Horizontal Bone Augmentation using Autogenous Block Grafts and Particulate Xenograft in the Severe Atrophic Maxillary Anterior Ridges: A Cone-beam Computed tomography Case Series

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Abstract

Purpose: the aim of the present study was to use cone-beam computed tomography (CBCT) to assess horizontal bone augmentation using block grafts, harvested from either 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)].

Material and methods: An overall of 14 healthy partially edentulous patients requiring extensive horizontal bone reconstruction in the anterior maxilla were selected for the study. A total of 19 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).

Results: 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 is further confirmed by non-parametric Mann-Whitney test (p=0.007) due to the small sample size. Moreover, mean "pristine ridge" and "grafted ridge" values showed a direct association (Spearman coefficient of correlation= 0.336).

Conclusion: A combination of block graft, obtained from with iliac crest or mandibular ramus, particulate xenograft then covered with an absorbable collagen membrane is a predictable technique for augmenting anterior maxillary horizontal ridge deficiency.

Keywords: 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 are often recommended to provide the required ridge width and height. Generally speaking, guided bone regeneration (GBR) [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 reconstruction of the severe resorbed maxilla [4]. These block grafts can be harvested either from intraoral or extraoral sites. The origin of the block grafts can be of endochondral or intramembranous type. While endonchondral block grafts such as iliac crest (IC) undergo the “creeping substitution” process, which takes longer and have greater amount of bone resorption. Nyström et al. observed a reduction in width of IC onlay block grafts, from 12.2 mm to 8.7 mm at 12 months [5]. On the contrary, intramembranous block grafts such as mandibular ramus (MR) or chin undergo “reverse creeping substitution”, which it takes longer for the graft to resorb hence it can hold space longer for the bone to fill in [6]. It was reported 60% of resorption when this type of graft was used to graft the anterior maxilla[7]. Similar findings were also observed in an animal study (56% of resorption of intramembranous blocks) [8]. However, endonchondral bone blocks display a more complete graft resorption during healing [8]. In addition, intraoral block grafts are more convenient for clinician to harvest and use for horizontal bone augmentation. Furthermore, harvesting grafts from intraoral sites reduce costs and the procedure is often performed as an outpatient procedure [9]. On the contrary, extraoral sources provide larger blocks and it is often selected for more extensive reconstructions.

After block grafts are fixed, particulate grafts are often added for filling the gaps and also augmenting site more. 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] since it does not only act as a space maintainer but also holds space longer term since 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 by 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 also linked higher membrane exposure rate and subsequent infection with the usage of membrane [7, 18]. However, developing the bioabsorbable membranes have made it easier when compared to non-resorbable membranes since bioabsorbable membranes can overcome the drawbacks associated with non-resorbable membranes while achieving the similar outcomes [19, 20]. Hence, bioabsorbable membranes, such as collagen ones, have often been used as tissue barriers for bone augmentation to minimize graft resorption and to promote primary wound closure [14, 21].

Henceforth, the aim of this study was to evaluate the amount of horizontal bone gain, by cone-beam computed tomography (CBCT), when iliac crest or the mandibular ramus, particulate xenograft and a collagen membrane for the correction of severe maxillary anterior ridge defect.

Material and methods

A total of 14 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 must meet the following inclusion criteria: age between 18 and 85 year old, no systemic diseases or conditions known to alter bone metabolism, and exhibit adequate oral hygiene. Patients were excluded if they were pregnant, smokers, taking medications known to modify bone metabolism or had taken antibiotics for more than two weeks in the past 3 months. Overall, nineteen 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 smoothened with a large bur.

Harvesting procedures of the iliac crest block graft

Under general anesthesia with local anesthesia and 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 patient´s needs.

Recipient site preparation

At the recipient site, a mid-crestal incision was performed with intra-sulcular 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 one or two 1.5mm diameter titanium fixation screws (Level One 1.5 Neuro, KLS Martin LP, Jacksonville, FL, USA). After achieving stability of the graft, sharp edges were smoothened using a fissure bur. A bone substitute of bovine origin (Bio-Oss®, GeistlichPharma AG, Wolhousen, Switzerland) was packed around the pristine ridge acting as a “recipient bed” to fill any voids. Then, a collagen absorbable membrane (Bio-Gide, GeistlichPharma AG, Wolhousen, Switzerland) 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 non-resorbable sutures (Cytoplast™ Suture, Osteogenics Biomedical Inc., Lubbock, TX, USA).

Cone beam computed tomography (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, USA). The imaging parameters were set at 120kVp, 18.66mAs, scan time 20 seconds, resolution 0.4 mm, and a field of view (FOV) which varied based on the scanned region. The amount of horizontal bone was measured prior to bone grafting surgery and at the time of implant placement (≈ 5 months) (Figure 1). All the measurements were performed by the same calibrated examiner (AM). Presence of adjacent or opposing teeth to the edentulous span was required to identify the position measured at both time points. Each graft was plotted on the sagittal images approximately at the mid-face of it using the i-CAT Vision (Imaging Sciences International LLC, Hatfield, PA, USA)(Figure 2). Then, a perpendicular line was drawn following residual bone inclination. Subsequently, three horizontal lines recorded bone width at 5, 7 and 11 mm from the crest. In the cases where the titanium fixation screw blocked an accurate measurement, the measure was performed at the closest clear area to the fixation screw. The error in radiographic assessment was determined through repeated measurements of five randomly selected patients. The mean difference was 0.5 ± 0.25 mm between the measurements.

Statistic analysis

The statistic analysis was performed using SPSS (v. 19) (IBM, Chicago, IL, USA). Due to the small sample size, it was based on a descriptive analysis of both groups. Mann-Whitney test was used to contrast the influence of "type of graft". The correlation between mean values of "pristine ridge" and "grafted ridge" was carried out using the Spearman test.

Limitations of the study

Possible bias may arise from the present study due to 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 fulfilling the inclusion criteria. Furthermore, some bias may emerge from the measurements as were only taken two CBCT (one prior the surgery and other before implant placement [≈ 5 months]) in order to avoid taking an unnecessary extra radiograph exposition to the patients. Anyhow, we aimed to report horizontal bone augmentation and not the resorption of these types of grafts, which has already been reported previously [23-25].

Furthermore, precautions must be exercised when interpreting the results of this study due to the small sample size. However, in order to carry out a thorough research, in an attempt to overcome the limitations that entails a retrospective study, we selected only cases that may reproduce, 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"). The mean values for "pristine ridge" at each measured level (5, 7 and 11mm) were 4.41 mm, 5.31 mm and 5.91 mm, respectively. An increased in width was found for "grafted ridge" and there were 8.63 mm, 9.22 mm and 9.72 mm for the levels 5, 7 and 11 mm, respectively. Since we included 5 patients with two grafts each, in order to control the subject factor, we have 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, showing the mean values of the paired data.

Data showed the IC group had significantly greater ridge width gain than MR in the mean value obtained from the 3 levels "grafted ridges" measured. The t-student test for independent samples confirmed this finding. Nonetheless, due to the small sample size, the non-parametric test Mann-Whitney (Table 3) was also used to assess the influence of "type of graft", same result (p=0,007) was found. On the contrary, as expected, in the "pristine ridge" no difference was identified (p=0,897). At baseline, no difference was noted at pristine ridge (5.25 mm and 5.16 mm for the MR and IC groups, respectively). However, IC group had a mean horizontal bone gain of 4.93 mm versus 3.23 mm in MR group. Nonetheless, both procedures ended up achieving proper ridge width (≥5mm) 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 0,336. Even though, this was not found to be significant (p=0,159).

Discussion

Results obtained from this study suggested that IC and RM block grafts in combination with ABB then covered with an absorbable collagen membrane is 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 statistical significant difference was found between both groups showing a clear tendency for the IC group to obtain greater horizontal bone augmentation (p=0,007). Even though, both procedures ended up achieving proper ridge width (≥5mm) for implant placement. Hence, the results obtained from this study suggested that it does not really matter the source of bone block, although IL lasts longer than MR, 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, since endochondral origin bone takes longer than intramembranous origin block graft to resorb. In this sense, it is also worthy to be mentioned that other factors (e.g. graft size) might determine the final bone augmentation achieved and also the resorption rate along the time. As consequence to this fact, IL might end up in a greater amount of bone gain compared to other grafts due to the size of the blocks that can be obtained. As aforementioned, longer follow-up clinical trials are needed to validate this assumption.

Interestingly, our study found out that IC had significant more bone fill than MR (p=0.007) despite the higher graft resorption is expected from the IC [5,26,27]. Since both block grafts resulted similar outcome for reconstruction of the anterior maxilla, the choice between the two depends on other factors. Contrary to the use of intraoral block grafts, IC bone blocks provide a much large amount of bone for horizontal augmentation. The choice of donor site was not only based on the residual ridge width, but also the amount of graft needed to reconstruct the sites. Hence, in the larger area or the demand for more bone graft, clinician often opted to use the IC instead of MR. However, MR has higher patient acceptance rate due to its less invasiveness and easiness for harvesting [28].

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

Furthermore, the placement of a collagen barrier membrane over the graft sites might exclude unwanted cells from the wound hence protect the wound and therefore promote the bone regeneration[15]. Although from the histological 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 the additional use of 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, it is noticed that additional use of ABB and absorbable membrane revealed successful outcomes for proper implant placement when compared to previous studies where none of this biomaterials were used [5, 7].

The potential concerns existed in this study were: small sample size, short study period and no randomization performed. Therefore, future studies with randomization of larger sample size and longer follow-up is 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 iliac crest or mandibular ramus, particulate xenograft and then covered with an absorbable collagen membrane is a predictable technique in augmenting anterior maxillary horizontal ridge deficiency.

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Table 1. Means bone width and standard deviations (SD) of the measured spans for "pristine ridge" and "grafted ridge"

Donor site	Graft (N)	Patient (N)	Pristine ridge (mm)	SD	Grafted Ridge (mm)	SD
MR	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
IC	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

MR= mandibular ramus; IC= iliac crest; SD= standard deviation; N= number

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)
MR	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
IC	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

MR= mandibular ramus; IC= iliac crest; N= number

Table 3. Differences in terms of horizontal bone augmentation (mm) between Iliac crest (IL) grafted ridges and mandibular ramus (RM) grafted ridges 5 months after grafting surgery

			Pristine Ridge (mm)	Grafted Ridge (mm)
Donor site	MR	Mean	5,25	8,48
		Median	5,03	8,45
		S.D.	0,92	0.76
		N	8	8
	IC	Mean	5,16	10,09
		Median	5,13	10,03
		S.D.	0,73	0,65
		N	6	6
Student test			P=0,846	P=0,001
Mann-Whitney test			P=0,897	P=0,007

MR= mandibular ramus; IC= iliac crest; SD= standard deviation; N= number

LEGENDS

Figure 1. 1.A. Depiction of the measurements at all the levels for a “pristine ridge” **1.B.** Depiction of the measurements at all the levels for a “grafted ridge”

Figure 2. 2.A. Sagittal plotted by cone beam computed tomography (CBCT) of the measured ridge prior to bone grafting surgery **2.B.** Sagittal plotted by cone beam computed tomography (CBCT) of the measured ridge prior to implant placement (≈ 5 months after the grafting surgery).

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

Figure 1
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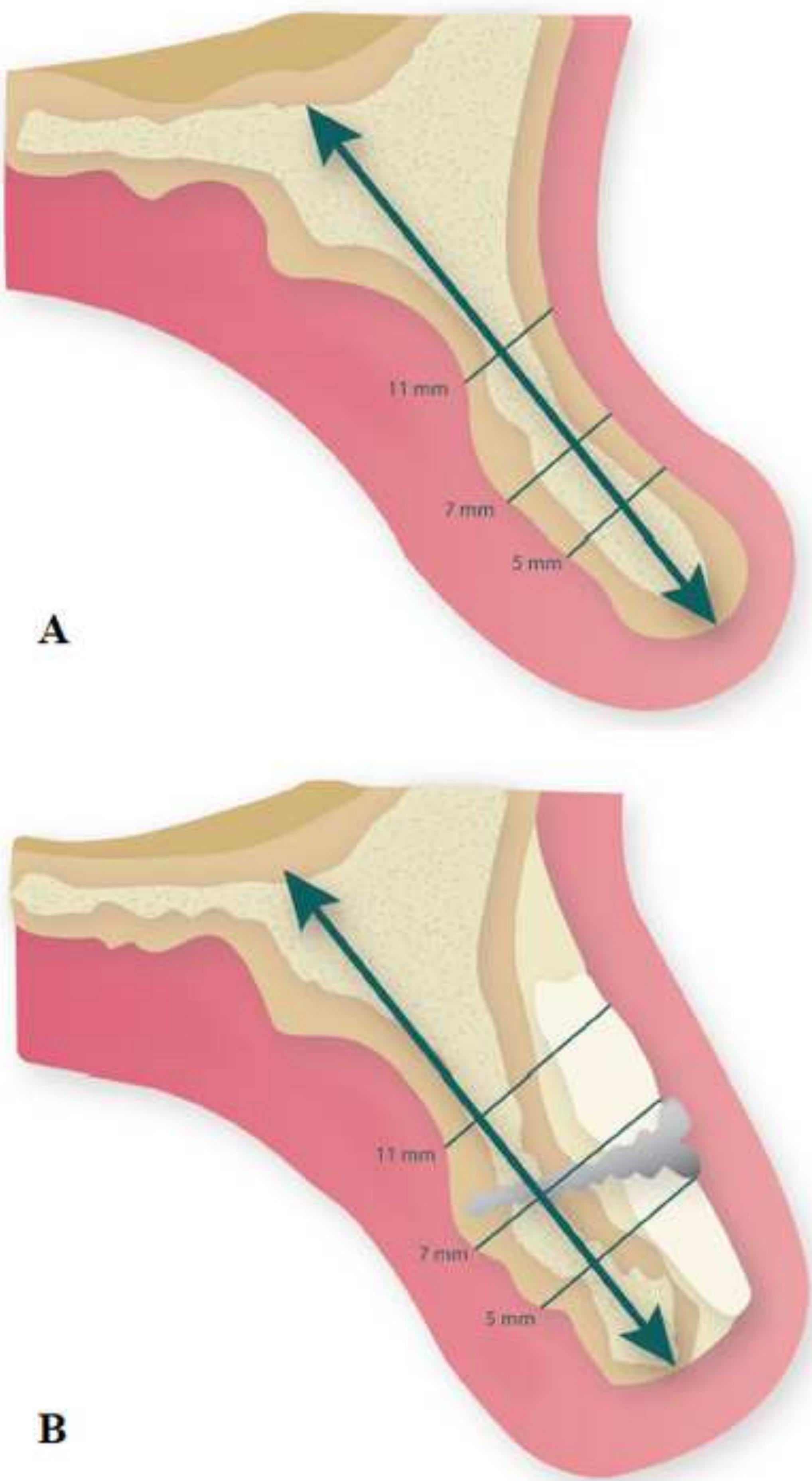

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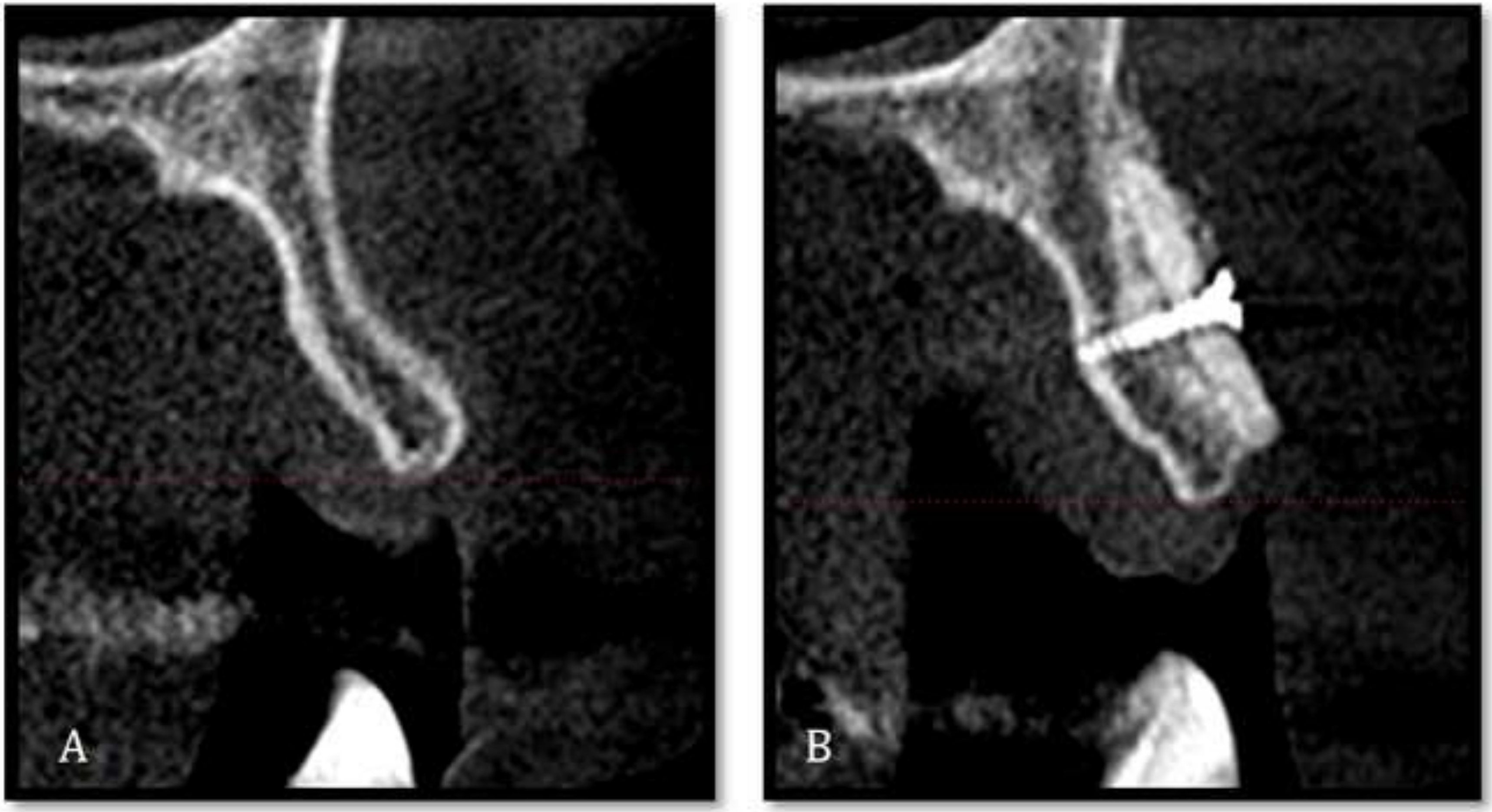

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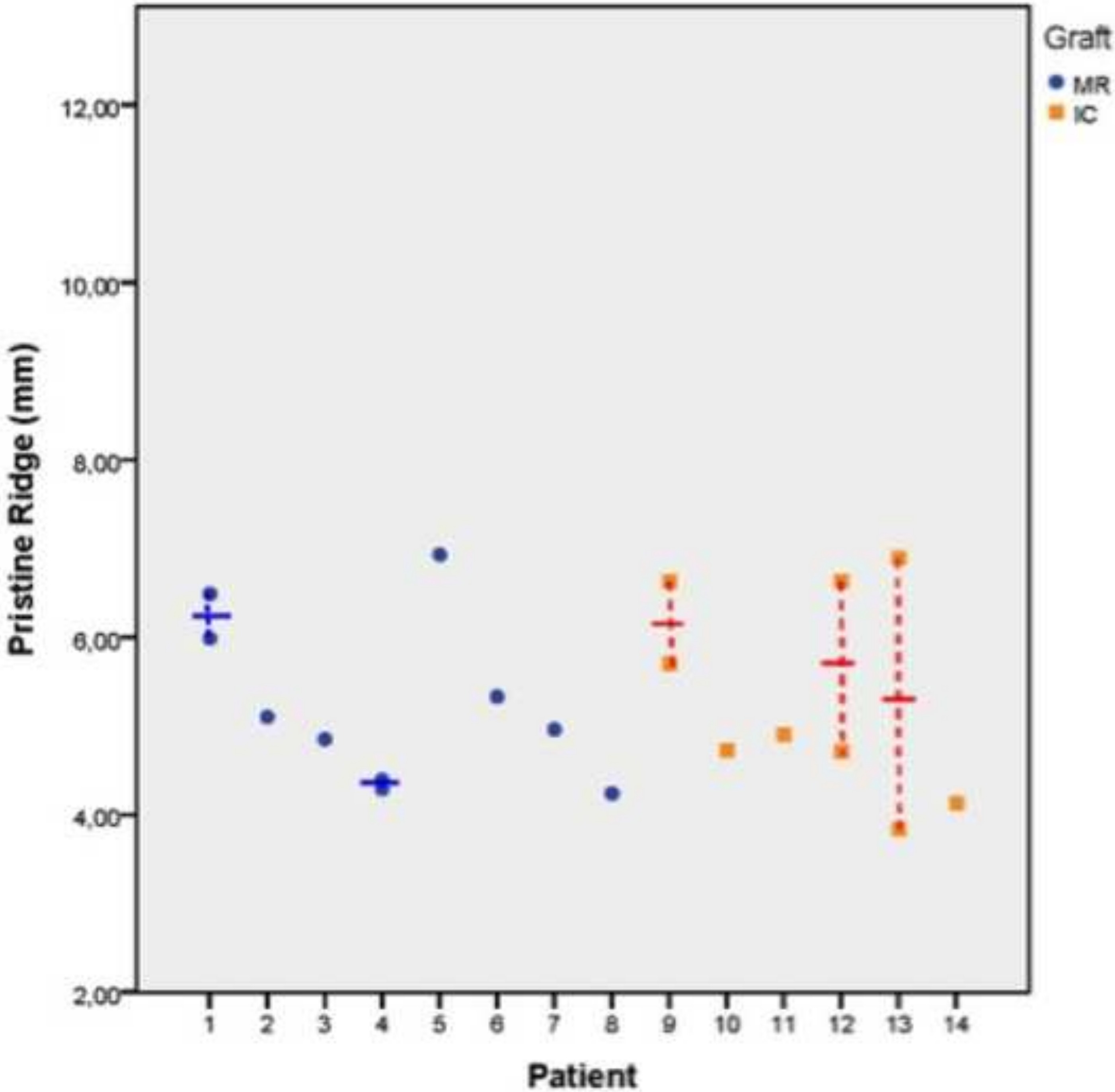

Figure 4

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