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Immediate implant placement into posterior sockets with or without buccal bone dehiscence defects: A retrospective cohort study

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ABSTRACT

Objectives: To evaluate bone reconstruction and soft tissue reactions at immediate implants placed into intact sockets and those with buccal bone dehiscence defects.
Methods: Fifty-nine internal connection implants from four different manufacturers were immediately placed in intact sockets(non-dehiscence group, n = 40), and in alveoli with buccal bone dehiscence defects: 1) Group 1(n = N10), the defect depth measured 3–5 mm from the gingival margin. 2) Group 2(n = 9), the depth ranged from 5 mm to 7 mm. The surrounding bony voids were grafted with deproteinized bovine bone mineral (DBBM) particles. Cone beam computed tomography(CBCT) was performed immediately after surgery (T1), and at 6 months later(T2). Radiographs were taken at prosthesis placement and one year postloading(T3). Soft tissue parameters were measured at baseline (T0), prosthesis placement and T3.
Results: No implants were lost during the observation period. For the dehiscence groups, the buccal bone plates were radiographically reconstructed to comparable horizontal and vertical bone volumes compared with the non-dehiscence group. Marginal bone loss occurred between the time of final restoration and 1-year postloading was not statistically different(P = 0.732) between groups. Soft tissue parameters did not reveal inferior results for the dehiscence groups.
Conclusions: Within the limitations of this study, flapless implant placement into compromised sockets in combination with DBBM grafting may be a viable technique to reconstitute the defected buccal bone plates due to space maintenance and primary socket closure provided by healing abutments and bone grafts.
Clinical significance: Immediate implants and DBBM grafting without using membranes may be indicated for sockets with buccal bone defects.

1. Introduction

Immediate implant placement into fresh sockets has been shown to be a predictable alternative to delayed approaches [1–3]. Immediate implants do not affect the marginal bone loss or the occurrence of postoperative infection in comparison with implants placed in mature bone [4]. The pre-extraction lesions of natural teeth may result in defected buccal bone plates and soft tissue recessions. Elian et al. categorized the fresh sockets into three types based on the presence or absence of the buccal hard and soft tissue [5]. For type I sockets where facial soft tissue and buccal plate of bone are both intact, implant treatment is highly predictable. For type II sockets where facial soft tissue is present but the buccal plate is partially missing, postoperative soft tissue recession may occur [5]. As a result, different bone regenerative procedures have been suggested to treat sockets of this type [6–9].

A number of studies demonstrated improved bone regeneration of buccal dehiscence defects with the application of bone grafts and collagen membranes [10–12]. Betti et al. reviewed available articles to evaluate the evidence that barrier membranes prevent bone resorption [13]. However, the evidence is weak because of lack of adequate control groups in most studies. Some controlled trials[14,15]found no particular advantages of barrier membranes in graft preservation compared with periosteal coverage alone. Moreover, without the use of bone grafts under the membrane, the inadequate space making effect may result in compromised bone healing, due to collapse of absorbable membranes [16]. The indication of barrier membranes used to prevent bone resorption is still disputable.

The purpose of this study was to evaluate bone reconstruction and soft tissue reactions at immediate implants placed into type I and type II sockets using DBBM particles and no membranes at the time of tooth removal.

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2. Material and methods

2.1. Patient recruitment

This retrospective cohort study was approved by the ethical committee of the West China Hospital of Stomatology, Sichuan University (WCHSIRB-D-2015-083). The study included patients treated consecutively at the Department of Oral Implantology, West China Hospital of Stomatology, Sichuan University, between the years 2013 and 2015. The inclusion criteria were:1)posterior single tooth indicated for extraction due to caries, periapical lesions, nonactive periodontal disease, *endo*-perio disease, and tooth fracture. 2)sufficient native bone to allow for immediate implant insertion. 3)availability of complete CBCT scans, radiographs and clinical records. Exclusion criteria before enrollment were: 1)acute infection in the area that will receive an implant. 2)heavy smokers(> 10 cigarettes per day). 3)pregnant women. 4) compromised lingual bone walls due to pre-extraction lesions. 5)presence of buccal soft tissue recession.

2.2. Clinical procedures

All surgical procedures were performed by an experienced surgeon (Y. M.). Hopeless molars were decoronated and sectioned into individual roots before surgery. Under local anaesthesia, pre-extraction osteotomy was made through natural roots (Fig. 1). The residual roots helped to guide and stabilize the drills. Before the last drill, the root fragments were carefully extracted without flap elevation. The mesiodistal widths of the buccal bone defects were measured with a vernier caliper(HISING, Shandong, China). Using the gingival margin as a reference, the mid-facial depths of dehiscence defects were measured with a probe (Hu-Friedy Co., Chicago, USA). All sites were distributed into three groups. In Group 1, the dehiscence depth ranged from 3 mm to 5 mm. In Group 2, the defect depth measured between 5 mm and 7 mm. For the non-dehiscence group, the buccal bone plate was intact (type I socket). The fresh sockets were then thoroughly curetted to remove any visible apical/periodontal granulation tissue. The last osteotomy drill was used for final preparation. Internal connection implants(Institut Straumann AG, Basel, Switzerland; NobelActive®, Nobel Biocare, Göteborg, Sweden; Dentium Korea,Seoul, Korea; Osstem Implant Co., Ltd., Busan, Korea), 4.0–6.0 mm in diameter and 8–12 mm in length, were immediately inserted. Implant platforms were located at 3 mm below the buccal gingival margin. The insertion torque exceeded 35 N cm for all implants. Transalveolar sinus floor augmentation was performed in cases with limited bone height. Following implant insertion, marginal gaps around the implants and the buccal dehiscence defects of test sites were densely filled with DBBM particles (Bio-Oss, Geistlich Biomaterials, Wolhusen, LU, Switzerland). A healing abutment, with diameter close to that of the fresh socket, was installed to facilitate primary wound closure. (Fig. 2)All implants were non-submerged during healing.

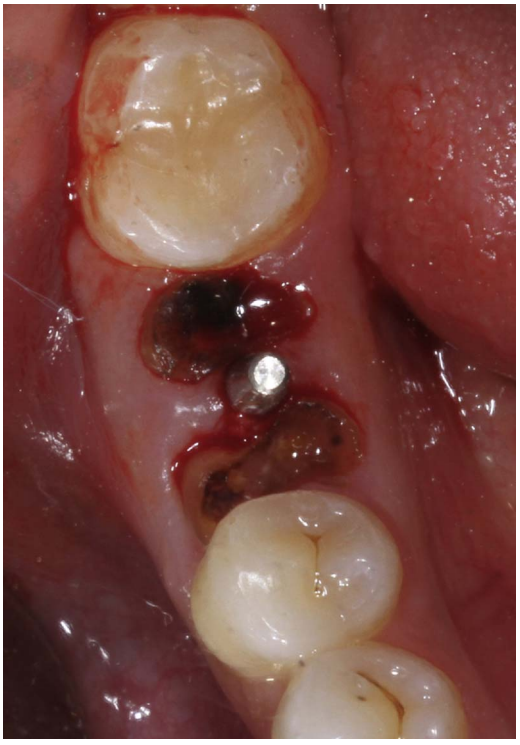

Fig. 1. Pre-extraction osteotomy was made through natural roots.

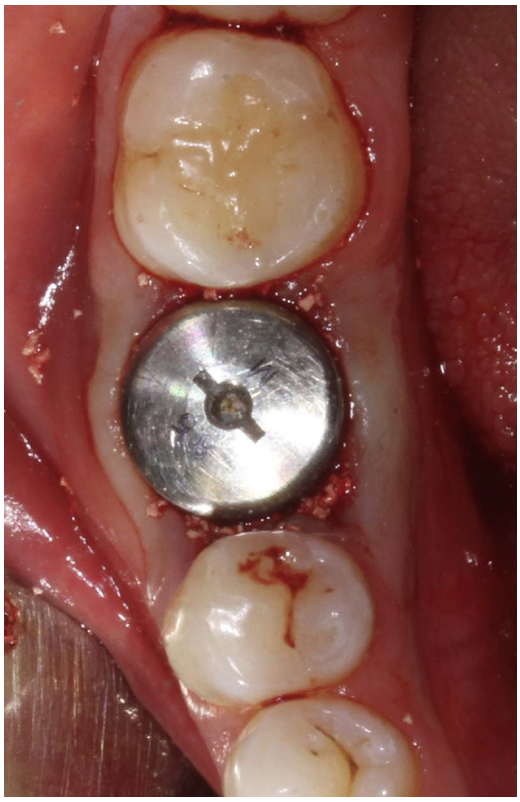

Fig. 2. A wide healing abutment was installed to facilitate primary wound closure.

Amoxicillin was administered to every patient for five days. Mouth rinsing with 0.12% chlorhexidine three times a day for a week was prescribed.

After a healing period of at least 6 months, the prosthetic treatment was completed. The implants were restored with cemented crowns. Patients were scheduled for recall one year following restoration.

2.3. Radiographic evaluation

CBCT (3DAccuitomo 170®, J. Morita Mfg. Corp., Kyoto. Japan) was performed immediately after surgery(T1) and at 6 months later(T2). Periapical standard radiographs were obtained with a paralleling device (Dentsply/Rinn Corporation, Elgin, IL, USA) at the time of final crown delivery, and at one year after prosthetic loading(T3).

All measurements were done by the same researcher. The following landmarks were defined(Fig. 3) on CBCT images:

1. Implant platform(P)
2. Top of buccal bone crest (C)
3. Outer border of buccal plate(OC)
4. Implant surface(S)

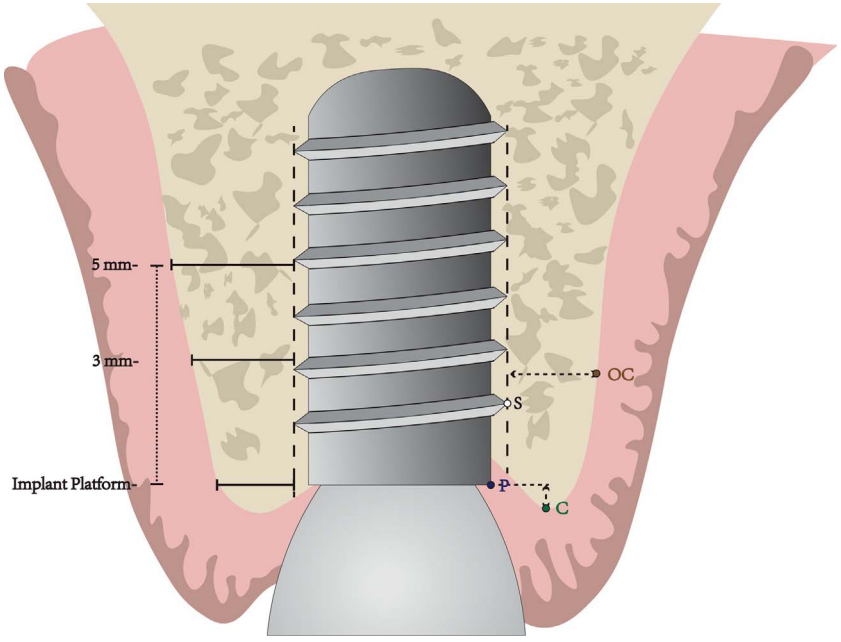

Fig. 3. Landmarks used for CBCT measurements. P, implant platform. C, top of buccal bone crest. OC, outer border of buccal plate. S, implant surface.

The following distances were measured:

1. P-C: the vertical distance between P and C. A positive value indicated that the bone crest was located coronally to implant platform, while a negative value meant the opposite.
2. OCS: the distance between implant surface and OC. It was measured along the implant at three levels, including the implant platform level(OCS-0), 3mm(OCS-3) and5mm(OCS-5) apical to P.

On periapical radiographs, the distance from implant platform to the most coronal bone position contacting the implant was measured on the mesial and distal aspect of each implant. The amount of bone changes over one year after restoration was calculated for all groups.

2.4. Clinical parameters

The following parameters were recorded at baseline, final crown delivery and T3: (1)Jemt papilla index score(PIS) [17]: no papilla = 0, less than one half the height of the papilla = 1, more than half of the height of the interproximal space = 2, papilla fills the entire proximal space = 3, hyperplastic papilla = 4; (2)Width of keratinized mucosa: width of keratinized mucosa was measured mid-facially. The amount of width reduction was recorded. (3)Facial mucosal level (FML): the vertical distance between the mid-buccal mucosal margin to reference tooth cusps. (4)CPF: convex profile of facial aspect [18].The presence (score 2), partial presence(score 1), or absence(score 0) of a convex profile on the buccal aspect was noted.

2.5. Statistical analysis

The collected data was analyzed using SPSS 16.0(SPSS Inc, Chicago, IL, USA). Quantitative measurements were described as mean ± standard deviation(SD). Baseline characteristics were compared among three groups through Chi Square Test. Measures of skewness and kurtosis or Kolmogorov-Smirnov tests were applied to check the normality of the sample. One-way ANOVA was used to determine the differences among three groups and the inter-group difference if normality assumptions were satisfied and the homogeneity of variance was met. Kruskal-Wallis test and Mann-Whitney Test were applied when the sample was not normally distributed. For ranked data like PIS and CPF, the differences among three groups were determined through Kruskal-Wallis Test. All comparisons were executed at the 0.05 level of significance.

3. Results

76 patients were screened for eligibility. 21 patients were not included for the following reasons: 11 patients had incomplete data, 5 patients had missing adjacent teeth, 3 patients had external connection implants, and 2 patients' buccal flaps were raised.

55 patients (mean age 38.62 ± 13.14, range 18–69 years) with a total of 59 implants were considered eligible and enrolled. The baseline characteristics are listed in Table 1. There were no significant differences with respect to gender, reasons for extraction, the proportion of sites showing primary periapical inflammation, and the constituent

Table 1
Baseline characteristics.

	Group 1	Group 2	Non-dehiscence Group	P value
Gender				
Male	5	7	19	P = 0.281
Female	5	2	20	
Reasons for tooth extraction				
Caries	2	1	5	P = 0.296
Periapical lesions	2	4	23	
Nonactive periodontal disease	3	0	3	
Endo-perio disease	2	2	4	
Tooth fracture	1	2	5	
Implant location				
Upper jaw	1	6	22	P = 0.020
Lower jaw	9	3	18	
Periapical inflammation				
Yes	8	9	35	P = 0.360
No	2	0	4	
Implant systems				
Straumann	1	3	11	P = 0.074
NobelActive	3	5	5	
Dentium	5	1	18	
Osstem	1	0	6	
Chi Square Test				

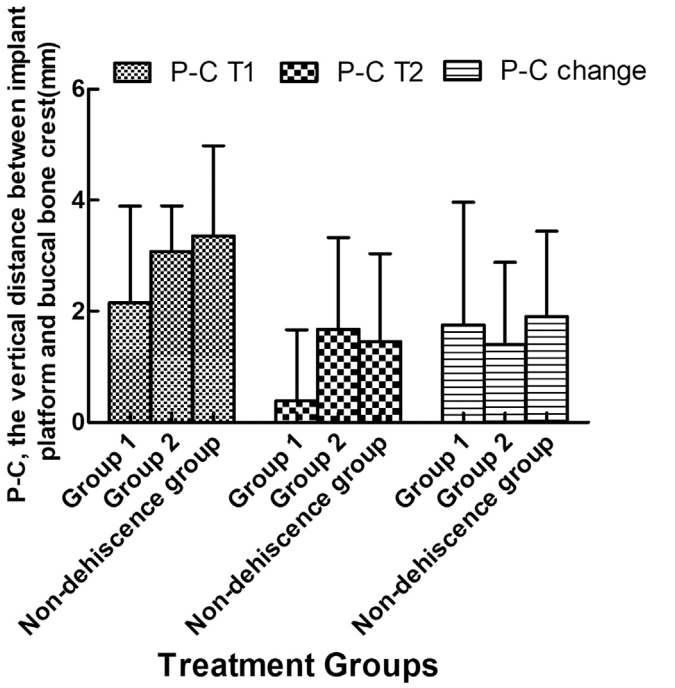

Fig 4. Vertical linear measurements.

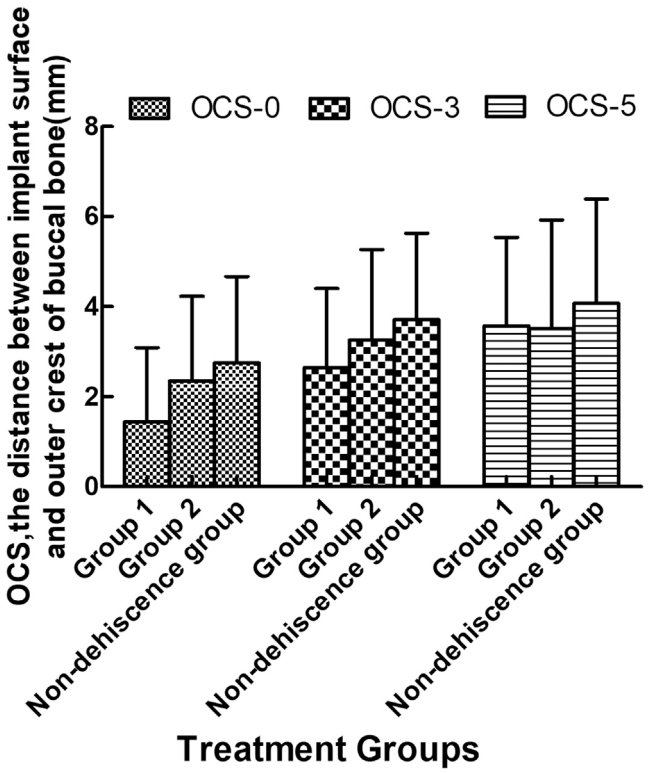

Fig. 5. Buccal bone widths at T2.

ratio of four implant systems among three groups. The coronal widths of dehiscence defects measured 4.89 ± 2.29 mm for Group 1, and 6.78 ± 2.43 mm for Group 2. 100% implant survival rate was observed for all implants.

3.1. Radiographic evaluation

Before treatment, 100% of implants in Group 1 and Group 2 had 0 mm of buccal bone at the implant platform(OCS-0). 22% in Group 2 had 0 mm of bone at 3 mm apical to the implant platform(OCS-3).

Fig. 4 illustrates the vertical linear measurements. Following grafting procedures, the distance between buccal bone crest(C) and the implant platform(P) amounted to 2.15 ± 1.74 mm, 3.08 ± 0.82 mm, and 3.36 ± 1.62 mm for Group 1, 2 and the non-dehiscence group, respectively. The differences between groups did not reach statistical significance (P = 0.097). After 6 months, a comparable amount of vertical bone reduction (P-C change) was observed for three groups (P = 0.697). The resulting buccal bone height (P-C) at T2 measured 0.39 ± 1.28 mm, 1.68 ± 1.65 mm, and 1.45 ± 1.59 mm for Group 1, 2 and the non-dehiscence group, respectively. The differences among groups were not statistically significant(P = 0.124).

The facial bone plates for Group 1 and Group 2, where 0 mm existed at OCS-0 before treatment, were reconstructed to a comparable level with the non-dehiscence group after 6 months (P = 0.065, Fig. 5). The corresponding bone widths at the implant platform were 1.44 ± 1.65 mm for Group 1, 2.35 ± 1.88 mm for Group 2, and 2.75 ± 1.92 mm for the non-dehiscence group. No significant differences were found among groups regarding the bone thickness at the other two horizontal levels(P = 0.261 for OCS-3, P = 0.982 for OCS-5),either. The buccal bone reduction at the implant platform level measured 0.51 ± 0.62 mm for Group 1, 1.75 ± 1.47 mm for Group 2, and 0.88 ± 1.11 mm for the non-dehiscence group. The differences were insignificant among three groups (P = 0.326).

The marginal bone level changes between the time of prosthesis placement and T3 were comparable amongst the three groups (P = 0.723), i.e. −0.20 ± 0.68 mm for Group 1, −0.20 ± 0.28 mm for Group 2, and −0.18 ± 1.17 mm for the non-dehiscence group. (Fig. 6)

Soft tissue reactions between the time of surgery and final prosthesis placement are revealed in Table 2. Comparable amount of FML alterations was observed for three groups (P = 0.932). Reduction of keratinized mucosa was also similar (P = 0.220). The PIS and CPF scores did not exhibit significant inter-group differences at the two time points. After a year of functional loading, the three groups underwent similar amount of FML alterations(P = 0.279) and reduction of keratinized mucosa(P = 0.600). The PIS(P = 0.527) and CPF(P = 0.495) scores were comparable at T3.

4. Discussion

In the present study, bone reconstitution and soft tissue reactions were compared between type I and type II sockets following the same grafting procedures. Despite no use of barrier membranes, buccal bone plates of type II sockets were reconstructed to a comparable level with type I sockets. Soft tissue reactions did not reveal inferior results for type II sockets.

Botticelli et al. found that healing of marginal defects in fresh sockets was incomplete when no regenerative procedures were applied [19]. Many researchers [5,7,20] proposed multiple socket repair techniques by using bone grafts and membranes. In a cost-effective way, our protocol did not involve the use of barrier membranes to reduce surgical trauma and treatment cost. Barrier membranes are usually expected to prevent bone resorption by maintaining space and secluding the grafted area from connective tissue cells [21,22]. However, there is continuing debate regarding whether membranes should be used to cover the augmented site [23]. A systematic review [13] appraised the available evidence of barrier membranes' preventive effects. Clinically relevant conclusions could not be drawn because of small number of human studies, ambiguity, and lack of control groups as well as significant results of reviewed articles. In the controlled clinical trial by Chen et al. [24], reduction in buccal bone width(BBD)did not reveal significant differences between groups with or without membranes (both grafted with DBBM). The study by Al-Hazmi et al. [14]

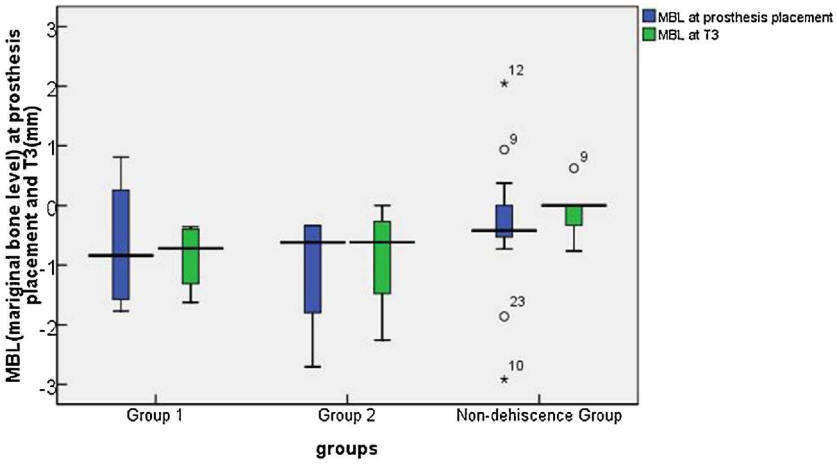

Fig 6. Marginal bone level at prosthesis placement and T3.

Table 2
Soft tissue alterations occurred between T0 and prosthesis placement.

	Facial mucosal level(FML) alterations(mm)	Width reduction of keratinized mucosa(mm)
Group 1	0.81 ± 1.09	0.31 ± 1.00
Group 2	−0.01 ± 1.10	1.17 ± 1.30
Non-dehiscence Group	0.65 ± 1.14	0.43 ± 0.96
P value	P = 0.932	P = 0.220

Kruskal-Wallis Test, One-way ANOVA.

demonstrated that guided bone regeneration(GBR) around immediate implants with buccal dehiscence-type defects was enhanced when treated merely with xenograft and PDGF(platelet-derived growth factor) compared to when a collagen membrane was placed over the graft. The less than ideal treatment outcomes of membranes might be attributed to obstruction to the chemotactic effects of the growth factor on periosteal pluripotential mesenchymal cells caused by membranes. Likewise, in the study by Gielkens et al. [23], all three membrane groups(a copolymer sheet, a collagen membrane, an expanded polytetrafluoroethylene membrane) and the control group showed similar results on graft modeling and incorporation. In brief, the preventive effect of membranes is still disputable. Moreover, membrane application increases the costs of surgical procedures [25].

Buccal flaps are frequently raised to allow for primary closure of GBR sites. Some experimental studies [9,10] investigated healing of buccal dehiscence defects grafted with DBBM and covered with collagen membranes following flap surgery. After 4 months, the labial bone width was less than 1 mm at 3 mm below the implant shoulder. According our results, the mean buccal bone width at OCS-3 exceeded 2 mm for all groups at 6 months post-surgery. (Fig. 5) A possible explanation for this discrepancy is our flapless and space maintaining protocol with the help of healing abutments. Blanco et al. [26] reported a significantly reduced buccal biological width and a minor reduction in buccal bone wall resorption for flapless surgery compared to flap therapy. Some researchers modified the socket repair techniques [5,7] by placing part of a trimmed membrane into the socket's dehiscence area while leaving the rest part covering the open socket. These techniques successfully avoided reflecting or coronally advancing the buccal flap. However, premature membrane exposure might jeopardize bone healing [27]. New bone formation around implants with membrane exposure showed statistically and clinically significant reduction compared to sites where the membrane remained submerged [28].

As no membranes were used in our study, the DBBM grafts in the test groups were in direct contact with the remaining periosteum. The inner layer of periosteum contains multipotent mesenchymal stem cells and osteoprogenitor cells that contribute to normal bone growth, healing, and regeneration [29]. Periosteum has been successfully used as a membrane for guided tissue regeneration in numerous studies [30–32]. Steigmann et al. [32] proposed a buccal periosteal pocket flap for horizontal bone augmentation. The inner periosteal pocket forms space for bone regeneration, whereas the outer split-thickness mucosa layer allows for tension-free soft tissue closure. The cases showed a mean 389% ± 301% gain in bone width (range, 50–1420%) after 24 weeks.

The PASS principle for GBR procedures [33] included primary wound closure, angiogenesis, space creation, and wound stability. Among them, space maintenance and primary soft tissue closure are the two most important factors affecting GBR using collagen membranes [34]. Botticelli et al. [16] made open defects (5.3 mm or 7.3 mm in mesio-distal width, 5 mm in height)at the implants' buccal side, and merely placed a resorbable membrane over the defects and 3–4 mm of neighboring bone tissue. Healing was incomplete and the defect was not entirely resolved after 4 months. The authors suggested that this compromised bone fill may be related to an inadequate space making effect offered by the barrier membrane, since the collagen barrier may have collapsed into the buccal defect. In the study by Okazaki et al. [35], polytetrafluoroethylene membrane reinforced with a thin titanium mesh was placed to cover the secluded graft space. The space was filled with autogenous blood clots (control group) or deproteinized bone particles (experimental group). Histomorphometric results revealed that bone grafts acted to maintain newly formed bone, and were beneficial in inhibiting rapid decrease of regenerated bone. In our protocol, healing abutments whose diameter was close to the extraction sockets were chosen. The wide healing abutments facilitated primary socket closure, protection of blood clots and space maintenance for DBBM particles. This may partially explain the comparable amount of horizontal and vertical bone volumes reconstructed by dehiscence groups in comparison with type I sockets. Similar promising results were obtained by Sarnachiaro et al. [36] In their study, immediate implants were installed in a flapless approach. Following GBR procedures, all implants were provisionally restored with custom-healing abutments that conformed to the shape of root cervix. After 6 to 9 months, the net gain of labial plate thickness amounted to 3 mm at the implant head where 0 mm existed pre-surgery. Our results showed net bone gain of 1.44 ± 1.65 mm for Group 1, and 2.35 ± 1.88 mm for Group 2 at the implant platform. The custom-healing abutments that supported the soft-tissue submergence profile and contained the bone graft particles may have contributed to the promising bone gains revealed in their study.

Cochran et al. evaluated the radiographs of 596 implants in 192 patients at five international sites. Clinically significant marginal bone remodeling (86% of the total mean bone loss over the 5-year follow-up)

occurred between the time of implant placement and final prosthesis placement. Between final restoration and 1 year of loading, an estimated 0.22 ± 0.42 mm of bone loss occurred. And < 0.05 mm additional mean bone loss per year was observed between 1 and 5 years after prosthesis placement [37]. We may infer from this study that, despite the short follow-up period, the one-year results may justify our treatment protocols to some extent. The marginal bone loss occurred during one year of loading presented with negative means and larger standard deviations(-0.20 ± 0.68 mm, −0.20 ± 0.28 mm, and −0.18 ± 1.17 mm for Group 1, 2 and the non-dehiscence group), which indicated that some implants gained bone on the mesial and distal aspects. Defect fill around immediate implants might continue after functional loading.

Limitations of this study should be considered when evaluating the results. The small number of subjects in dehiscence groups should be noted. Studies with longer observation period and larger sample size are needed.

5. Conclusions

Within the limitations of this study, flapless immediate implant placement into compromised sockets in combination with DBBM grafting may be a viable technique to reconstitute the defected buccal bone plates.

Acknowledgements

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