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ORIGINAL ARTICLE

A Simplified GBR Treatment and Evaluation of Posterior Seibert Class I Ridge Defects via Bio-collagen and Platelet-Rich Fibrin: A Retrospective Study

Zhi Wang[1] · Yafeng Zheng[1] · Jiaqi Xu[2] · Qi Jia[3] · Heng Bo Jiang[2] · Eui-Seok Lee[4]

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Abstract

BACKGROUND: Classical guided bone regeneration (GBR) treatments can achieve favorable clinical results for ridge defects. However, extensive bone augmentation in the non-esthetic area in the posterior region for minor ridge defects is unnecessary. Therefore, this study used a collagen and Platelet-rich fibrin (PRF) mixture for bone augmentation on minor posterior ridge defects and evaluated the effects.
METHODS: 22 Seibert Class I ridge defects were treated with BC and covered with a PRF membrane (simplified guided bone regeneration, simplified GBR) and other 22 were treated with Bio-Oss and covered with Bio-Gide (classical GBR). Cone-beam computed tomography imaging was conducted 6 months post-surgery to compare the ridge's horizontal width (HW) and buccal ridge's horizontal width to assess the osteogenic effect. In addition, the buccal ridge contour morphology was studied and classified.
RESULTS: The buccal ridge contour of simplified GBR was Type A in 14 cases, Type B in 7 cases, and Type C in 1 case and it of classical GBR was Type A in 11 cases, Type B in 8 cases, and Type C in 3 cases. The mean HW significantly increased by 1.50 mm of simplified GBR treatment, while it increased by 1.83 mm in classical GBR treatment.
CONCLUSION: The combined use of BC and PRF had a significant effect on bone augmentation and this treatment exhibited promising clinical results for correcting posterior Seibert Class I ridge defects. The morphological classification of the reconstructive effect in this study can be utilized in future clinical work.

Keywords Implant · Bone augmentation · Bio-collagen

✉ Zhi Wang
diana5401@163.com

✉ Eui-Seok Lee
ees225@korea.ac.kr

[1] Second Clinical Division, School and Hospital of Stomatology, Peking University, Beijing 100101, China

[2] Department of Stomatological Technology, School of Stomatology, Shandong First Medical University, Jinan 250117, Shandong, China

[3] Department and Research Institute of Dental Biomaterials and Bioengineering, Yonsei University College of Dentistry, Seoul 03722, Republic of Korea

[4] Department of Oral and Maxillofacial Surgery, Korea University Guro Hospital, Seoul 08308, Republic of Korea

1 Introduction

Oral implants are a popular treatment for restoring missing teeth. However, implant therapy often results in ridge defects caused by prolonged dental absence, periodontitis, tumors, or trauma [1]. Satisfactory bone volume and morphologies are essential for favorable long-term implant prognosis [2]. Several surgical techniques to augment bone volume during implantation have been proposed, establishing different treatments for various ridge defects. These methods include guided bone regeneration (GBR), split bone regeneration, block bone grafting, and distraction osteogenesis, among which GBR is most widely used [3, 4]. GBR isolates the surgical site from connective tissue cells by implementing a physical barrier between soft and bone tissues. This technique permits osteoblast proliferation and bone formation by utilizing the different migration rates of periodontal tissue cells [5, 6]. This membrane prevents gingival soft tissue from entering the affected ridge region and allows predentin cells to occupy the surface and differentiate into osteoblasts, fibroblasts, and odontoblasts, promoting healing [5]. GBR techniques modulate osteogenesis, osteoconduction, and osteoinduction to achieve osseointegration [1], enabling clinicians to augment defective alveolar ridge heights and widths to treat implant dehiscences and fenestrations [7–9].

Deproteinized bovine bone mineral (DBBM) is often used for alveolar ridge augmentation and is the most well-documented bone substitute [10, 11]. Bio-Oss® (Geistlich Pharma, Wolhusen, LU, Switzerland) exhibits identical physical and chemical properties to the human bone mineral phase with excellent osteoconductive and neovascularization properties and low resorption [12, 13]. Absorbable materials, such as collagen, have been successfully used for GBR in recent studies [14]. Bio-Oss Collagen® (BC, Geistlich Pharma, Wolhusen, LU, Switzerland) has been in clinical use for many years and is an allogeneic bone substitute material block comprising 90% DBBM and 10% high-purity porcine collagen [15]. BC incorporates collagen and bone benefits, aiding cell adhesion and growth, while collagen sustains and safeguards cells. Meanwhile, stress on BC significantly increases its surface, providing a matrix for blood vessel formation and advantageous scaffolding conditions for bone formation [16].

Platelet-rich fibrin (PRF) comprises a compact fibrin network with platelet and leukocyte concentrates continuously releasing bioactive factors higher than physiological levels, essential for tissue repair and wound healing [17]. PRF can be easily obtained from autologous sources as polymerization occurs naturally at a single centrifugation stage without activators [18]. The joint application of PRF and other autologous materials increases surgical site membrane stability and improves bone and soft tissue healing by modifying the membrane's biodegradability [19].

Although many BC studies have demonstrated its effective osteoinduction in its function time [20, 21], some doubt its efficacy [22, 23]. However, most BC research involved histological studies on rabbit calvaria and extraction sockets, with relatively limited clinical morphology data. PRF is increasingly used in various regenerative dental procedures, including maxillary sinus floor elevation, implant placement, and alveolar ridge regeneration [24–26]. A systematic review reported that adding PRF to Bio-Oss did not significantly improve bone regeneration during maxillary sinus floor elevation [27], even though it was helpful in the early healing phase [28]. Additional bone regeneration and wound healing studies are needed, especially regarding special ridge defects.

The combined application of various biomaterials has garnered considerable interest for jawbone augmentation surgery. Classical GBR (bone graft + biofilm + tension reduction) treatments can achieve favorable clinical results for some minor ridge defects in the posterior region. However, extensive bone augmentation in the non-esthetic (posterior) area is unnecessary. Results can be predicted through a simplified bone grafting approach, eliminating excessive bone grafts, biofilm coverings, and extensive tension reduction. Based on the favorable collagen and PRF characteristics, this study used a collagen and PRF mixture for bone augmentation on minor posterior ridge defects (Seibert Class I ridge defects) and radiographic observation with clinical considerations. And to demonstrate the effectiveness of this simplified treatment, it was compared to the classical GBR treatment. The null hypothesis was no significant bone width differences before and after surgery using this simplified GBR treatment and no significant bone width differences between the simplified treatment and classical treatment, with a 95% confidence interval.

2 Materials and treatments

2.1 Participants

A total of 20 patients with 22 lost posterior teeth with Seibert Class I ridge defects and 20 patients with 22 lost posterior teeth with Seibert Class I ridge defects from the Second Clinical Division of Peking University School of Stomatology for ridge. The Biomedical Ethics Committee of the Peking University School of Stomatology approved this study (PKUSSIIT2022-080). Inclusion and exclusion criteria are listed in Table 1 (Fig. 1).

20 patients including 22 tooth position and averaging 50.3 years were treated with simplified GBR while 20 patients including 22 tooth position and averaging 46.9 years were treated with classical GBR. Tooth positions were shown in Table 2.

2.2 Surgical procedures

To ensure homogeneity, the surgeries were performed by the same dental specialist, and data collection and compilation were completed by another dental specialists. A total of 2 doctors participated in this experiment. Patients were given 2 g of amoxicillin 1 h before surgery (patients with allergies were given 600 mg of clindamycin 1 h before surgery). A compound chlorhexidine gargle solution was

Table 1 Inclusion and exclusion criteria

Inclusion criteria
Age: 21–69 years
Good plaque control
Systemically healthy
Stable periodontal health
Continuous imaging data before and after surgery
A 3-month healing phase following extraction
Seibert Class I alveolar ridge defect (posterior buccolingual dimension 2–5 mm [Fig. 1]) in at least one missing tooth
Exclusion criteria
History of smoking
Periodontal disease and lack of treatment
History of head and neck radiation therapy/chemotherapy
History of oral bisphosphonate/intravenous bisphosphonate use > 3 years
Diseases affecting the alveolar bone (i.e., uncontrolled diabetes, immunodeficiency)

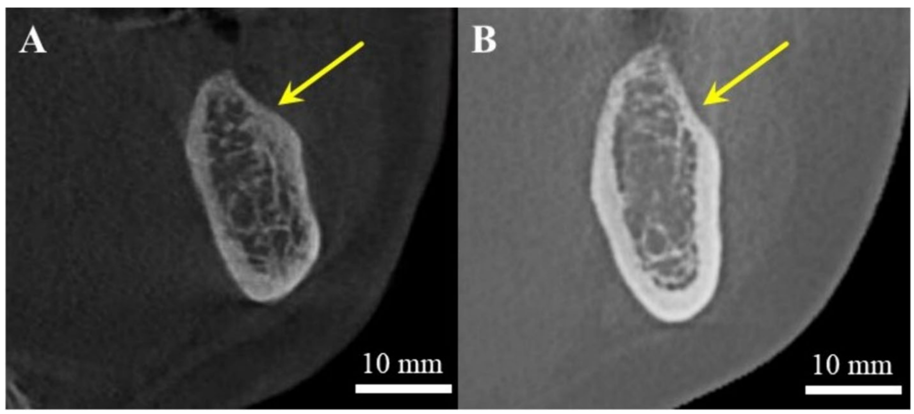


Fig. 1 Seibert Class I ridge defect

Table 2 Number of cases under different surgical treatments and tooth positions

Tooth positions	Surgical treatments	
	Simplified GBR	Classical GBR
First premolar	5	4
Second premolar	4	2
First molar	11	15
Second molar	2	1

used to rinse the cavity, and articaine hydrochloride with adrenaline was applied for local anesthesia. A full-layer flap was buccally and lingually lifted after creating a mid-alveolar ridge incision via keratinized gingiva.

Per the routine procedure, the points were fixed, holes were prepared, and implants (Straumann, BL, Switzerland) of the appropriate diameter were implanted at bone level. Multiple neoangiogenetic cortical pores were made in the recipient bone bed to enable osteoprogenitor cell migration. For the simplified GBR treatment, PRF was obtained by spinning 10 mL of anterior elbow vein blood in a centrifuge (PC-02, PROCESS, Nice, France) at a pre-programmed speed (700 rpm for 14 min with 60 g force). BC was adapted and molded over the defect to the adjacent buccal morphology level and covered with the PRF membrane. Tension-free primary closure was achieved with interrupted sutures (5-0 Nylon, JiaHe, Hunan, China). For the classical GBR treatment, the Bio-Oss particles were placed at the defect site, which was then covered with Bio-Gide barrier membrane. It is then de-tensioned, repositioned, and sutured.

Patients were administered antibiotics (amoxicillin 250 mg) and analgesics (ibuprofen and paracetamol) for a maximum of 5 days post-surgery. Patients were instructed to not brush the surgical site and were prescribed cotrimoxazole mouthwash (0.12%) as an auxiliary to oral hygiene maintenance during the first few weeks post-surgery. All patients' wounds healed without wound dehiscence. The patients followed the rigorous postoperative care program, and progress was reviewed every 2 weeks for 8 weeks post-surgery.

2.3 Methods of assessment

Cone-beam computed tomography (CBCT; HiRes-3D-Max, LargeV, Beijing, China) scans were performed pre-surgery and 6 months post-surgery.

1. The ridge's horizontal width (HW) was measured before and after surgery 2 mm from the ridge crest, which is located on the line connecting the cementoenamel junction of the teeth on both sides (Fig. 2A).
2. The buccal ridge's horizontal width (BHW) adjacent to the implants was measured 1 mm and 2 mm below the ridge crest through the longitudinal axis perpendicular to the alveolar ridge (Fig. 2B).

The buccal bone contour was _nalysed post-surgery. One-way ANOVA was performed for HWs among before and after the two surgical treatments with a 5% significance level.

3 Results

3.1 Classification and morphological analysis

The buccal bone contour was morphologically evaluated 6 months post-surgery and divided into Types A, B, and C (Fig. 3). The yellow line was used as a reference, connecting the implant's buccal fixed point to the outermost edge of the buccal bone plate 5 mm from the ridge crest. Type A: the bone contour is located at the upper edge of the reference line. Type B: the bone contour overlaps with the reference line. Type C: the bone contour is located below the reference line.

Figure 4 shows the morphological analysis of the buccal bone contour. For simplified GBR groups, there were 14 Type A cases (64%), seven Type B cases (32%), and one Type C case (5%). For classical GBR groups, there were 11 Type A cases (50%), seven Type B cases (36%), and one Type C case (14%).

3.2 Width measurements

Tables 3 and 4 display BHW measurements. At 1 mm below the ridge crest of simplified GBR treatment, there were 4 positions with BHWs lower than 1.5 mm, 10 with BHWs between 1.5 and 2 mm, and 8 with BHWs greater than 2 mm. At 1 mm below the ridge crest of classical GBR treatment, there were 12 positions with BHWs lower than 1.5 mm, 6 with BHWs between 1.5 and 2 mm, and 4 with BHWs greater than 2 mm. The mean BHW of the 22 positions of simplified GBR treatment was 1.76 ± 0.41 mm, while it was 1.69 ± 0.95 mm in classical GBR treatment.

At 2 mm below the ridge crest of simplified GBR treatment, there were 2 positions with BHWs lower than 2 mm, 17 with BHWs between 2 and 3 mm, and 3 with BHWs greater than 3 mm. At 2 mm below the ridge crest of classical GBR treatment, there were 8 positions with BHWs lower than 2 mm, 12 with BHWs between 2 and 3 mm, and 2 with BHWs greater than 3 mm. The mean BHW of the 22 positions of simplified GBR treatment was 2.44 ± 0.41 mm, while it was 2.49 ± 1.61 mm in classical GBR treatment.

Table 5 and Fig. 5 indicate HWs before and after surgery of simplified and classical GBR treatment. Post-surgery HWs were significantly higher than pre-surgery HWs in both simplified GBR treatment and classical GBR treatment. The mean HW significantly increased by 1.50 mm of simplified GBR treatment, while it increased by 1.83 mm in classical GBR treatment. The post hoc power value between HWs before and after surgery was 0.98 of simplified treatment and was 0.99 of classical treatment.

Figure 6 presents the increasing value of simplified and classical GBR treatment. The mean increasing value of simplified GBR treatment is 1.50 ± 0.94 mm, while the

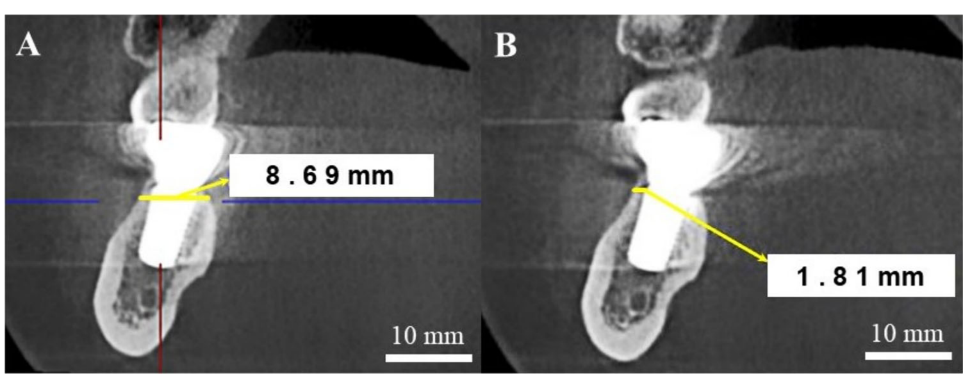


Fig. 2 **A** HW and **B** BHW measurements

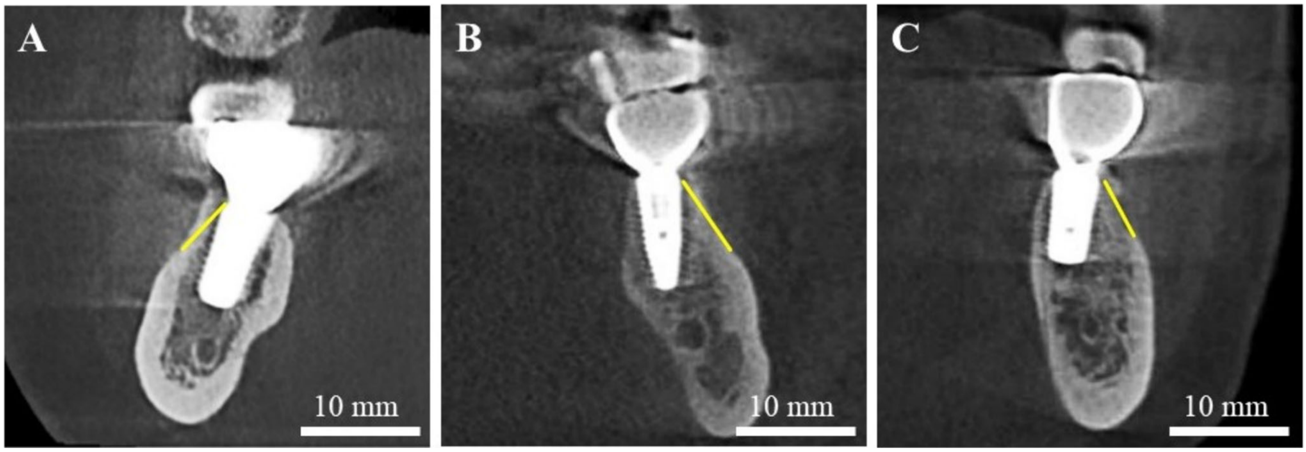


Fig. 3 Classification relative to buccal bone contour: **A** Type A, **B** Type B, **C** Type C

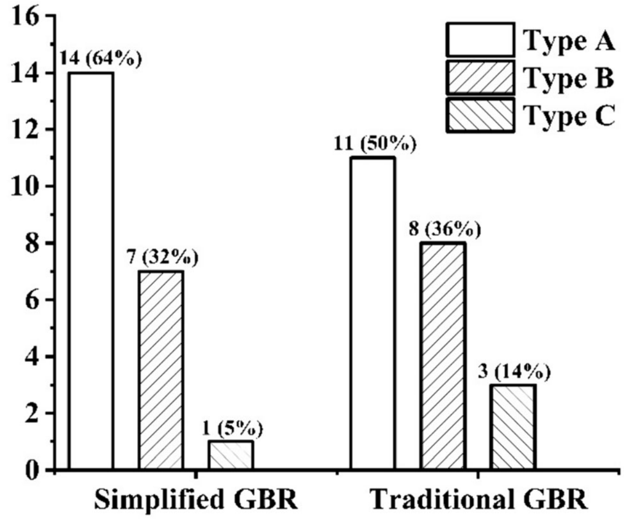


Fig. 4 Morphological analysis of the buccal bone contour

Table 3 Number of cases under different surgical treatments and BHWs adjacent to implants 1 mm below the ridge crest

Surgical treatments		
BHW (mm)	Simplified GBR	Classical GBR
BHW < 1.5	4	12
1.5 ≤ BHW < 2	10	6
2 ≤ BHW	8	4
Mean BHW	1.76 ± 0.41	1.69 ± 0.95

mean increasing value of classical GBR treatment is 1.82 ± 0.91 mm. There is no significant difference between these two treatments.

Table 4 Number of cases under different surgical treatments and BHWs adjacent to implants 2 mm below the ridge crest

Surgical treatments		
BHW (mm)	Simplified GBR	Classical GBR
BHW < 2	2	8
2 ≤ BHW < 3	17	12
3 ≤ BHW	3	2
Mean BHW	2.44 ± 0.41	2.49 ± 1.61

Table 5 Mean ± SD HWs before and after surgery

Surgical treatments	Mean ± SD (mm)
Before simplified GBR	6.28 ± 1.19
After simplified GBR	7.78 ± 1.17
Before classical GBR	6.17 ± 1.25
After classical GBR	8.00 ± 1.56

4 Discussion

This study demonstrated that the combined use of BC and PRF had a significant effect on bone augmentation and this simplified treatment exhibited promising clinical results for correcting posterior Seibert Class I ridge defects. The morphological classification of the reconstructive effect can be utilized in future clinical work.

Due to the overlying soft tissue pressure, membrane collapse often jeopardizes vertical ridge augmentation using GBR. Only Seibert Class I ridge defects were included in this study, as Seibert Classes II and III require vertical alveolar ridge augmentation. The operative protocol followed in this study was established by previous studies [2]. In addition, all selected cases in this study were

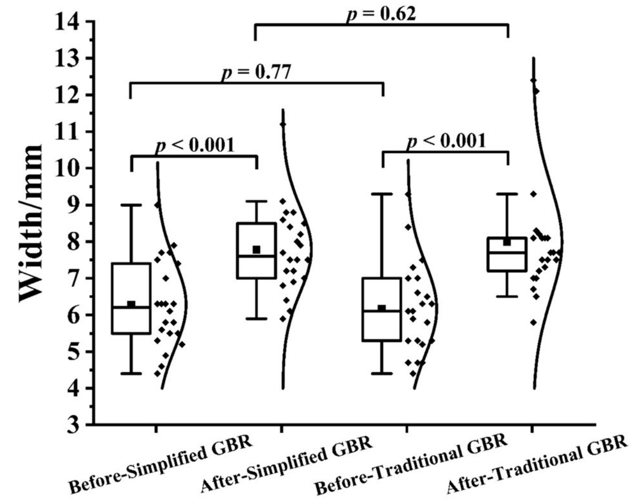


Fig. 5 HWs before and after surgery 2 mm from ridge crest. [F (3, 84) = 12.11, F (1, 42) before and after-simplified GBR = 17.81, F (1, 42) before and after-traditional GBR = 18.38, F (1, 42) before-simplified and traditional GBR = 0.09, F (1, 42) after-simplified and traditional GBR = 0.25]

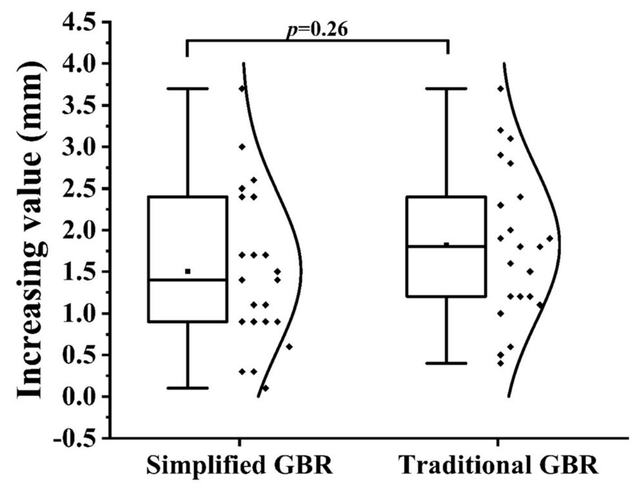


Fig. 6 Increasing value after surgery of the simplified and classical treatment. [F (1, 42) = 1.298]

posterior teeth. The posterior region is a non-esthetic region that requires a smaller buccal bone width. The bone reconstruction width that can be achieved through this treatment is relatively small and does not meet esthetic region requirements. Contour bone grafting is unnecessary for the non-esthetic region esthetic region to ensure a stable esthetic effect.

CBCT is a reliable, reproducible, and feasible method for assessing bone gain following GBR [2, 29]. Anatomical points were measured to assess the horizontal increments at three predetermined points along the alveolar bone apices and measure bone gain at the implant location. In addition to the tomographic examination, favorable graft results were clinically confirmed in some patients who underwent a second-stage surgery with an abutment installation [30]. CBCT artifacts can impact the evaluation of the GBR bone width during implantation. However, this study processed CT data by reducing artifacts, so the effect was not influenced. Bone widths 2 mm, 3 mm, 4 mm, and 6 mm from the ridge crest were selected to evaluate bone augmentation using GBR [2, 31]. Bone widths at 1 mm and 2 mm from the crest were chosen for evaluation due to the small ridge defect area (concentrated within 2 mm of the ridge crest) limiting the bone graft area. The buccal bone morphology described in this study is a novel contribution. Bone width can objectively reflect increased bone mass, and the provided bone morphology description can more precisely reflect bone grafting effects and offset errors from CT artifacts.

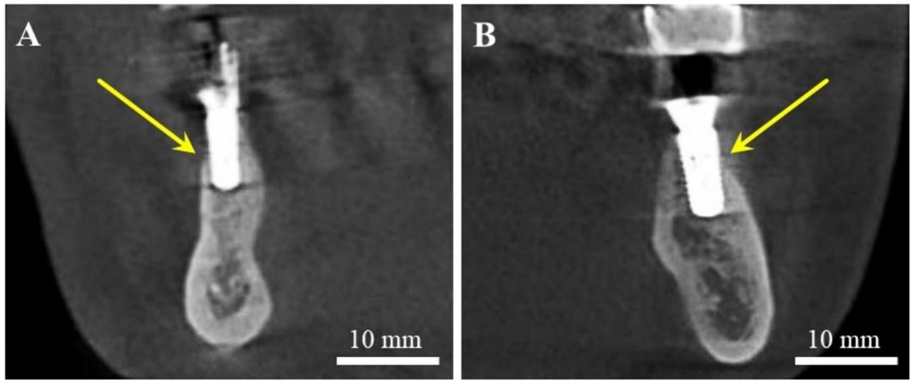
Combining PRF with bone grafts improves angiogenesis, stem cell migration, and osteogenic differentiation, facilitating graft integration and clinical outcomes [32]. Their implementation reduced tissue dehiscence, improved soft tissue healing, minimized infection in the surgical area, and diminished postoperative pain and swelling [32]. However, evidence of PRF's impact on hard tissues requires additional study. Previous GBR studies covered the bone with a BC membrane, so PRF's effect on bone augmentation could not be determined. Therefore, we included PRF in this study. Notably, a few cases without PRF (not included in this study's statistics) had poor bone augmentation results (Fig. 7).

Insufficient buccolingual bone volume often allows for implant placement and survival. However, this can result in receding gums, an unattractive appearance, difficulty maintaining good oral hygiene, and increased peri-implant infection risks because the implant surface is not entirely covered by bone [33, 34]. A 1 to 1.5 mm bone thickness on the implant's buccal and lingual/palatal sides is recommended to ensure a successful outcome regardless of the dental implant location. Some clinical studies have indicated that a 1 mm minimum bone width is required on the implant's buccal and lingual sides for long-term bone coverage and implant success [35]. Therefore, this study considered a BHW greater than 1 mm as successful. Furthermore, there was a statistically significant increase in post-surgery BWs compared to pre-surgery BWs. And there is no significant difference between the simplified and classical treatments.

Thus, this study's simplified surgical approach and assessment methods can be extrapolated for clinical Seibert Class I ridge defects. In addition, two case required a second-stage surgery, demonstrating that clinical bone augmentation results can be visualized during second-stage surgeries (Fig. 8).

PRF can modestly increase angiogenesis and inflammation makers VEGF and IL-6 that are osteoinductive

Fig. 7 Cases without PRF



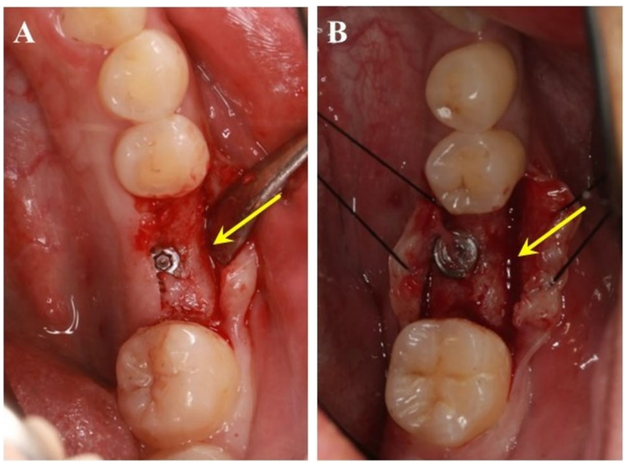


Fig. 8 Bone augmentation results during second-stage surgery

[36]. And PRF is being studied and proven in osteogenesis, although some believe the evidence is not sufficient [22, 23]. Currently, the clinical use of PRF in GBR is mainly in the field of maxillary sinus elevation [37]. The present study is based on the properties of PRF, i.e., it forms a meshwork that facilitates osteoblast migration, proliferation and differentiation, while providing a scaffold for tissue healing. However, our limitation is that there are no controlled trials because of the fewer number of cases. This paper therefore focuses only on the combined effect of collagen + PRF, with insufficient evidence for the role of a sole PRF.

This technique only applies to minor defects as this study only considered relatively small Seibert Class I ridge defects. Although the database utilized in this study ensured the power of the normality test, the number of cases was relatively small, and the follow-up period was short. Among all subjects, only five required a second surgery. Therefore, we could not visualize the healing of all patients. In addition, as the surgery performed here was bone augmentation, there was no way to collect bone tissue for histological observation. Future studies should examine combined BC and PRF applications using more cases and methods.

Author contributions Conceptualization, Z.W. and E.-S.L.; Methodology, Z.W.; Software, J.X. and Q.J.; Validation, Z.W. and H.-B.J.; Formal Analysis, J.X. and Y.Z.; Investigation, Y.Z.; Resources, Q.J.; Data Curation, Z.W.; Writing – Original Draft Preparation, Z.W., Y.Z. J.X. and Q.J.; Writing – Review & Editing, H.-B.J. and E.-S.L.; Project Administration, Z.W. and E.-S.L.

Data availability The original contributions presented in the study are included in the article; further inquiries can be directed to the corresponding authors.

Declarations

Conflict of interest The authors have no financial conflicts of interest.

Ethical statement The Biomedical Ethics Committee of the Peking University School of Stomatology approved this study (PKUS-SIIT2022-080)

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