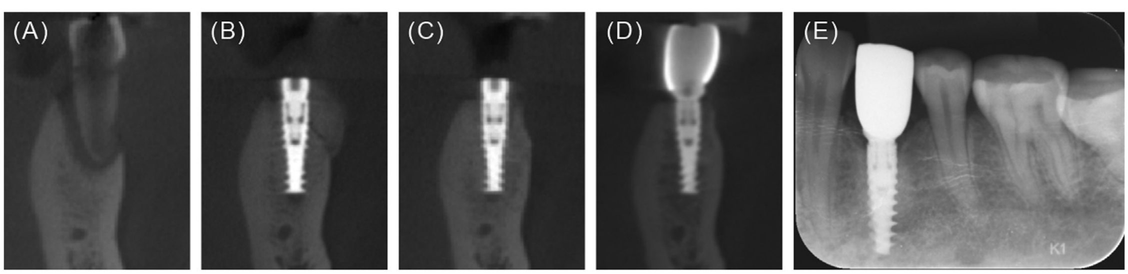

Fig. 2. Hard tissue alterations through the observation period. (A) CBCT showing a compromised mandibular first premolar with the presence of a continuous hypodense shadow and buccal bone resorption. (B) Radiographic CBCT view immediately after surgery. (C) Radiographic CBCT view at 6 months after surgery. (D) Radiographic CBCT view and (E) peri-apical digital radiograph at the 2-year follow-up.

these measurements were named BW0, BW3, and BW5 (Fig. 3).

Peri-apical digital radiographs using the parallel technique were taken to evaluate the amount of marginal bone change at the mesial and distal aspects between the time of prosthesis delivery and 2 years following implant insertion (Fig. 2E). The mean value of mesial and distal marginal bone loss (MBL) was determined as the final value. The known implant diameter was used as a reference to adjust the radiograph for distortion.

Intraoral measurements

Implant survival and complications (delayed healing, pain, swelling, etc.) during the healing period were recorded. The mid-buccal width of keratinized mucosa (WKM) was evaluated from the gingival margin to the mucogingival junction of the tooth. Papilla conditions were assessed with the Jemt papilla index score (PIS)[20] : no papilla = 0, less than half of the height of the interproximal space = 1, more than one half the height of the interproximal space = 2, papilla fills the entire proximal space = 3, and hyperplastic papilla = 4. The convex profile of the facial aspect (CPF)[21] was also recorded: the presence of a convex profile on the buccal aspect = 2, partial presence = 1, and absence = 0. WKM, PIS, and CPF measurements were performed at T0, T2, and T3 (Fig. 4).

The study was recorded according to the STROBE guidelines (https://www.strobe-statement.org/).

Statistical analysis

The statistical analyses were conducted using IBM SPSS Statistics version 20.0 (IBM Corp., Armonk, NY, USA). The data were analysed at the patient level. For those patients with multiple implants, the patient means were calculated considering potential within-patient correlation. Descriptive statistics were derived as the mean and standard deviation (SD) values. Baseline data were compared using the χ^2 test or Fisher's exact test. Linear regression analysis and logistic regression analysis were used to evaluate the possible confounding effects of implant location, implant system, and implant size. Normality and homogeneity of variances were assessed using the Shapiro–Wilk test

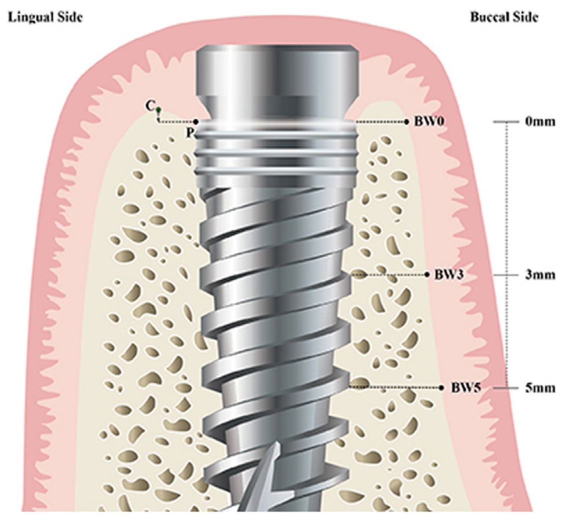

Fig. 3. Schematic diagram of the measurements made at the different bone levels on the CBCT scans in this study. P, implant platform; C, uppermost point of the buccal/lingual bone crest; BW, buccal bone width. BW0, BW3, and BW5 represent the buccal bone width measured at 0, 3, and 5 mm below the implant platform level, respectively.

and Levene test, respectively. The *t*-test was used to determine the inter-group differences when continuous data met the requirements of normality and variance homogeneity. The Mann–Whitney test was employed to evaluate differences between the groups for ranked or non-normally distributed data. All statistical analyses were performed at a level of significance of 5%.

Results

This study included 30 patients (13 female and 17 male; mean age 50.93 ± 11.17 years) who underwent immediate placement of 32 implants in the posterior regions. There were 15 patients (17 implants) in group A and 15 patients (15 implants) in group B. As shown in Table 1, there was no significant difference in patient sex, age, reason for tooth extraction, or implant location between the two groups. The mean buccal defect height was 1.95 ± 2.08 mm in group A and 3.33 ± 2.83 mm in group B (P = 0.139). The soft tissue defect in group B was 1.76 ± 0.91 mm. Twenty-six patients attended the 2-year follow-up investigation; three patients in group A and one patient in group B were lost to follow-up due to migration, loss of contact, and other unknown reasons.

Radiographic measurements

No peri-implant radiolucency was recorded in any of the cases. The CBCT linear measurements are displayed in Table 2. Following a healing period of 6 months, the mean change in buccal P–C was 0.83 ± 0.99 mm in group A and 0.82 ± 0.97 mm in group B, with no significant inter-group difference (P = 0.978). Similar results were found for the lingual P–C alteration. Regarding the alteration of buccal bone thickness, there was a trend towards greater buccal bone width resorption at 0 mm below the implant platform (BW0) in group B (1.59 ± 0.93 mm) than in group A (0.87 ± 1.00 mm) (P = 0.050). Corresponding measurements for BW3 and BW5 in the two groups were also statistically similar. Both groups showed a good maintenance of bone levels during the 2 years of follow-up. The average MBL was 0.07 ± 0.32 mm in group A and 0.08 ± 0.27 mm in group B (P = 0.957).

Intraoral measurements

No osseointegration failure was encountered, and an implant survival rate of 100% was observed during the evaluation period of this study.

No acute inflammation was reported after the surgery. At the time of suture removal, delayed wound healing was reported in three patients in group A and four patients in group B. In these cases, a yellow pseudomembrane was found to cover the implant site at first, and keratinization was observed eventually without any intervention at about 3 weeks after the surgery. No patient in either group complained of pain or swelling.

Soft tissue measurements at T0 and T2 are displayed in Table 3. At 6 months after surgery, a mean keratinized mucosa reduction of 0.56 ± 1.42 mm was observed in group A, while in group B, the width of keratinized mucosa had increased by a mean 0.67 ± 0.92 mm. The difference between the two groups was statistically significant (P = 0.009). An improved or stable PIS at 6 months was noticed in 67% of patients in group A and 60% of patients in group B. Regarding the measurement of CPF, this was well maintained in 60% of patients in group A and 60% of patients in group B. There was no significant difference in the mean PIS and CPF change between the two groups (P = 0.983 for

Fig. 4. Soft tissue alterations through the observation period. (A) A compromised mandibular first premolar with the presence of a buccal bone defect and mucogingival recession. (B) Keratinized mucosa formed after a healing period of 6 months. (C) The soft tissue level at the implant site was stable at the 2-year follow-up.

Table 1. Baseline characteristics of the study groups (group A: bone defect only; group B: bone and soft tissue defect).

Demographics	Categories	Group A	Group B	*P*-value
Sex	Male	8	9	1.000
	Female	7	6	
Age (years)		50.80 ± 13.30	51.07 ± 9.02	0.949
Total implants		17	15	
Reason for tooth extraction	Peri-apical lesions	2	2	0.964
	Periodontal disease	9	9	
	Residual roots/crowns	3	2	
	Tooth fracture	3	2	
Implant location	Maxillary premolar	0	1	0.104
	Maxillary molar	9	4	
	Mandible premolar	1	5	
	Mandible molar	7	5	
Implant system	Straumann	13	10	0.699
	NobelActive	4	5	
Implant diameter (mm)		4.68 ± 0.08	4.48 ± 0.13	0.295
Implant length (mm)		9.71 ± 0.29	10.20 ± 0.32	0.331

Results are reported as the number of patients, or as the mean ± standard deviation values.

Table 2. Dimensional alterations of the hard tissue in the two groups (group A: bone defect only; group B: bone and soft tissue defect) between T1 (immediately after surgery) and T2 (6 months after surgery).

Item	T1	T2	Mean change (loss)	*P*-value[a]
Buccal P–C				
Group A	2.09 ± 0.75	1.26 ± 0.95	0.83 ± 0.99	0.978
Group B	2.08 ± 0.80	1.26 ± 1.04	0.82 ± 0.97	
Lingual P–C				
Group A	1.87 ± 1.45	0.77 ± 1.36	1.10 ± 1.25	0.290
Group B	1.39 ± 1.32	0.78 ± 1.09	0.61 ± 0.99	
BW0				
Group A	3.72 ± 1.94	2.85 ± 1.46	0.87 ± 1.00	0.050
Group B	3.68 ± 1.24	2.10 ± 1.00	1.59 ± 0.93	
BW3				
Group A	4.95 ± 1.35	4.17 ± 1.54	0.78 ± 0.75	0.520
Group B	4.18 ± 1.49	3.17 ± 1.26	1.01 ± 0.79	
BW5				
Group A	5.58 ± 1.33	5.12 ± 1.43	0.45 ± 0.61	0.311
Group B	4.17 ± 1.47	3.51 ± 1.51	0.66 ± 0.48	

P–C, vertical distance between the implant platform and the top of the bone crest; BW, the buccal bone width at 0, 3, and 5 mm below the platform level of the implant. Bone loss equals the change in value compared with the baseline value (T1). Data reported as the mean ± standard deviation values.

[a] *P*-values correspond to the differences in mean change (loss) between the two groups (*t*-test or Mann–Whitney test).

Table 3. Dimensional alterations of the soft tissue in the two groups (group A: bone defect only; group B: bone and soft tissue defect) between T0 (before tooth extraction) and T2 (6 months after surgery).

Item	T0	T2	Mean change (loss)	*P*-value[a]
WKM				
Group A	3.05 ± 2.08	2.49 ± 1.68	0.56 ± 1.42	0.009
Group B	1.84 ± 1.53	2.51 ± 1.17	−0.67 ± 0.92	
PIS				
Group A	1.27 ± 1.28	1.20 ± 0.94	0.07 ± 0.80	0.983
Group B	1.80 ± 0.94	1.67 ± 0.82	0.13 ± 1.13	
CPF				
Group A	1.87 ± 0.35	1.57 ± 0.50	0.30 ± 0.59	0.833
Group B	1.67 ± 0.49	1.40 ± 0.63	0.27 ± 0.59	

WKM, the width of keratinized mucosa; PIS, papilla index score; CPF, convex profile of facial aspect. Data reported as the mean ± standard deviation values.

[a] *P*-values correspond to the differences in mean change (loss) between the two groups (*t*-test or Mann–Whitney test).

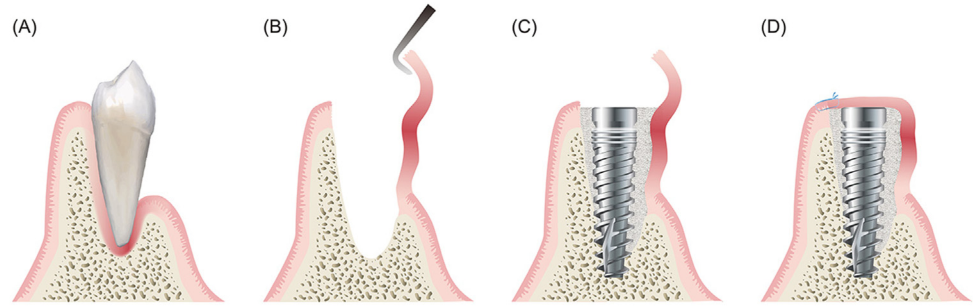

Fig. 5. Schematic diagram of the hood technique. (A) A premolar site with a buccal bone defect and gingival recession. (B) After tooth extraction, a small incision is made on the lingual side of the socket to separate the reactive soft tissue from the bone wall, with the pedicle left on the buccal gingiva. (C) An implant is immediately inserted, and deproteinized bovine bone mineral (DBBM) is used to fill the osseous defect. (D) Primary wound closure is obtained with the elevated reactive soft tissue.

PIS, P = 0.833 for CPF). At the 2-year follow-up (T3), the reduction of WKM was 0.08 ± 0.48 mm in group A and 0.04 ± 0.56 mm in group B, with no significant difference between the groups (P = 0.870). Differences between the groups for PIS (P = 0.615) and CPF (P = 0.400) changes at T3 did not reach statistical significance.

Discussion

The reactive soft tissue, composed of granulation tissue covered by long junctional epithelium, is one of the local proliferative and defensive responses during the chronic inflammatory process[22]. It is generally believed that thorough curettage of this tissue in compromised extraction sockets helps to improve the wound healing capacity. However, recent studies have demonstrated the feasibility of leaving the reactive soft tissue in situ in infected fresh sockets[23,24], as it may contribute to bone repair in ridge preservation and does not compromise clinical outcomes even in cases of immediate implant placement[25]. Mardinger et al.[22] sutured the elevated reactive soft tissue over the bone graft to seal the extraction site and the histological analysis confirmed its conversion into keratinized gingiva after 6 months, verifying the potential preservation value of this tissue.

Sockets combining hard and soft tissue defects present challenges for immediate implant placement. There are several but limited studies describing the treatment protocols for the repair of both defects. A case series of 10 patients by Lee et al.[14] reported secondary soft tissue level improvement when combining a bone graft and a sub-epithelial connective tissue graft covered by a coronally advanced flap. A retrospective study with follow-up of between 1 and 8 years demonstrated greater enhancement of the buccal soft tissue level and higher stability for treatment with connective tissue grafts and bone grafts compared to bone grafts alone[15]. Additionally, in one study a composite graft (cancellous and cortical bone and a soft tissue graft) from the maxillary tuberosity was introduced to repair gingival recession and the buccal bone wall in a single procedure[13]. However, the surgical operations for the soft tissue grafts above was complex and technique-sensitive. Furthermore, donor sites with additional surgical trauma could result in postoperative bleeding and discomfort. In contrast, with the hood technique presented in this study (Fig. 5), adequate soft tissue with its vascularity originating from the buccal gingiva can be obtained in situ for primary wound closure with just a single incision, which simplifies the surgical operation and partially reduces the surgical trauma.

Granulation tissue, a major part of the reactive soft tissue, may induce epithelium and contribute to wound healing. Researchers have found that granulation tissue fibroblasts from both chronically inflamed periodontal lesions and healing wounds behave similarly in vitro[26]. Thus it can be postulated that granulation tissue formed in chronic inflammation may facilitate wound healing when used as primary closure. In addition, it might possess the ability to induce the formation of keratinized gingival epithelium[18]. Therefore, it is speculated that following the elevation of reactive soft tissue, epithelial cells start to migrate from the surrounding gingiva based on the granulation tissue over the implant and finally produce keratinized mucosa. In this study, the recession of the keratinized mucosa after 6 months was 0.56 mm in group A (type II sockets), indicating improved retention of the soft tissue level when compared to those cases without any soft tissue treatment during immediate implant placement in other studies[11,19]. Moreover, the width of keratinized mucosa increased 0.67 mm after a healing period of 6 months in group B (type III sockets) and remained stable after 2 years, in line with another study evaluating soft tissue level changes in type III sockets following connective soft tissue grafting during immediate implantation (0.6 mm)[15]. Hence, the hood technique might play a bigger role in the re-establishment of soft tissue in type III sockets with a soft tissue defect than in type II sockets with intact soft tissue. This could be explained by the soft tissue defect being compensated by the pedicle of reactive soft tissue, providing a larger scaffold for migrating cells to produce keratinized mucosa.

In this study, BW0, BW3, BW5, buccal P–C, and lingual P–C were measured to determine whether the soft tissue defect affects the outcomes of bone regeneration when utilizing reactive soft tissue as primary closure. It was observed that there were no significant differences in the alterations of these five parameters between the two groups (except for BW0, P = 0.050), indicating that primary closure with a pedicle of reactive soft tissue could create the same protective environment for the bone substitute as the intact buccal gingiva. In other words, type III sockets become equivalent to type II sockets after the pedicle of soft tissue is raised, which helps to obtain primary wound closure without tension and provides enough space for bone substitute.

It should be noted, however, that the reactive soft tissue is softer and less tough than the normal gingiva, which might slightly weaken the support for the bone substitute. Correspondingly, there was a non-significant trend towards greater resorption of the bone width at the implant platform level (BW0) in group B when compared with group A. Nevertheless, the buccal bone plate in group B, which was 0 mm at BW0 before treatment, was still reconstructed to an acceptable mean level of 2.10 mm after the healing period of 6 months and this was maintained after 2 years (Fig. 2D and 2E), implying that there may be a positive effect on bone regeneration when there is direct contact with reactive soft tissue containing granulation tissue and epithelial tissue. This might be explained at the cellular level. Granulation tissue has been proven to carry bone-forming capability, as osteoblasts have been detected lining granulation tissue[27]. Besides, mesenchymal stem cells have been isolated from inflamed peri-apical or periodontal granulation tissue[28], and these were able to generate mineralized tissues when transplanted into an ectopic animal model[29]. In terms of immunology, the main source of the inflammatory environment with bacteria is removed after tooth extraction and the local environment starts to change to a repair-promoting type, with a strong and adequate blood supply from the residual granulation tissue[30], which might facilitate tissue regeneration after implant placement and bone substitute filling.

In summary, the results highlight some important aspects of the study: (1) the presentation of a simplified surgical technique for reconstructing the buccal bone wall and repairing the mucogingival recession in a single procedure during immediate implantation; (2) the expanded indications for application of the hood technique to various types of extraction socket.

There are some disadvantages of this technique that should be mentioned. First, bleeding was observed immediately after elevating the reactive soft tissue, and this may affect the visualization and identification of the bone morphology to some extent. Second, elevation of the reactive soft tissue might be more difficult in some cases with narrow sockets. Third, delayed wound healing was observed in some cases. This may be associated with the complex process of epithelial cell migration and new connective tissue formation, and residual inflammatory stimuli to some extent. Nevertheless, the prolonged healing did not impact the final healing capacity of the epithelial cells, as keratinized mucosa eventually formed in those cases. The application of plasma rich in growth factors or concentrated growth factors to enhance the soft tissue healing could be considered in such cases.

Importantly, considering the limited numbers of patients, specific inclusion criteria, and short follow-up period, caution is required when drawing any broad conclusions. There is a need for studies with a larger sample size, more homogeneous cases, and an extended follow-up in the future.

In conclusion, the hood technique may be a viable alternative for tissue augmentation during immediate implantation in posterior compromised sockets of different types, even in cases where a buccal bony defect and soft tissue recession need to be repaired at the same time.

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Competing interests

None.

Ethical approval

This study and all procedures were conducted with the approval of the Ethics Committee of the West China Hospital of Stomatology (WCHSIRB-D-2017-033-R1).

Patient consent

Patient consent was obtained to publish the clinical photographs.

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