Review Article

DIMENSIONAL CHANGES OF BUCCAL BONE AFTER IMMEDIATE IMPLANTATION USING DIFFERENT GRAFTING MATERIALS: A SYSTEMATIC REVIEW

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ABSTRACT

The purpose of the systematic review is to evaluate the influence of different grafting materials on buccal bone resorption after immediate implantation. A systematic review of the literature was performed according to the PRISMA guidelines in search of clinical trials published between 2017 and 2022. The research was conducted in electronic databases, including PubMed Medline, Wiley Online Library, The Cochrane Library, and references of relevant studies. In total, 10 studies were included in the systematic review. Seven of included studies are randomized clinical trials, and 3 are described as cohort studies. Considering all involved studies with various grafting materials, the slightest buccal bone reduction after 3 months in vertical dimension was achieved using PRP material (the change of buccal bone reduction 0.03 ± 0.08 mm). After 4-6 months, the greatest results in the horizontal dimension were achieved by using the no grafting technique (0.1 ± 0.6 mm) and in the vertical dimension by using PRP material (0.07 ± 0.10 mm). After 9-12 months, the lowest bone resorption in vertical buccal bone was reached by using PRF material (0.7 ± 0.5 mm). Biomaterials (PRP and PRF) have favorable results in buccal bone resorption prevention after applying in jump space during immediate dental implantation.

Key words: Immediate implantation, Jump gap, Jump space, Grafting.

Introduction

After the loss of teeth, inevitable bone remodeling processes of the alveolar ridge begin [1]. The maximum bone resorption is observed in the first 3 – 6 months after tooth loss [1-4]. Although it slows down later, after 6 months, 29% – 63% of bone width and 11% – 22% of bone height are lost [1]. If no treatment is performed to restore extracted teeth, up to 40 – 60% of bone volume is lost after 3 years [5, 6]. Generally, greater bone loss is more likely on the buccal side than on the lingual side [7].

After losing a tooth, aesthetic, masticatory, and speech functions could be impaired. To restore the tooth as soon as possible and preserve alveolar bone resorption, immediate implantation is suggested [8, 9].

One undesirable occurrence of immediate implantation is residual space between the implant and the socket wall, called the jumping gap, which may lead to bone loss and implant stability reduction. Beneficial to sustain the appropriate volume of alveolar bone after tooth removal with immediate implantation and reduce resorption, the jumping gap could be filled with different materials. Biomaterials, including xenograft, alloplastic graft materials, and platelet concentrates in preserving alveolar ridge have already become common clinical practice and can considerably reduce postoperative alveolar bone resorption [10]. Xenografts have been shown to exhibit excellent properties: biocompatibility, osteoconductivity, slow resorption rate, and maintaining augmented bone volume [11]. Alloplastic grafts are also appropriate materials stimulating osteoconductivity and are particularly effective for bone grafting [12]. Different platelet concentrates have become popular substances as alternatives to prevent significant bone resorption [13]. Platelet concentrates have demonstrated the ability to improve soft tissue healing after surgical procedures [14, 15]. Nonetheless, there is still controversy about hard tissue healing using platelet concentrates [16].

The purpose of the present systematic review is to evaluate vertical and horizontal changes of buccal bone following immediate implantation and identify different grafting material's influence on the buccal bone resorption.

Materials and Methods

Protocol and registration

Systematic review aimed to evaluate the influence of different graft materials in reducing alveolar ridge buccal wall dimensions after immediate dental implantation.

Electronic databases were searched for clinical studies evaluating the vertical and horizontal change of the buccal wall of the alveolar ridge after immediate dental implantation with jumping gap grafting using different materials.

A systematic review was performed in accordance with the guidelines of the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) [17]. The systematic review protocol was documented in advance. The protocol for the review was registered prospectively in the PROSPERO, registration number: CRD42022360891.

Focus question

The focused clinical question development according to the PICO criteria for the present review:

- (P) Population: Patients for whom tooth extraction and immediate dental implantation are appropriate.
- Intervention: Grafting jumping space with different materials in immediate dental implantation.
- (C) Comparison: Different grafting materials (or natural blood clots) in immediate dental implantation.
- (O) Outcome: Radiologically evaluated and determined vertical and horizontal buccal bone reduction after grafting jumping space in immediate dental implantation procedure.

Which grafting material causes the least vertical and horizontal buccal bone reduction after immediate dental implantation?

Search strategy

The research was conducted independently by two reviewers in electronic databases, including PubMed Medline, Wiley Online Library, The Cochrane Library, and references of relevant studies from March 21 to May 27, 2022. Databases were searched using the following query: ((immediate) AND (implantation) AND (graft OR grafting OR platelet) AND (buccal OR labial OR alveolar) AND (dimension OR vertical OR horizontal OR width OR jump OR space OR gap) AND (reduction OR change) AND (bone)).

Study selection

In the studies, a dental implant should be implanted into the socket of the recently extracted tooth, and the jumping space between the implant and the buccal bone wall should be grafted with different grafting materials. Vertical and horizontal changes in the reduction of buccal wall dimensions should be assessed by radiographic examination.

Clinical studies with humans, published less than 5 years ago (from 2017 to 2022), written in English, and identifying changes in the reduction of alveolar ridge buccal bone were analyzed in this systematic review. All meta-analyses, systematic and narrative reviews, letters to the editor, case reports or case series, animal and in vitro studies, or those with incomparable results, were excluded.

After applying predefined selection criteria, titles and abstracts were first screened, followed by a full-text review and analysis of full articles. Any disagreement between the reviewers regarding the inclusion of studies in the systematic review was resolved in consultation with the specialist in the oral and maxillofacial surgery field.

The risk of bias (quality) assessment was also evaluated in included articles. The tool used for randomized trials: RoB 2 tool: A revised Cochrane risk of bias tool for randomized trials [18], a tool used for cohort studies: the Newcastle-Ottawa scale (NOS) [19].

Quality assessment

Systematic risk bias in randomized trials was determined based on the RoB 2 estimation algorithms. Considering the randomized sequences of the studies, deviation from the planned intervention, lack of outcome data, outcome assessment, and selective outcomes, the overall level of systematic risk of the randomized trials was determined (low, some concerns, or high).

Quality assessment of cohort studies was performed using the Newcastle-Ottawa scale, where the total maximum score is 9. Studies that scored ≥ 7 were considered high-quality. Bias was assessed by considering selection, comparability, and outcomes.

Results and Discussion

Study selection

The initial database search showed 6058 articles, an additional search through other sources added 9 more records. After applying the publication year filter (clinical studies published 2017-2022) and duplicates removed, 1153 records remained. Of these, 1132 did not meet the inclusion criteria. For full-text assessment, 21 articles were involved. Finally, 10 fulfilled all inclusion criteria and underwent qualitative data synthesis in this systematic review. **Figure 1**, demonstrates the PRISMA flow diagram.

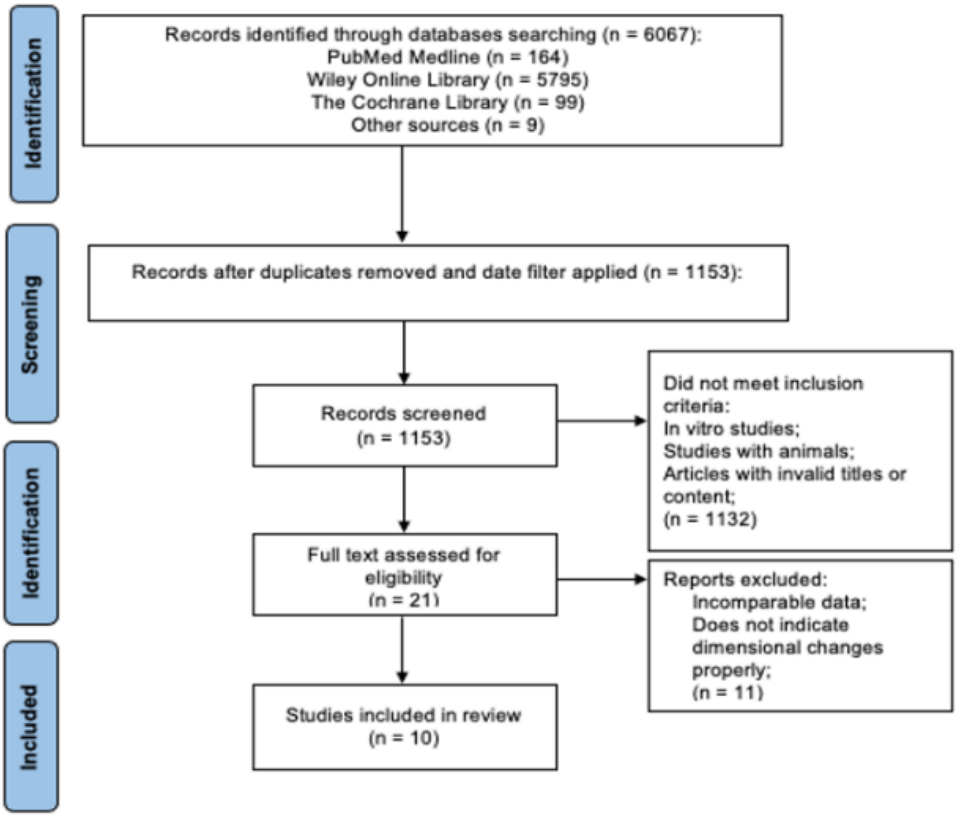

Figure 1. PRISMA flow diagram.

Study characteristics

In total, 10 studies were included in the systematic review. The main results are shown in **Tables 1 and 2**. Seven of included studies are randomized controlled clinical trials (RCT), and 3 are described as cohort studies. The number of patients in trials varied from 12 to 48 [20-29]. Six clinical trials [20, 24, 26-29] investigated flapless immediate implantation and 6 with flap elevation during implantation [21-23, 25-27]. Three studies investigated the maxillary anterior region [24, 25, 28], 5 studies analyzed the maxillary premolar region [20, 24-27], in 1 article, implantation sites were specified as maxillary and mandibular regions [22], and 1 publication described implantation site as premolar and molar region without jaws clarification [21], and 1 study described implantation site as a molar region [29].

In involved studies jump gap was filled with a blood clot, platelet concentrates (PRF and PRP), xenograft, or alloplastic graft [20-29]. The dimensional changes were evaluated in follow-ups from 3-12 months [20-29].

Table 1. General characteristics of the selected studies.

Author	Type of study	Material	Patients	Implants	Site	Evaluation	Flap type	Immediate restorations
Elbrashy *et al*. [20]	Randomized clinical trial (RCT)	platelet rich fibrin (PRF) and xenograft	20	Width 3.6–4.1 mm and length 10–14 mm	Maxillary premolar region	CBCT	Flapless	No
Öncü & Erbeyoğlu [21]	Cohort study	L-PRF and no material	30	Width 4.1 mm and length 12 mm	Premolar and molar	Intraoral radiographs	Flap	No
Khan *et al*. [22]	Cohort study	PRF and no material	17 (38 sites)	-	Maxillary and mandible	Intraoral radiographs	Flap	No
Khan *et al*. [23]	Randomized clinical trial (RCT)	PRP and no material	12	-	-	CBCT	Flap	No

Abdullah *et al*. [24]	Randomized clinical trial (RCT)	Xenograft	23	-	Maxillary anterior and premolar region	CBCT	Flapless	Yes
Paknejad *et al*.[25]	Randomized clinical trial (RCT)	Xenograft and no material	20	Width 3.5-4.3 mm and length 12-14 mm	Maxillary anterior and premolar region	CBCT	Flap	Healing abutment (HA)
Grassi FR *et al*. [26]	Randomized clinical trial (RCT)	Open flap with no material, open flap and xenograft and flapless with no material	45	Width 4.1 mm and length 10-13.5 mm	Maxillary premolar region	CBCT	Flap and flapless	No
Naji BM *et al*. [27]	Randomized clinical trial (RCT)	Open flap with no material, open flap and alloplastic graft and flapless with no material	48	Width 3.7 mm and length 11.5-13 mm	Maxillary premolar region	CBCT	Flap and flapless	No
Abd-Elrahman A *et al*. [28]	Randomized clinical trial (RCT)	No material	- (20 (recipient sites)	Width 3.3-3.7 mm and length 14-16 mm	Maxillary esthetic zone	CBCT	Flapless	Yes
Chen *et al*. [29]	Cohort study	Xenograft	15	Width 4.1-4.8 mm and length 8-12 mm	Molar region	CBCT	Flapless	Healing abutment (HA)

Quality assessment

The risk of bias was assessed for all included studies. RoB 2 tool was used for randomized clinical trials and the Newcastle-Ottawa scale for cohort studies. Four of 7 randomized clinical trials were identified as low-risk, two as high-risk, and one as having some concerns. All 3 cohort studies show high methodological quality. The entire quality assessment process is graphically represented in **Figure 2** and **Table 2**.

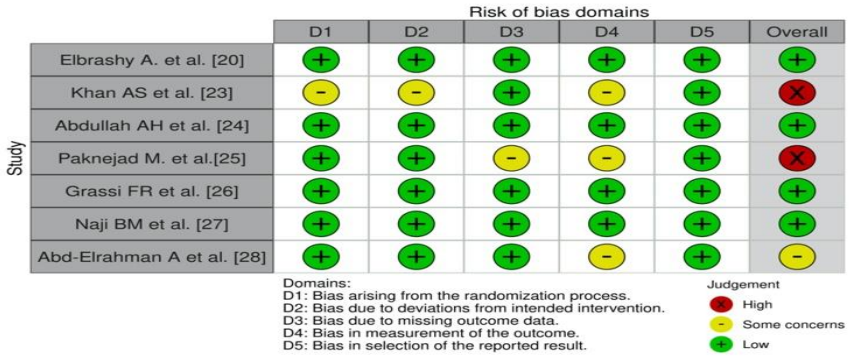

Figure 2. Quality assessment of randomized clinical trials (RoB 2 tool).

Table 2. Quality assessment of cohort studies (NOS).

Study	Selection				Comparability (★★)	Outcomes			Total score (out of 9)
	Representativeness of the exposed cohort (★)	Selection of the non-exposed cohort (★)	Ascertainment of exposure (★)	Outcome not present at the start of the study (★)		Assessment of outcome (★)	Length of follow-up (★)	Adequacy of follow-up (★)	
Oncu and Erbeyoglu [21]	★	★	★	★	★★		★	★	**8**
Khan *et al*. [22]	★	★	★	★	★★	★	★		**8**
Chen *et al*. [29]	★	★	★	★	★	★	★	★	8

Autologous platelet concentrates
Four studies observed platelet concentrates usage on purpose to reduce bone resorption after immediate implantation [20-23]. Three studies evaluated platelet-rich fibrin (PRF) [20-22] and 1 platelet-rich plasma (PRP) [24] influence on the change in bone reduction. These studies were followed up for 3-12 months.

After 3 months, the change in vertical buccal bone reduction reached 0.71 mm in the mesial and 0.77 mm in the distal part after applying PRF in the immediate dental implantation procedure [22]. The use of PRP liquid during the immediate implantation procedure led to a vertical change in reduction that reached 0.03 ± 0.08 mm in the mesial and 0.07 ± 0.16 mm in the distal part after the same period [23].

After 4-6 months, the horizontal buccal bone reduction was 1.63 mm [20], and the reduction in vertical dimension was from 0.84 mm to 1.85 ± 0.89 mm [20, 22] in studies with PRF.

In one study investigating the PRP effect, vertical buccal bone resorption was 0.07 ± 0.10 mm in the mesial and 0.07 ± 0.16 mm in the distal part [23].

After 9-12 months, two studies observed changes in vertical bone resorption using PRF after immediate implant placement [21, 22]. Results varied from 0.7 ± 0.5 mm to 1.00 mm [21, 22].

Evaluating all analyzed autologous platelet concentrates studies, the greatest results (the lowest bone resorption) in vertical dimension after 3 and 4-6 months were reached with PRP, and after 9-12 months with PRF.

Xenograft
Five included studies assessed buccal bone resorption after immediate implantation with augmentation using xenograft [20, 24-26, 29]. These studies evaluated bone changes from 4 to 12 months [20, 24-26, 29].

After 4-6 months, the change in horizontal buccal bone reduction was from 0.4 ± 0.8 mm to 0.59 mm [20, 26, 29]. The resorption in the vertical dimension of the alveolar bone reached from 0.3 ± 0.7 mm to 1.30 ± 2.38 mm after the same period of follow-up [20, 25, 26, 29].

After 9-12 months, the use of xenograft during implant placement led to a horizontal change in buccal bone resorption that reached 0.34 mm ± 0.31 mm [24].

Alloplastic graft
One study included a grafting method with an alloplastic graft in immediate implantation [27]. The change in horizontal buccal bone reduction after 6 months was 0.37 ± 0.09 mm [27].

No grafting method
Seven studies observed immediate implantation without grafting material [21-23, 25-28]. Studies followed up from 3-12 months [21-23, 25-28].

After 3 months, the change in vertical buccal bone reduction varied from 0.07 ± 0.10 mm to 1.19 mm [22, 23].

After 4-6 months, the reduction in horizontal alveolar buccal bone varied from 0.24 ± 0.11 mm to 1.0 ± 1.1 mm in included studies [26-28]. The change in vertical alveolar buccal bone resorption ranged from 0.1 ± 0.6 mm to 2.14 ± 0.52 mm [22, 23, 25, 26, 28].

After 9-12 months, the vertical buccal bone reduction was from 1.3 ± 0.6 mm to 1.44 mm without grafting during immediate implantation [21, 22].

Table 3. Dimensional changes of buccal bone after immediate implantation.

Author	Material	Follow-up	Horizontal buccal bone reduction	P value	Vertical buccal bone reduction	P value
Elbrashy *et al*. [20]	Platelet rich fibrin (PRF) and xenograft	6 months	PRF group 1.63 mm; xenograft group 0.59 mm.	P < 0.001	PRF group 1.85 ± 0.89 mm; xenograft group 0.77 ± 0.32 mm.	P = 0.005
Oncu and Erbeyoglu [21]	L-PRF and no material	12 months	-	-	L-PRF group 0.7 ± 0.5 mm; no material group 1.3 ± 0.6 mm.	P ≤ 0.05
Khan *et al*. [22]	PRF and no material	3, 6, 9 months	-	-	PRF group mesial part after 3 months- 0.71 mm, 6 months- 0.84 mm, 9 months 0.96 mm, distal part after 3 months- 0.77 mm, 6 months- 0.88 mm, 9 months 1.00 mm; no material group mesial part after 3 months- 1.08 mm, 6 months- 1.19 mm, 9 months 1.33 mm, distal part after 3	P < 0.001

					months- 1.19 mm, 6 months- 1.29 mm, 9 months 1.44 mm	
Khan *et al*. [23]	PRP and no material	12, 26 weeks	-	-	PRP group mesial part after 12 weeks 0.03 ± 0.08 mm, after 26 weeks- 0.07 ± 0.10 mm, distal part after 12 weeks 0.07 ± 0.16 mm, after 26 weeks- 0.07 ± 0.16 mm; no material group mesial part after 12 weeks 0.37 ± 0.80 mm, after 26 weeks- 0.43 ± 0.77 mm, distal part after 12 weeks 0.07 ± 0.10 mm, after 26 weeks- 0.17 ± 0.20 mm;	P > 0.05
Abdullah *et al*. [24]	Xenograft	12 months	0.34 ± 0.31 mm	-	-	-
Paknejad *et al*. [25]	Xenograft and no material	4-6 months	-	-	Xenograft group 1,30 ± 2.38 mm; No material group 1,66 ± 2.67 mm	P = 0.72
Grassi *et al*. [26]	Open flap with no material, open flap and xenograft and flapless with no material	6 months	Open flap with no material group 1.1 ± 0.9 mm, open flap and xenograft group 0.4 ± 0.8 mm, and flapless with no material group 1.0 ± 1.1 mm;	flap and xenograft versus flap no graft P = 0.03, others P > 0.05	Open flap with no material group 0.2 ± 0.6 mm, open flap and xenograft group 0.3 ± 0.7 mm, and flapless with no material group 0.1 ± 0.6 mm	P > 0.05
Naji *et al*. [27]	Open flap with no material, open flap and alloplastic graft and flapless with no material	6 months	Open flap with no material group 0.91± 0.54 mm, open flap and alloplastic graft group 0.37 ± 0.09 mm, and flapless with no material group 0.24 ± 0.11 mm;	P < 0.003 0.016*Ivs II 0.744 I vs III 0.003* II vs III		-
Abd-Elrahman *et al*. [28]	No material	6 months	0.28 ± 0.15 mm	-	0.77 ± 0.35 mm	-
Chen *et al*. [29]	Xenograft	6 months	0.48 ± 0.28 mm	P < 0.01	0.74 ±0.32 mm	P < 0.01

The main focus of the present study was to evaluate dimensional changes in buccal bone following immediate implantation during a 3 – 12 months period and to identify different grafting material's influence on buccal bone reduction. The best results in the vertical dimension of buccal bone reduction were obtained with the PRP material [23] after 3 months. After 4 – 6 months – the jump gap is filled with a natural blood clot in the horizontal plane [24] and PRP material in the vertical plane [23]. After 9 – 12 months, in the vertical dimension, the best results were achieved with PRF material [21]. According to the included studies, the lowest buccal bone loss was achieved with PRP, PRF, or without filling jump space with regenerative materials. It is important to mention the surgical procedure's methodology (tooth extraction, flap or flapless technique), the prosthetic protocol, the anatomical buccal bone features, jump space width, implant design, implantation site, and gingival biotype which may influence bone loss after immediate implantation. Thus, more systematically organized clinical trials are needed to draw firm conclusions.

Naji *et al*. [27] conducted a study comparing open flap with no material, open flap with alloplastic graft, and flapless with no material methods. The lowest bone loss was in the flapless without regenerative material group. Comparing the flapless with no material group and the open flap with no material group, buccal bone loss was greater in the open flap with no material group. Therefore, it can be concluded that the surgical method had a significant influence on the results. The flapless approach has been shown to have better results and is associated with better clinical outcomes, reduced healing time, and less discomfort and inflammation. The flapless technique does not separate the periosteum, therefore, preserves sufficient blood supply to the underlying buccal bone, which is associated with better clinical outcomes [30].

The dental implant design also affects bone changes after implantation. A comparative study by Patil *et al*. [31] revealed that using a micro-threaded rough collar design received statistically significantly less bone loss than using a smooth collar design (P < 0.05). Micro-threaded rough collar design was received by applying Sandblast Large grit Acid etch (SLA) [31]. Acid-etching protocol increases cell adhesion and bone formation. Consequently, osteoblasts

growth is enhanced on SLA surfaces of implants and promotes greater osseointegration [32].

The jumping space width is one of the key factors for buccal bone changes after immediate implantation. A retrospective cone-beam computed tomography analysis demonstrated that the change in buccal bone horizontal dimension was statistically significantly thicker in the wide gap (> 2 mm) group than in the narrow gap (≤ 2 mm) group (1.9 ± 0.9 mm and 0.5 ± 0.6 mm, respectively). The grafting of more than 2 mm buccal gaps promoted a thicker buccal bone wall. It was suggested that the wider gap promotes more space for the bone graft, and the bone graft can reach the farthest point of the bone defect. Also, the implant is threaded further away from a buccal bone and reduces resorption [33]. Nonetheless, immediately placed implants with or without bone grafting have similar hard and soft tissue changes when the jumping distance is narrower than 2 mm [34].

As an alternative to regenerative materials, a collagen matrix could be used to fill the jumping gap. Jump space (3 – 4 mm) filled with collagen matrix causes marginal bone loss ranging from 0.28 ± 0.39 mm to 0.34 ± 0.48 mm [35]. Although comparative studies are lacking, this material may be promising in carefully selected cases.

Gingiva biotype also could affect the change of buccal bone reduction after implantation. In the study by Wallner *et al*. [36], there was no significant difference between gingival biotypes and bone loss (P > 0.05). The retrospective study by Sun *et al*. [37] noted that thick gingiva ensures less bone loss after implantation than thin gingiva. However, the impact of the gingiva biotype on bone change after implantation remains controversial.

Our main point was to evaluate the influence of different grafting materials on dimensional changes in buccal bone following immediate implantation. However, there is a lack of clinical studies independently evaluating several factors that may influence bone changes after immediate implantation.

Conclusion

In conclusion, the slightest buccal bone reduction ***after 3 months*** in vertical dimension was achieved using PRP material (the change of buccal bone reduction 0.03 ± 0.08 mm). ***After 4-6 months***, the best results in horizontal dimension were shown by forming a natural blood clot in jumping space (0.1 ± 0.6 mm) and in vertical dimension by using PRP material (0.07 ± 0.10 mm). ***After 9-12 months***, the lowest bone resorption in vertical buccal bone was reached using PRF grafting material (0.7 ± 0.5 mm).

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Ethics statement: None

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