Horizontal Bone Augmentation Using Autogenous Block Grafts and Particulate Xenograft in the Severe Atrophic Maxillary Anterior Ridges: A Cone-Beam Computerized Tomography Case Series

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The aim of the present study was to use cone-beam computerized tomography (CBCT) to assess horizontal bone augmentation using block grafts, harvested from either the iliac crest (IC) or mandibular ramus (MR) combined with particulate xenograft and a collagen membrane for in the severe maxillary anterior ridge defects (cases Class III-IV according to Cadwood and Howell's classification). Fourteen healthy partially edentulous patients requiring extensive horizontal bone reconstruction in the anterior maxilla were selected for the study. Nineteen onlay block grafts (from IC or MR) were placed. The amount of horizontal bone gain was recorded by CBCT at 3 levels (5, 7, and 11 mm from the residual ridge) and at the time of bone grafting as well as the time of implant placement (≈5 months). Both block donor sites provided enough ridge width for proper implant placement. Nonetheless, IC had significantly greater ridge width gain than MR (Student *t* test) (4.93 mm vs 3.23 mm). This was further confirmed by nonparametric Mann-Whitney test ($P = .007$). Moreover, mean pristine ridge and grafted ridge values showed a direct association (Spearman coefficient of correlation = .336). A combination of block graft, obtained from the IC or MR, combined with particulate xenograft then covered with an absorbable collagen membrane is a predictable technique for augmenting anterior maxillary horizontal ridge deficiency.

Key Words: bone graft, mandibular ramus, iliac crest, horizontal bone augmentation, block graft

INTRODUCTION

Ridge resorption resulting from tooth loss often compromises ideal implant placement. Hence, in these situations bone augmentation is often recommended to provide the required ridge width and height. Generally speaking, guided bone regeneration,[1] ridge splitting, block graft, or distraction osteogenesis have all been applied for this purpose and have shown some promising results.[2,3] Nonetheless, autogenous block graft remains one of the main methods for reconstructing severely resorbed maxilla.[4] These block grafts can be harvested from intraoral or extraoral sites. Although endochondral or intramembranous type block grafts can be used, endonchondral block grafts, such as iliac crest (IC), undergo the creeping substitution process, which takes longer and results in a greater amount of bone resorption. Nyström et al[5] observed a reduction in width of IC onlay block grafts from 12.2 mm to 8.7 mm at 12 months. On the contrary, intramembranous block grafts, such as mandibular ramus (MR) or chin, undergo reverse creeping substitution, which means it takes longer for the graft to resorb; hence, it can hold space for the bone to fill in for a longer period.[6] When this type of graft was used to graft the anterior maxilla, 60% resorption was reported.[7] Similar findings were also observed in an animal study (56% resorption of intramembranous blocks).[8] However, endonchondral bone blocks display a more complete graft

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resorption during healing.[8] In addition, intraoral block grafts are more convenient for clinicians to harvest and use for horizontal bone augmentation. Furthermore, harvesting grafts from intraoral sites reduces costs, and the procedure is often performed as an outpatient procedure.[9] In contrast, extraoral sources provide larger blocks and are often selected for more extensive reconstructions.

After block grafts are fixed, particulate grafts are often added for filling the gaps and augmenting the site. Bovine-derived bone substitute (Bio-Oss, GeistlichPharma AG, Wolhousen, Switzerland), an osteoconductive material, has shown to be predictable in augmenting alveolar ridges horizontally[10–12] as it not only acts as a space maintainer but also holds space longer because it resorbs very slowly.[13] A recent randomized controlled trial compared the use of autogenous block grafts with or without particulate anorganic bovine bone (ABB).[14] Results from this study demonstrated that packing ABB around block grafts minimized block graft resorption.[14] Moreover, in order to exclude unwanted cells into the wound, a membrane is often used to protect the grafts.[15,16] Although some authors have shown the inefficacy of using membranes when performing onlay block grafts,[17] others have noted a higher membrane exposure rate and subsequent infection with the use of membrane.[7,18] However, compared with nonresorbable membranes, bioabsorbable membranes have made the process easier as they avoid the drawbacks associated with nonresorbable membranes while achieving similar outcomes.[19,20] Hence, collagen and other bioabsorbable membranes have often been used as tissue barriers for bone augmentation to minimize graft resorption and promote primary wound closure.[14,21]

The aim of this study was to use cone-beam computerized tomography (CBCT) to evaluate the amount of horizontal bone gain achieved by use of the iliac crest or mandibular ramus, particulate xenograft, and a collagen membrane to correct severe maxillary anterior ridge defect.

Materials and Methods

Fourteen healthy partially edentulous patients requiring extensive horizontal bone reconstruction in the anterior maxilla (class III-IV atrophy according to Cawood and Howell classification[22]) were enrolled in this study from November 2011 to September 2012. Patients enrolled in the study had to meet the following inclusion criteria: age between 18 and 85 years, no systemic diseases or conditions known to alter bone metabolism, and adequate oral hygiene. Patients were excluded if they were pregnant, smokers, or taking medications known to modify bone metabolism or if they had had taken antibiotics for more than 2 weeks in the previous 3 months. Overall, 19 onlay block grafts, either IC or MR, were placed. For isolated small defects, MR was used; for cases with extensive atrophy, IC was used.

Harvesting procedures of the ramus block graft

Under local anesthesia and intravenous conscious sedation, an incision was made in the posterior mandible following the external oblique ridge. A full-thickness flap was reflected, exposing the lateral aspect of the ramus. Rectangular grafts were harvested using fissure burs to delineate the block and curved chisels and mallet to detach the graft. Sharp edges around the blocks were subsequently smoothed with a large bur.

Harvesting procedures of the iliac crest block graft

Under general anesthesia with local anesthesia, an incision was performed in the anterior iliac crest. A rectangular-shaped bone block was marked with a fissure bur and harvested using a saw blade and then harvested using a chisel. The amount of bone harvested was according to the patient's needs.

Recipient site preparation

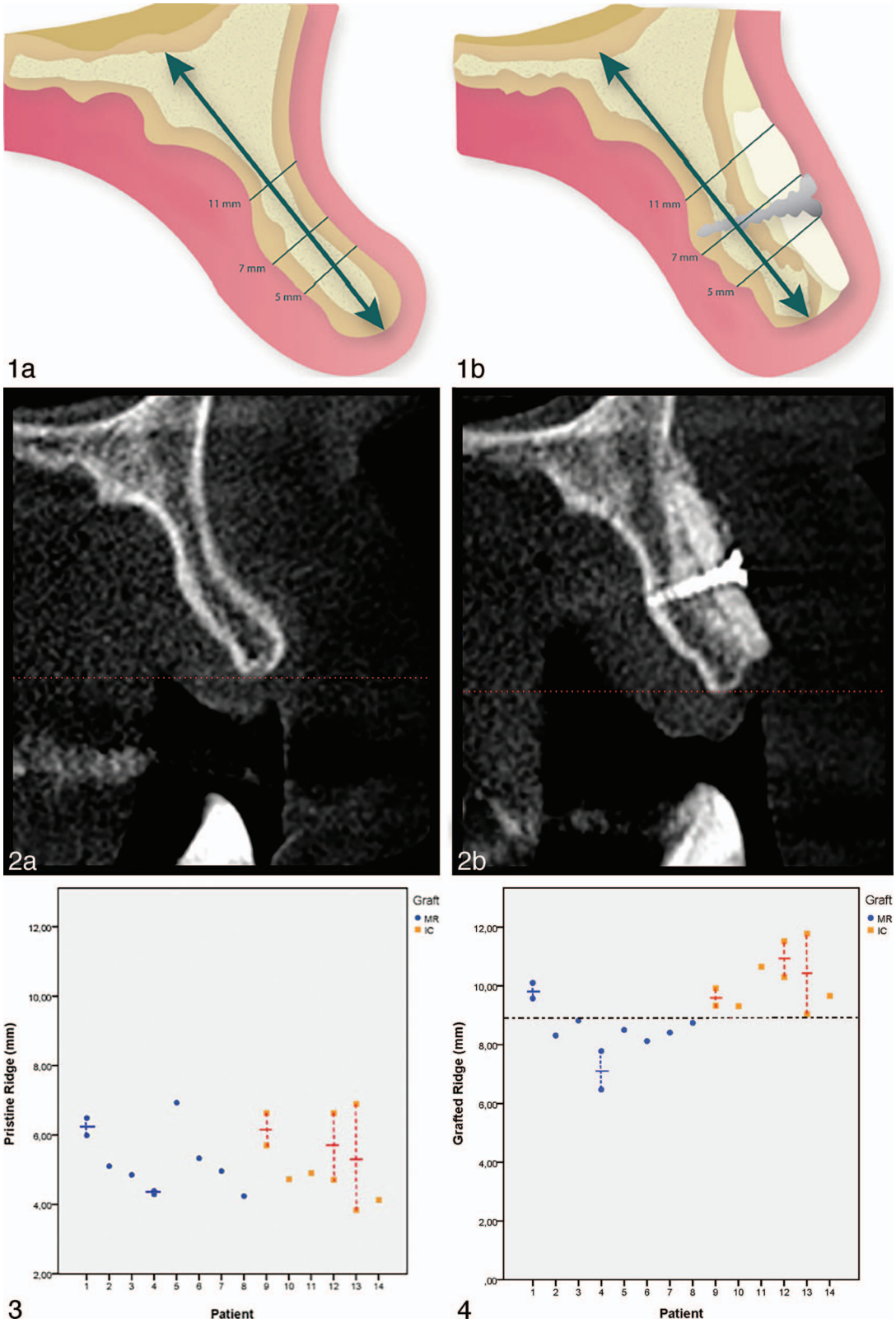
At the recipient site, a midcrestal incision was performed with intrasulcular and vertical releasing incisions, after which a full-thickness flap was reflected. The block graft was adapted to the recipient sites and anchored to the residual ridge by 1 or 2 titanium fixation screws 1.5 mm in diameter (Level One 1.5 Neuro, KLS Martin LP, Jacksonville, Fla). After achieving stability of the graft, sharp edges were smoothed using a fissure bur. Bio-Oss , a bone substitute of bovine origin, was packed around the pristine ridge to act as a recipient bed and fill any voids. Then, a collagen absorbable membrane (Bio-Gide, Geistlich-Pharma AG) was placed over the graft. Finally, the buccal flap was scored to ensure a tension-free closure, and the flaps were sutured with both absorbable and nonresorbable sutures (Cytoplast Suture, Osteogenics Biomedical Inc, Lubbock, Tex).

CBCT examination

Image from the maxillary arch of the patients were acquired by CBCT i-CAT Model 17–19 (Imaging Sciences International LLC, Hatfield, Pa). The imaging parameters were set at 120 kVp, 18.66mAs, scan time 20 seconds, resolution 0.4 mm, and a field of view that varied based on the scanned region. The amount of horizontal bone was measured before bone-grafting surgery and at the time of implant placement (≈5 months) (Figure 1). All the measurements were performed by the same calibrated examiner (A.M.). Presence of teeth adjacent to or opposing the edentulous span was required to identify the position measured at both time points. Each graft was plotted on the sagittal images at approximately the midface using the i-CAT Vision (Imaging Sciences International LLC) (Figure 2). Then, a perpendicular line was drawn following residual bone inclination. Subsequently, 3 horizontal lines recorded bone width at 5, 7, and 11 mm from the crest. In cases where the titanium fixation screw blocked an accurate measurement, the measure was performed at the closest clear area to the fixation screw. Error in radiographic assessment was determined through repeated measurements of 5 randomly selected patients. The mean difference was 0.5 $\pm$ 0.25 mm between the measurements.

Statistical analysis

Statistical analysis was performed using SPSS (version 19, IBM, Chicago, Ill). Because of the small sample size, statistical analysis was based on a descriptive analysis of both groups. A Mann-Whitney test was used to contrast the influence of type of graft.



Figures 1–4. Figure 1. (a) Depiction of the measurements at all levels for a pristine ridge. (b) Depiction of the measurements at all levels for a grafted ridge. **Figure 2.** (a) Sagittal view of the measured ridge before bone grafting surgery plotted by cone-beam computerized tomography (CBCT). (b) Sagittal view of the measured ridge before implant placement (≈5 months after the grafting surgery) plotted by CBCT. **Figure 3.** Plot for pristine ridge for patients with mean values for paired data. **Figure 4.** Plot for grafted ridge for patients with mean values for paired data.

The correlation between mean values of pristine ridge and grafted ridge was analyzed using the Spearman test.

Limitations of the study

Possible bias may arise from the present study because of its retrospective nature. Neither the surgical procedures nor patient enrollment were randomized or masked. All the patients were enrolled from a cohort of consecutively treated patients who fulfilled the inclusion criteria. Furthermore, some bias may emerge from the measurements as only 2 CBCTs were taken (1 before the surgery and the other before implant placement [≈5 months]) to avoid an unnecessary radiograph exposure to the patients. In any event, we aimed to report horizontal bone augmentation and not resorption of these types of grafts, which has already been reported previously[23–25]

Furthermore, precautions must be exercised when interpreting the study results because of the small sample size. However, in order to carry out a thorough study and overcome the limitations of a retrospective study, we selected only cases that would likely produce, with minimum risk of bias, precise results.

Results

Table 1 displays the mean width of each ridge from all the levels measured (pristine and grafted). Mean values for pristine ridge at each measured level (5, 7, and 11 mm) were 4.41 mm, 5.31 mm, and 5.91 mm, respectively. An increase in width was found for grafted ridge: 8.63 mm, 9.22, mm and 9.72 mm for levels 5, 7, and 11 mm, respectively. We included 5 patients with 2 grafts each, so to control the subject factor, we used the mean value obtained of both grafts for these subjects (Table 2). Figures 3 and 4 present the results for pristine ridge and grafted ridge, respectively, and show the mean values of the paired data.

Data showed that the IC group had significantly greater ridge width gain than the MR group in the mean value obtained from the 3 levels of grafted ridges measured. The Student *t* test for independent samples confirmed this finding. Nonetheless, because of the small sample size, the nonparametric test Mann-Whitney (Table 3) was also used to assess the influence of type of graft, and the same result ($P = .007$) was found. As expected, no difference was identified in the pristine ridge ($P = .897$). At baseline, no difference was noted at pristine ridge (5.25 mm and 5.16 mm for the MR and IC groups, respectively). However, the IC group had a mean horizontal bone gain of 4.93 mm vs 3.23 mm in the MR group. Nonetheless, both procedures achieved proper ridge width (≥5 mm) for implant placement.

Mean pristine ridge and grafted ridge values showed a direct association. In other words, the higher the values obtained in pristine ridge the higher the values in grafted ridge. The Spearman coefficient of correlation was .336, even though this was not found to be significant ($P = .159$).

Discussion

Results obtained from this study suggest that IC and MR block grafts, in combination with ABB and then covered with an absorbable collagen membrane, are a predictable approach for augmenting severely reabsorbed anterior maxilla horizontal deficient ridges. Generally speaking, the IC group had a gain of 4.93 mm bone width, while the MR group had a mean gain of 3.23 mm when assessed by CBCT. Consequently, a statistically significant difference was found between both groups, thus showing a clear tendency for the IC group to obtain greater horizontal bone augmentation ($P = .007$), though both procedures ended up achieving proper ridge width (≥5 mm) for implant placement. Hence, the results obtained from this study suggest that the source of bone block does not matter, as long as the voids are filled and the site is secured with a barrier membrane under the primary wound closure. It is important to note that this study had a short follow-up and, thus, further long-term studies are needed to verify this finding as endochondral origin bone takes longer to resorb than intramembranous origin block graft. In this sense, it is also worth mentioning that other factors (eg, graft size) might determine the final bone augmentation achieved and the resorption rate over time. As a result, IC might result in a greater amount of bone gain compared with other grafts because of the size of the blocks that can be obtained. As mentioned previously, clinical trials with a longer follow-up are needed to validate this assumption.

Interestingly, our study found out that IC had significant more bone fill than MR ($P = .007$) despite the higher graft resorption expected from the IC.[5,26,27] Because both block grafts resulted in a similar outcome for reconstruction of the anterior maxilla, the choice between the 2 depends on other factors. In contrast to intraoral block grafts, IC bone blocks provide a much larger amount of bone for horizontal augmentation. The choice of donor site was based not only on the residual ridge width but also on the amount of graft needed to reconstruct the sites. Hence, in larger areas or when more bone graft is needed, clinicians often opt to use IC instead of MR. However, MR has higher patient acceptance because it is less invasive and is easier to harvest.[28]

It is important to note that adding an ABB to fill the voids created between the graft and recipient bed might minimize bone graft resorption because of its osteoconductive properties and the slow graft resorption rate as demonstrated in many previous publications.[14,21,29,30]

Furthermore, placement of a collagen barrier membrane over the graft sites might exclude unwanted cells from the wound, protect the wound, and therefore promote bone regeneration.[15] From the histologic and immunohistochemical standpoints no difference was found between the sites treated with or without membrane when block graft was used as the graft materials..[31,32] However, recent studies have shown that using a membrane during block graft procedures actually minimizes bone resorption.[14,31,32] Our study did not aim to show the efficacy of placing a barrier membrane and its influence in bone resorption. However, we noted that the additional use of ABB and absorbable membrane had successful outcomes for proper implant placement compared with the results in previous studies where these biomaterials were not used.[5,7]

The potential concerns in this study are the small sample size and short study period; in addition, no randomization was performed. Therefore, future studies with randomization, a

Table 1

Mean bone width and standard deviations of the measured spans for pristine ridge and grafted ridge

Donor Site	Graft (N)	Patient (N)	Pristine Ridge (mm)	SD	Grafted Ridge (mm)	SD
Mandibular ramus	1	1	5.99	0.37	9.57	1.13
	2		6.49	1.49	10.10	0.94
	3	2	5.10	1.18	8.31	0.79
	4	3	4.85	0.03	8.82	0.24
	5	4	4.29	0.19	7.78	0.87
	6		4.39	0.28	6.47	0.01
	7	5	6.93	3.39	8.50	1.64
	8	6	5.33	0.73	8.12	0.18
	9	7	4.96	1.71	8.41	0.60
	10	8	4.24	0.51	8.74	.94
Iliac crest	11	9	6.63	3.12	9.33	1.83
	12		5.70	1.81	9.91	0.16
	13	10	4.72	0.76	9.31	1.07
	14	11	4.90	2.40	10.65	1.76
	15	12	4.71	0.43	10.30	1.79
	16		6.63	1.93	11.51	1.78
	17	13	6.90	0.42	11.78	0.87
	18	14	3.83	0.69	9.04	0.76
	19		4.13	1.93	9.66	1.59

Table 2

Mean bone width and for each subject included in the present study for pristine ridge and grafted ridge

Donor Site	Patient (N)	Pristine Ridge (mm)	Grafted Ridge (mm)
Mandibular ramus	1	6.24	9.84
	2	5.10	8.31
	3	4.85	8.82
	4	4.34	7.13
	5	6.93	8.50
	6	5.33	8.12
	7	4.96	8.41
	8	4.24	8.74
Iliac crest	9	6.17	9.62
	10	4.72	9.31
	11	4.90	10.65
	12	5.67	10.91
	13	5.37	10.41
	14	4.13	9.66

Table 3

Differences in terms of horizontal bone augmentation between iliac crest grafted ridges and mandibular ramus grafted ridges 5 months after grafting surgery

	Pristine Ridge (mm)	Grafted Ridge (mm)
Donor Site		
Mandibular ramus		
Mean	5.25	8.48
Median	5.03	8.45
SD	0.92	0.76
N	8	8
Iliac crest		
Mean	5.16	10.09
Median	5.13	10.03
SD	0.73	0.65
N	6	6
Student *t* test	$P = 0.846$	$P = 0.001$
Mann-Whitney test	$P = 0.897$	$P = 0.007$

larger sample size, and a longer follow-up are needed to verify the findings reported in this study.

Conclusion

Within the limitations of the present study, a combination of block graft obtained from the IC or MR, combined with particulate xenograft and then covered with an absorbable collagen membrane is a predictable technique in augmenting anterior maxillary horizontal ridge deficiency.

Abbreviations

ABB: anorganic bovine bone
CBCT: cone-beam computerized tomography
IC: iliac crest
MR: mandibular ramus

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