Clinical Outcomes of Alveolar Ridge Augmentation with In Situ Autogenous Block Bone: A Retrospective Review

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Purpose: To present clinical outcomes of alveolar ridge augmentation using in situ autogenous block bone and to compare the outcomes with previous studies. ***Materials and Methods:*** The medical records of patients with a severe horizontal bone defect in a partially edentulous alveolar ridge (width < 3.5 mm), who received bone augmentation using in situ autogenous block bone, were retrospectively reviewed. After a 6-month or longer healing period, the augmentation effect was examined before implant placement. Cone beam computed tomography (CBCT) was performed before and after surgeries. The alveolar width of the bone grafts was measured on the CBCT images. ***Results:*** A total of 16 patients (22 grafts) were included. Graft exposure was seen in three grafts, which were classified as failed cases. The augmentation volume at implant placement in the failed cases was significantly lower than that of the successful cases. There were no significant differences in augmentation between anterior maxillary and mandibular implant sites. ***Conclusion:*** Autogenous bone grafting using in situ block bone is an effective and reliable approach for horizontal bone augmentation in the mandible and anterior maxilla that eliminates second donor site morbidity. Complete release of the buccal flap and tension-free suture is the key to avoiding wound dehiscence and ensuring the effectiveness of bone augmentation. *Int J Oral Maxillofac Implants 2021;36:1008–1015. doi: 10.11607/jomi.8662*

Keywords: alveolar ridge augmentation, autogenous bone grafting, horizontal bone defect

Adequate volume and quality of the alveolar bone is necessary for implant-supported rehabilitation of the edentulous ridge. However, soft and/or hard tissue deficits due to changes following tooth loss are frequently encountered.[1–3] These situations often require bone augmentation prior to the placement of endosseous implants.

Autogenous onlay bone grafting is considered the "gold standard" and most effective approach in augmentation procedures due to its osteogenic potential.[4–6] Possible sources of autologous bone grafts include extraoral sources such as the iliac crest, and intraoral sources such as the mandibular symphysis and ramus.[5,7–9] All these harvesting techniques require surgery at two sites, the donor site and the recipient site; therefore, the morbidity of these donor sites must be considered. Bone harvested from intraoral sites is more readily available; furthermore, it is associated with minimal discomfort and less morbidity, and does not result in cutaneous scarring.[10,11] However, patients may still suffer from swelling, pain, difficulties with mouth opening and chewing, and sensory disturbance in the donor regions.[12]

Over the last 5 years, in situ autogenous block bone has been used in horizontal bone augmentation in the present authors' hospital and attained satisfactory results. In brief, the onlay bone graft is harvested from the apical side of the atrophic alveolar ridge, and then fixed at the lateral side of the ridge, thereby avoiding donor site surgery and its potential morbidity. Few previous studies[13] have investigated the outcomes of using in situ autogenous block bone in alveolar ridge augmentation prior to implant placement. This study presents clinical outcomes of alveolar ridge augmentation using in situ autogenous block bone and discusses them with a review of the literature.

MATERIALS AND METHODS

Patients and Study Design

A retrospective chart review of patients who underwent onlay graft surgery with in situ autogenous block

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bone in atrophic alveolar ridges (Class IV according to Cawood and Howell's classification[14]) prior to implant placement was conducted. The patients enrolled in this study were treated from January 2015 to June 2019 at the Department of Periodontology and Oral Implantology, Stomatological Hospital, Southern Medical University (Guangzhou, China). Those who had a sufficient vertical bone height and a marginal bone width of < 3.5 mm in the edentulous area were included in the study cohort. Patient exclusion criteria included *(1)* severe systemic diseases (including diabetes, malignant neoplasia, and immune system, pulmonary, renal, cardiovascular, and blood diseases), *(2)* chemotherapy or radiotherapy, *(3)* poor oral hygiene, and *(4)* noncompliance.

All patients included in the study were scheduled for onlay grafting using in situ autogenous block bone and implantation via a two-stage procedure. After a 6-month or longer healing period, implants were inserted. Written informed consent was obtained from all the included patients, and approval for this study was obtained from the ethical committee of the hospital. Personal information, such as age, sex, and graft location (anterior/posterior and maxilla/mandible) were collected from the patient records. Cone beam computed tomography (CBCT) was performed before grafting surgery, immediately after grafting surgery, just before implant placement, and immediately after implant placement.

Graft Surgery

CBCT images were carefully analyzed to ensure that sufficient bone could be achieved on the apical side of the atrophic alveolar ridge. Under local anesthesia, a crestal incision and two vertical releasing incisions were performed. The full-thickness mucoperiosteum flap was reflected to expose the alveolar ridge and the apical area. The round-shape bone block (5 to 7 mm in diameter) was harvested with a bone-harvesting trephine (Dentsply Sirona) in the apical area. The diameter of the block should exceed 5 mm to reduce the risk of splitting during fixation. The bone block thickness was adjusted, and the sharp edges were concurrently smoothed with a round bone bur. A 1-mm hole was then prepared through the center of the bone block. The recipient site on the lateral side of the edentulous ridge was decorticated and recontoured with a round bone bur for improved adaptation of the bone graft. At the same time, the recipient site was perforated multiple times using a 1-mm-diameter small round bur (Dentsply Sirona) to expose the medullary spaces and increase bleeding.[15] The bone block was positioned over the recipient site in the horizontal dimension with the endosteal side of the graft facing the cortical bone, and then fixed with a 1.5-mm titanium screw (Zimmer Biomet). Coral hydroxyapatite powder (Bio-osteon, YHJ) or bone particles (Bio-oss, Geistlich Pharma) were filled in the donor site defects and the surrounding area of the bone block. The onlay bone block and the bone particles were covered with a Bio-Gide membrane (Geistlich Pharma). Figure 1 presents the surgical procedures of the in situ autogenous block bone harvesting and fixing. Figures 2 and 3 show typical cases of in situ autogenous block bone grafting in the anterior maxilla and the mandible, respectively.

Elongation of the buccal flap was achieved through vertical and periosteal releasing incisions to reduce the tension caused by increased bone volume. The tension-free wound was sutured with 4-0 polypropylene sutures (Premilene, B. Braun) and removed 2 weeks later.

Postsurgical Care

Patients were instructed to take broad-spectrum antibiotics cefaclor (0.25 g, every 8 hours for 5 days), or roxithromycin (0.15 g, twice per day for 5 days) if allergic to cefaclor, and to use 0.5% chlorhexidine mouthwash three times daily during the first 2 weeks. One dose of dexamethasone (5 mg) was taken orally following the surgery, and ice packs were used for 24 hours. Nonsteroidal anti-inflammatory drugs were suggested only when the patients experienced pain. Smokers were instructed to quit smoking for 2 weeks following the graft surgery. Sutures were removed after 2 weeks. Removable prostheses were not recommended during the healing period. For esthetic reasons, a vacuum-formed appliance was used to avoid pressure on the graft sites.

Implant Placement

After a healing period of 6 months or longer, the implants were inserted in a routine fashion, provided that the alveolar ridges had a sufficient width. In brief, the full-thickness mucoperiosteum flap was reflected at the same surgical site as the bone augmentation. The fixation titanium screws were removed, and the implants were placed according to standard protocols. Crown restoration was performed 3 to 6 months later based on the primary stability of the implants.

Radiographic Evaluation of Bone Augmentation

CBCT scans obtained by a NewTom VGi (QR s.r.l) scanner (110 kVp, 3 to 8 mA, pulse mode) were analyzed with Carestream Vue PACS (Carestream Dental). The width of the alveolar ridge was measured at three levels: Levels 1, 2, and 3 were set at 1, 3, and 6 mm under the top of the alveolar ridge, respectively. The linear measurement tool of the aforementioned software was used to measure the width of the alveolar ridge. The block bone resorption rate equals "(A-B)/A * 100%" (A = the augmentation volume at bone grafting, B = augmentation volume at implant placement). All measurements

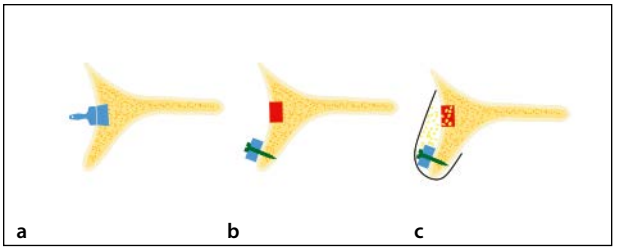

Fig 1 Diagram of in situ autogenous block bone harvesting and fixing surgical procedure. *(a)* The round-shape bone block was harvested with a bone-harvesting trephine. *(b)* The bone block was fixed at the buccal side of the alveolar ridge with a titanium screw. *(c)* Bone particles were filled in the defect of the donor site and the surrounding area of the bone block, and then covered with a collagen membrane.

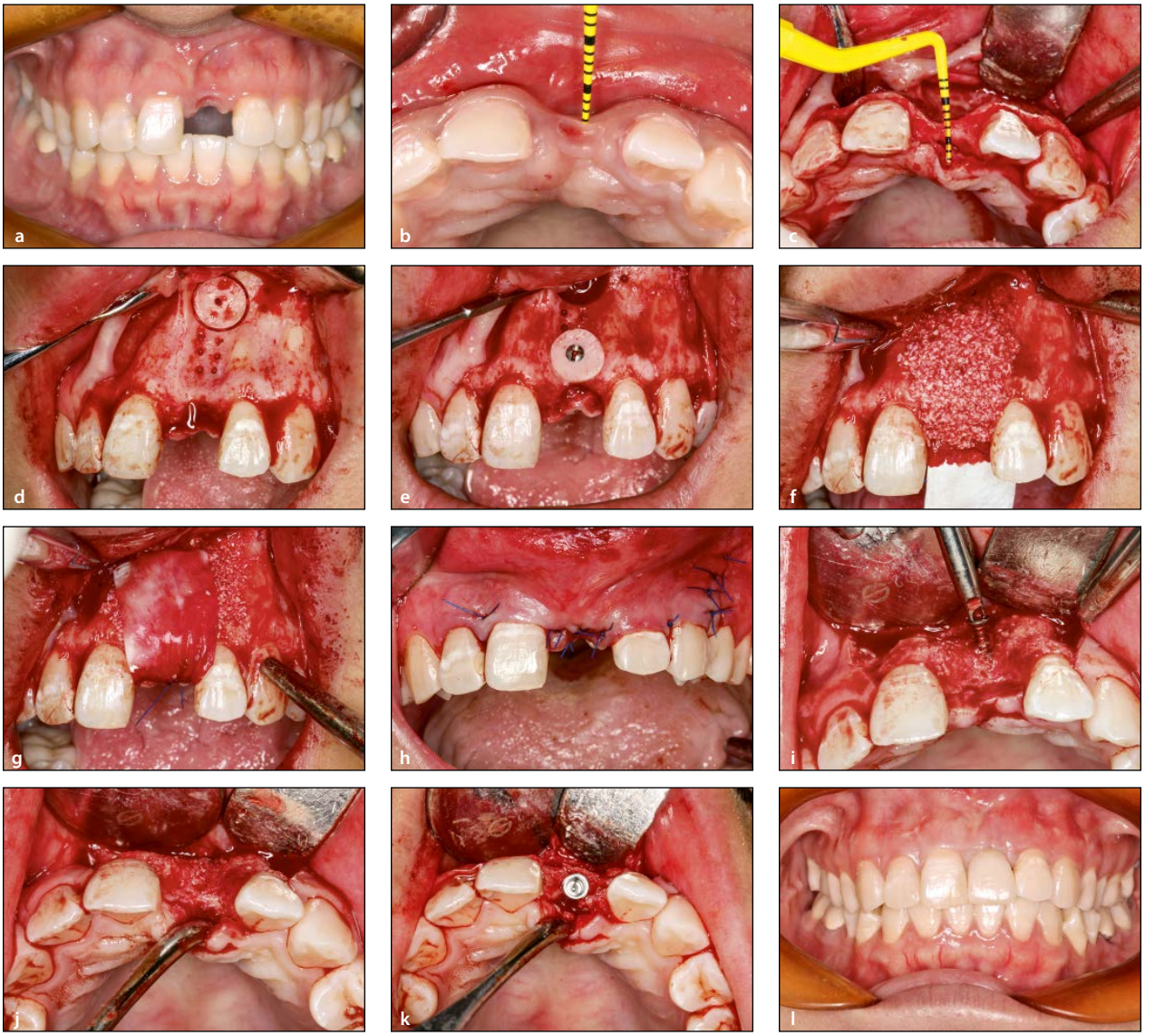

Fig 2 Preoperative images showing the narrow alveolar ridge in the *(a)* front view and *(b)* incisal view of an anterior maxillary single-tooth site. *(c)* A full-thickness mucoperiosteum flap was reflected to fully expose the alveolar ridge. *(d)* The round-shape bone block was harvested with a bone-harvesting trephine from the apical area, and the recipient site was perforated multiple times. *(e)* The bone block was fixed with a titanium screw. The surrounding area was *(f)* filled with bone particles and *(g)* covered with a collagen membrane. *(h)* Tension-free closure of the wound. *(i)* The fixation screw was removed 8 months after graft surgery. *(j)* Significant horizontal bone gain. *(k)* Implant placement. *(l)* Front view after definitive crown restoration.

were made in the same parasagittal computed tomography slice containing the entire long axis of the fixation screw. Figure 4 shows a diagram of CBCT measurements and the radiologic images of a typical case.

Statistical Analysis

Data are expressed as means (± SD) or numbers (%). The differences in mean values were analyzed with a two-tailed *t* test for independent samples. $P < .05$ was

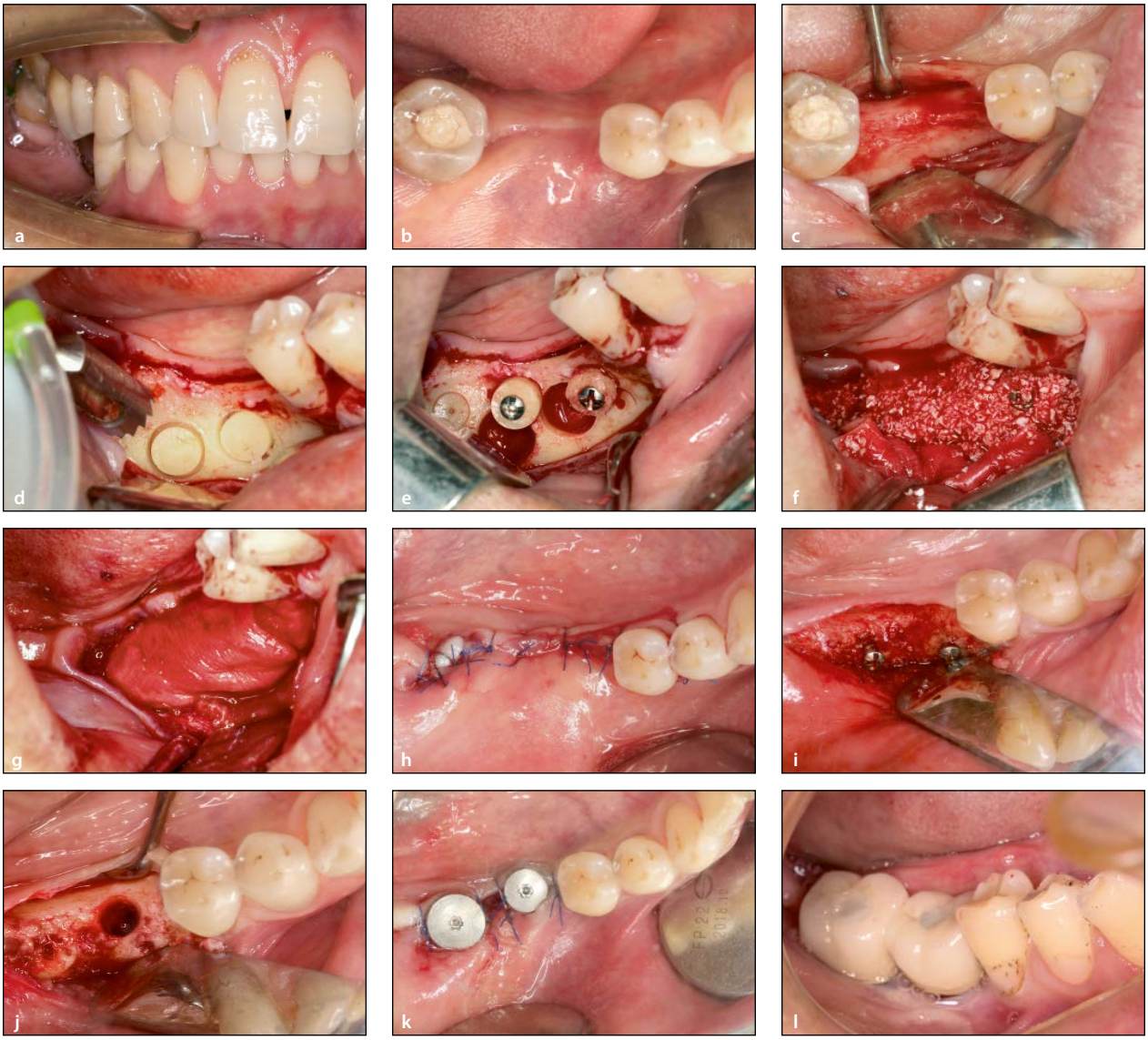

Fig 3 Preoperative images showing the narrow alveolar ridge in the *(a)* front view and *(b)* occlusal view of a posterior mandible with multiple teeth sites. *(c)* A full-thickness mucoperiosteum flap was reflected to fully expose the alveolar ridge. *(d)* Two round-shape bone blocks were harvested with a bone-harvesting trephine from the apical area. *(e)* The bone blocks were fixed with titanium screws. The surrounding area of the bone graft was *(f)* filled with bone particles and *(g)* covered with collagen membranes. *(h)* Tension-free closure of the wound. *(i)* Significant horizontal bone gain was observed 8 months after graft surgery. *(j, k)* Two implants were placed. *(l)* Front view after definitive crown restoration.

considered statistically significant. Statistical analysis was performed using Prism 8 (GraphPad Software).

RESULTS

This study included seven male and nine female patients, who underwent bone augmentation with 22 in situ autogenous bone blocks. Their ages ranged from 19 to 64 years, and the mean age was 36.4 years. The period between graft surgery and implant placement ranged from 5.5 to 13.2 months (mean: 8.4 ± 2.6 months). Among the 22 graft sites, 12 were in the anterior maxilla and 10 were in the mandible.

Wound dehiscence and graft exposure were observed within the first 4 weeks in three grafts (3/22, 13.6%), which were defined as having failed. The augmentation volume at implant placement in levels 2 and 3 was significantly higher in successful cases than in failed cases. The correlation between the alveolar width and graft exposure was further analyzed. There were no significant differences in the pristine width, width at bone grafting, or augmentation volume at bone grafting between the successful and failed cases. These results indicated that the pristine alveolar width and augmentation volume at bone grafting were not correlated with graft exposure. A comparison of the alveolar width between the successful and failed cases is summarized in Table 1.

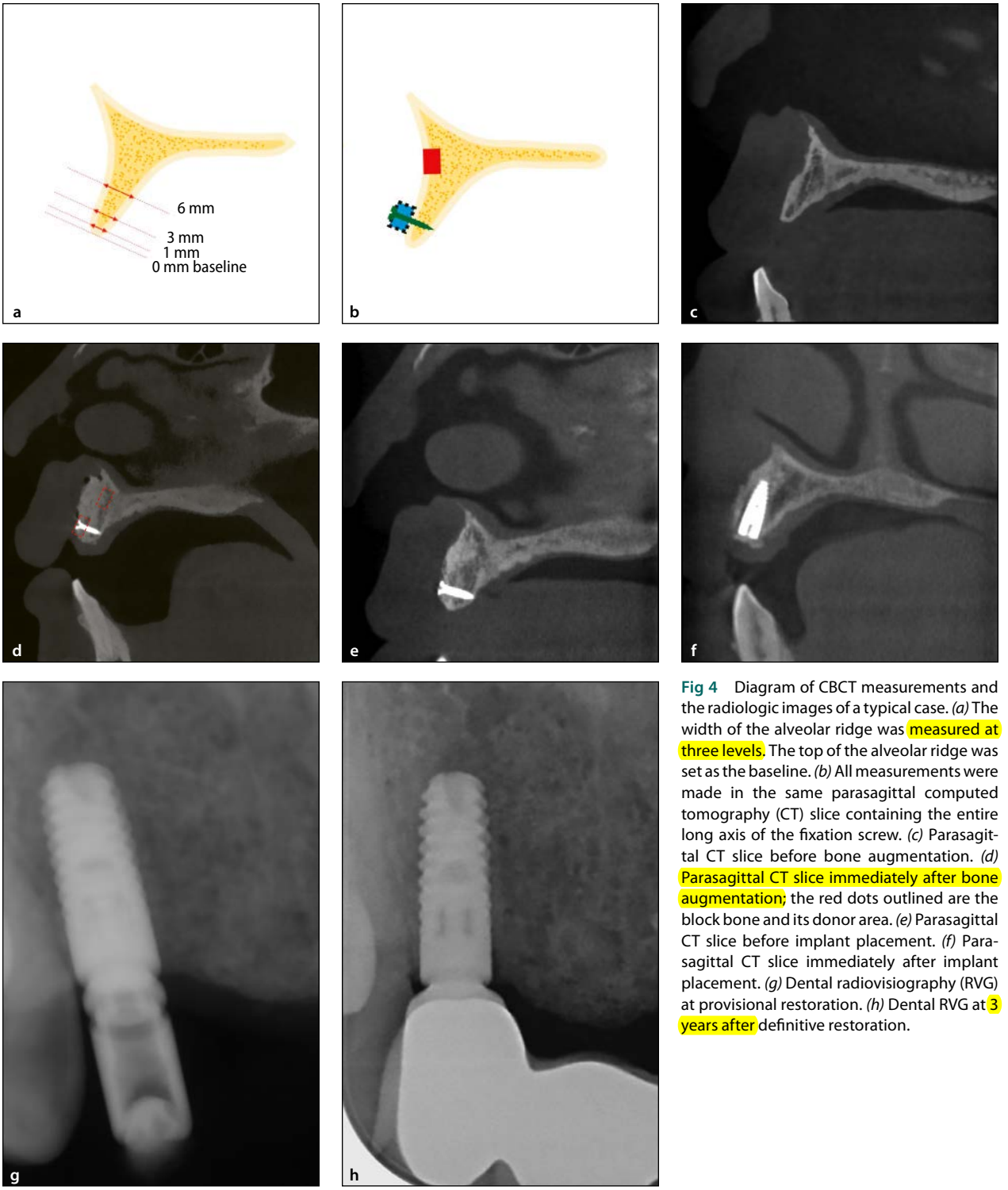

Fig 4 Diagram of CBCT measurements and the radiologic images of a typical case. *(a)* The width of the alveolar ridge was measured at three levels. The top of the alveolar ridge was set as the baseline. *(b)* All measurements were made in the same parasagittal computed tomography (CT) slice containing the entire long axis of the fixation screw. *(c)* Parasagittal CT slice before bone augmentation. *(d)* Parasagittal CT slice immediately after bone augmentation; the red dots outlined are the block bone and its donor area. *(e)* Parasagittal CT slice before implant placement. *(f)* Parasagittal CT slice immediately after implant placement. *(g)* Dental radiovisiography (RVG) at provisional restoration. *(h)* Dental RVG at 3 years after definitive restoration.

Table 1 Comparison of Alveolar Ridge Width Between Successful and Failed Cases

	Level 1				Level 2				Level 3			
	Mean (mm)	SD (mm)	Min–max (mm)	*P* value	Mean (mm)	SD (mm)	Min–max (mm)	*P* value	Mean (mm)	SD (mm)	Min–max (mm)	*P* value
Pristine width												
Successful	2.8	0.4	2.0–3.5	.544	3.9	0.9	2.2–5.3	.728	5.5	1.6	2.7–8.9	.740
Failed	2.6	0.4	2.3–3.1		4.1	1.0	2.7-5.1		5.2	1.4	3.3–6.6	
Width at bone grafting												
Successful	6.8	1.2	4.6–9.2	.223	8.8	1.3	6.6–11.3	.325	9.9	1.4	8.0–12.6	.184
Failed	7.8	1.4	5.9–9.2		9.7	1.9	7.1–11.1		11.3	2.3	8.0–13.2	
Augmentation volume at bone grafting												
Successful	4.1	1.4	1.5–7.2	.216	4.9	1.4	2.6–9.1	.441	4.4	1.7	2.6–9.4	.127
Failed	5.2	1.3	3.6–6.8		5.6	0.9	4.4–6.5		6.1	1.2	4.7–7.6	
Width at implant placement												
Successful	5.5	0.9	4.1–7.8	.012*	7.7	1.0	5.8–9.6	.010*	9.1	1.3	7.2–12.3	.024*
Failed	4.0	0.7	3.0–4.5		5.7	1.7	3.7–7.9		7.1	1.1	5.6–8.2	
Augmentation volume at implant placement												
Successful	2.7	1.1	1.0–4.7	.051	3.8	1.0	2.2–6.5	.003*	3.6	1.2	2.2–6.9	.041*
Failed	1.4	0.5	0.7–2.0		1.6	0.9	0.9-–2.8		1.9	0.3	1.6–2.3	

*Student *t* test, $P < .05$; SD = standard deviation.

Table 2 Comparison of Alveolar Ridge Width Between Cases Involving Anterior Maxilla and Mandible

	Level 1				Level 2				Level 3			
	Mean (mm)	SD (mm)	Min–max (mm)	*P* value	Mean (mm)	SD (mm)	Min–max (mm)	*P* value	Mean (mm)	SD (mm)	Min–max (mm)	*P* value
Pristine width												
Anterior Maxilla	2.7	0.4	2.0–3.5	.554	3.4	0.9	2.2–5.1	.018*	4.5	1.3	2.7–7.0	.007*
Mandible	2.8	0.4	2.0–3.3		4.4	0.6	3.3–5.3		6.4	1.2	4.5–8.9	
Width at bone grafting												
Anterior Maxilla	6.6	1.0	5.7–9.2	.400	8.4	1.3	6.6–11.3	.165	9.5	1.3	8.0–12.1	.294
Mandible	7.1	1.2	4.6–8.8		9.2	1.1	7.5–10.8		10.2	1.4	8.4–12.6	
Augmentation volume at bone grafting												
Anterior Maxilla	3.9	1.3	2.5–7.2	.602	5.0	1.8	2.8–9.1	.844	5.0	2.3	2.6–9.4	.150
Mandible	4.2	1.4	1.5–6.8		4.8	0.9	2.6–5.7		3.8	0.7	2.8–5.1	
Width at implant placement												
Anterior Maxilla	5.6	0.8	4.3–6.7	.712	7.4	1.1	5.8–8.9	.158	8.5	1.0	7.2–10.2	.080
Mandible	5.4	0.9	4.1–7.8		8.0	0.9	7.0–9.6		9.6	1.3	7.4–12.3	
Augmentation volume at implant placement												
Anterior Maxilla	2.9	1.0	1.5–4.7	.594	4.0	1.2	2.7-6.5	.495	4.0	1.5	2.5–6.9	.141
Mandible	2.6	1.1	1.0–4.6		3.7	0.8	2.2-5.1		3.2	0.5	2.2–4.1	

*Student *t* test, $P < .05$; SD = standard deviation.

The alveolar width of the successful cases in the anterior maxilla and mandible at different time points was then compared. Among the 19 grafting sites, 9 were in the anterior maxilla and 10 were in the mandible. There were significant differences in the pristine width at levels 2 and 3 between the anterior maxilla and mandible, which may be attributed to the differences in their natural shapes. On the other hand, no significant differences in the augmentation volume at bone grafting or implant placement were detected between the two groups. A comparison of the alveolar width of the successful cases between different regions is summarized in Table 2.

Table 3 Comparison of Block Bone Resorption Rates

		Level 1	*P* value	Level 2	*P* value	Level 3	*P* value
Region	Anterior maxilla	25.7%	.253	17.3%	.363	16.5%	.673
	Mandible	36.7%		23.5%		18.9%	
Augmentation volume at bone grafting at level 2	< 5 mm	30.8%	.886	14.2%	.036*	14.0%	.152
	> 5 mm	32.2%		27.6%		21.9%	
Overall		31.5%		20.6%		17.7%	

*Student *t* test, $P < .05$.

The block bone resorption rates of the successful cases before implant placement were 31.5%, 20.6%, and 17.7% at levels 1, 2, and 3, respectively (Table 3). No significant differences in the block bone resorption rates were found between the anterior maxillary sites and the mandibular sites at all three levels. The cases were further divided into two groups based on the augmentation volume at bone grafting in level 2 (5 mm as a threshold). The block bone resorption rate of the > 5 mm group was significantly higher than that of the < 5 mm group at level 2 (27.6% vs 14.2%, $P < .05$).

DISCUSSION

This retrospective review of patients with severe horizontal bone defects in a partially edentulous alveolar ridge demonstrated that autogenous bone grafting with in situ block bone is an effective and reliable approach for horizontal bone augmentation in the anterior maxilla and mandible that eliminates second donor site morbidity.

Anitua et al[16] advocated that an onlay bone graft from the lateral wall of the maxillary sinus is a useful and safe approach for horizontal bone augmentation with minimal surgical morbidity. In light of this previous study, in situ autogenous block bone was used for horizontal bone augmentation in the present authors' hospital. This technique prevents potential morbidity at a second surgical site. At the same time, it is simpler and less invasive than traditional methods. Yuan et al[13] recently reported a similar technique called the "in situ bone ring technique" in the anterior maxilla. There is one difference in the surgery procedure. The lateral side of the ridge is recontoured in the present study, while a circular groove is additionally prepared in Yuan et al's study. Nevertheless, a satisfactory horizontal bone gain following the in situ autogenous block bone graft was observed in both studies. Moreover, the present technique was not only applied to the anterior maxilla, but also the mandible. The results suggest that the effects of bone augmentation were similar in these two regions. Therefore, the in situ autogenous block bone technique can also be applied in the mandible.

Wound dehiscence and graft exposure are noteworthy negative impacts of bone augmentation. In the present study, the augmentation volume at implant placement was significantly lower in graft exposure cases, indicating that graft exposure leads to a higher rate of bone resorption. The present data suggested that the thickness of in situ autogenous block bone was not correlated with the rate of graft exposure. Notably, the highest augmentation volume at bone grafting was 9.4 mm. A previous study[17] demonstrated that the flap tension at the time of wound closure is positively associated with the risk of wound dehiscence. Overall, the authors suggest that performing routine periosteal releasing incisions can achieve easy closure of the mucosal flaps on the top of the grafts without tension, thereby reducing the risk of wound dehiscence.

A main drawback of the autogenous block bone graft is the resorption occurring in the early stages of healing.[18] In the present study, the donor site defects and the area surrounding the bone block were filled with xenografts and covered with collagen membranes, which minimized graft resorption during healing.[19–22] Elnayef et al[23] reviewed 15 studies on lateral ridge augmentation and concluded that the bone resorption rate for the block graft technique was 17.9%. The in situ autogenous bone graft resorption rate was consistent with the previous study.[23] Cordaro et al[5] reported that the block bone resorption was higher in mandibular recipient sites. Furthermore, Chappuis et al[24] observed that the bone grafts harvested from the chin maintained their volume better than those from the ramus. In the present study, no significant differences in the block bone resorption were detected between the different regions. The correlation between bone block thickness and the bone resorption was also investigated, which has been largely neglected in previous studies. A 5-mm alveolar width gain at level 2 was set as a threshold value, representing the bone graft thickness. The present study found that the thicker block bones were correlated with a higher bone resorption rate. A 3- to 4-mm horizontal bone gain could be considered sufficient for implant placement. On the other hand, a thicker bone graft may be associated with greater difficulties in achieving stable fixation and a tension-free

closure. Therefore, an in situ bone graft thickness of approximately 4 to 5 mm is recommended.

Alveolar ridge augmentation with in situ autogenous block bone has many advantages. Most importantly, the need for a second donor site and its accompanying morbidity is avoided. Furthermore, the medullary cavity is exposed following in situ block bone harvesting, which can provide a source of blood and osteoblasts for bone formation and remodeling. However, there are still certain limitations associated with the use of in situ autogenous block bone. First, it cannot be applied to the posterior maxillary edentulous ridge due to the presence of the maxillary sinus. In addition, it is difficult to apply in the mandibular premolar region, due to the risk of possible injury to the mental nerve. Second, the size of the bone block is limited by the roots of the adjacent teeth and the cortical bone thickness. In case of insufficient bone on the apical side of the edentulous alveolar ridge, the bone block would be harvested from the mandibular symphysis or ramus instead.

The potential limitations in this study were the small sample size and the short study period. Furthermore, no randomization was performed. A prospective randomized clinical trial with a larger sample size is warranted to evaluate the peri-implant health, marginal bone loss, implant survival, and esthetic effects at a longer follow-up period, and to verify the findings reported in this study.

CONCLUSIONS

Alveolar ridge augmentation using in situ autogenous block bone can achieve satisfactory outcomes in horizontal bone augmentation with a lower risk of complications and a shorter surgery time. This technique could be applied to narrow edentulous ridges in the anterior maxilla and mandible to provide sufficient ridge width prior to implant placement.

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