Dimensional Change of Intraoral Bone Block Graft in Ridge Augmentation

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Abstract

This study aimed to evaluate the dimensional change and microstructure of autogenous intraoral bone block graft in ridge augmentation. Thirteen patients with 32 tooth-sites were included in the study. There were 16 sites in the maxilla and 16 sites in the mandible. Donor sites comprised of 11 sites from the anterior ramus, 8 sites from the symphysis and 13 sites from the anterior iliac crest. Evaluation of dimensional change by measuring ridge width and height and remodel had been done by using clinical measurement and cone beam computed tomography (CT) at immediate and 4 months postoperatively. Bone biopsy had been done before implantation, microstructure of bone graft had been examine by micro CT and histomorphometry. Results from clinical measurement of model showed that the average final width gained from the iliac (4.00±0.76mm) was statistically significant different from the symphysis ($p<0.05$) and was highest, then the ramus (3.60±1.10 mm) and the symphysis (2.56±0.79 mm) respectively. Result from cone beam CT measurements showed that the average width gained immediately from the iliac (4.86±2.51 mm) was highest, then the ramus (3.85±1.49 mm) and the symphysis (3.15±1.45 mm) respectively. The immediate width gain from the iliac was statistically significant different from the ramus and the symphysis ($p<0.05$) at level = 1mm of measurements. The average final width gained of all groups were less than immediate width gained and the average width reduction from the iliac was highest (-1.64±1.53 mm), then the ramus (-0.65±0.75 mm) and the symphysis (-0.35±0.38 mm) respectively. The ridge height reduction was also maximum in the iliac group (-1.34±1.25 mm), then the symphysis (-0.33±0.22 mm) and the ramus (-0.30±0.34 mm) respectively. Micro CT showed no difference in the percentages of bone volume fraction (%BV/TV) from the ramus (84.66±8.36 %) and the symphysis (83.13±8.1 %). Histomorphometry showed no difference in the percentages of total bone area from the ramus (80.29±12.03 %) and the symphysis (84.98±14.50 %). It can be concluded that dimensional change of intraoral bone block graft is less than the iliac bone and microstructure

oframus and symphysis are comparable. Intraoral bone block is suitable for ridge deficiency that width gained was not more than 3 mm.

Keywords: autogenous bone, bone augmentation, bone block graft, bone remodeling, graft dimension, micro-CT, microstructure

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List of Abbreviations and Symbols

ANOVA	=	One-way analysis of variance
ASA	=	American Society of Anaesthesiologists'
BVF	=	Bone volume fraction
BV/TV	=	Bone volume per total volume
BS	=	Bone surface
et al	=	And others
H&E	=	Hematoxylin and eosin
kVp	=	Kilovoltage peak
mA	=	Miliampere
micro-CT	=	Micro computed tomography
mm	=	Millimeter
PRF	=	Platelet rich fibrin
Pts	=	Patients
ROI	=	Region of interest
SD	=	Standard deviation
s	=	Second
Tb.N	=	Trabecular number
Tb.Th	=	Trabecular thickness
Tb.Sp	=	Trabecular separation
W	=	Watt
3D	=	Three-dimensional

List of Papers and Proceedings

1. Prisana Pripatnanont, DDS, Phetsamone Thanakone, DDS, Narit Leepong, DDS. The Dimensional Change and the Microstructure of Intraoral Bone Block Graft in Ridge Augmentation, Preliminary Report. ***Int J Periodontics Restorative Dent.***
2. Phetsamon Thanakone, Prisana Pripatnanont, Narit Leepong. The effectiveness of intraoral bone block graft in bone augmentation. ***The 2nd ASEAN PlusThreeGraduate Research Congress.*** 5-7 Feb 2014, Bangkok, Thailand.

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14-May-2014

Manuscript title : The Dimensional Change and the Microstructure of Intraoral Bone Block Graft in Ridge Augmentation, Preliminary Report.

Dear Professor Pripatnanont

Thank you very much for submitting the above manuscript to The International Journal of Periodontics & Restorative Dentistry. The manuscript is being evaluated and we will contact you after we have received the comments of the referees.

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Acceptance Letter

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Dear MR. PHETSAMONE THANAKONE

On behalf of the 2nd AGRC Program Committee, we are pleased to inform you that your paper described above has been accepted for presentation at the 2nd ASEAN Plus Three Graduate Research Congress (2nd AGRC) which will take place on February 5-7, 2014 at the S31 Sukhumvit Hotel.

You are requested to visit the 2nd AGRC website http://www.grad.mahidol.ac.th/2AGRC/meeting-program.php to check the schedule for presentation.

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Thank you in advance for your contribution toward the success of the 2nd AGRC. We look forward to welcoming you in the 2nd AGRC2014.

Sukumal Chongthammakun
Program Committee, Chair
2nd ASEAN Plus Three Graduate Research Congress (2nd AGRC)

Faculty of Graduate Studies, Mahidol University
Salaya, Nakornpathom 73170, THAILAND

Introduction

Dental implants placed in deficient ridges have higher failure rates than those placed in ridges with a normal bone height.[1] Onlay grafts have been successfully used either in the presence of wide alveolar defects or when it is necessary to increase the horizontal diameter of the alveolar crest to obtain a good aesthetic result and to insert the implants in a correct way[1-3]

The goal of pre-implant bone augmentation of the deficient alveolar ridge is reconstruction of the proper alveolar anatomy through the techniques of socket preservation, horizontal and vertical ridge augmentation, sinus bone grafting, and others. Bone can be lost as a result of physiological resorption caused by dental loss, trauma, bone pathology or infection[4] and they often require hard and soft tissue reconstruction. Autogenous bone grafts have been used for many years for ridge augmentation and are still considered as the gold standard for jaw reconstruction.

Bone grafts were divided into four general categories: autografts, allografts, xenografts, and alloplasts. The use of these materials in regenerative procedures is based on the assumption that they possess osteogenic potential (contain bone-forming cells), are osteoinductive (contain bone inducing substances), or simply are osteoconductive (serve as a scaffold for bone formation).[5]

Autologous (autogenous) bone grafting involves utilizing bone obtained from the same individual receiving the graft. Autogenous bone harvested from intra oral or extra oral sites is the most predictable osteogenic organic graft for osseous tissue regeneration.[5-8]

Autogenous bone grafts have been used for many years for ridge augmentation and are still considered “the gold standard” due to their compatibility and osteogenic potentials to form the new bone by processes of osteogenesis, osteoinduction, and osteoconduction.[5, 9]

Extraoral site of autogenous block grafts particularly ilium provides a good source of bone material when compares to intra-oral site such as symphysis and retromolar-ramus areas that have limited bone not more than 4 tooth-sites.[9]

Although bone graft harvesting from iliac crest give a large amount of bone for reconstruction, it still possesses some drawbacks of donor site morbidity and faster rate of bone resorption than intra oral site.[10, 11] After bone block graft, timing for implantation should be not more than 4 months to maintain volume of graft and wait for bone integration.[12, 13]

Several studies have been proposed to achieve alveolar ridge augmentation in partially edentulous patients using bone blocks harvested from the mandible.[14] Mandibular bone either from the ramus or the symphysis is the ideal choice for limited area of surgical field.[15-17]

Clinical Significance

The autogenous bone is the gold standard grafting material, mainly due to its osteogenic, osteoinductive and osteoconductive properties.[18] The onlay block graft shave less osteogenic activity and slow revascularization[19, 20] than that of particulate bone marrow. Revascularization is important for graft incorporation and remodeling. Several studies have shown that intramembranous bone graft (mandibular bone) may have less resorption and better incorporation to the recipient site than the endochondral bone grafts (iliac crest). It could imply that embryologic origins affect resorption patterns; however, the microarchitecture type of the bone (cortical/cancellous ratio) responsible for volume maintenance of bone grafts. Remodeling of the bone block graft and reduction of bone volume after grafting are important for clinician to designate the type of bone graft.

Cone beam computer tomography (CBCT) offers the best radiographic method for the morphological and qualitative analysis of the residual bone.[21-23] Conventional CT scans have been used to evaluate bone dimensions, bone quality and alveolar width and height, when implant placement or bone grafting are planned. The introduction of CBCT technology reduces the cost and radiation dose for the patients and becomes a necessary tool for implant planning.

The use of Micro-Computed Tomography (Micro-CT) for noninvasive evaluation of the bone–implant interface was first suggested by Senneret al.[24] Micro-CT allows an assessment of the bone microarchitecture in three dimensions. This technique has been widely use for rapid, nondestructive fully three-dimensional view of bone specimens[23, 25, 26] and noninvasive imaging in animal models.[27, 28] It works on the same basis of physical and mathematical principles as CBCT but the micro-CT use a microfocus X-ray source so that much higher resolutions (up to 10 um) can be generated.[29]

Micro-Computed Tomography (Micro-CT) is a well–documented method to study bone microstructure because it provides accurate three-dimensional (3D) images and is time efficient[30] compared with conventional histomorphometry.[31, 32] Micro-CT images are the result of differences in radiation attenuation properties of bone, marrow space, and soft tissue.[33]

Micro-CT uses X-ray images to create cross-sections of a 3D-object that can be used to recreate models without destroying the original sample. No specimen preparation is required and testing is nondestructive. The resolutions of locally available Micro-CT systems are in the order of 6–72 um for nominal isotropic substances, depending on the size and density of the sample.[34]

The Micro-CT data can be used to calculate histomorphometric parameters[35] including bone surface (BS), bone volume (BV), mean trabecular thickness (Tb.Th), trabecular separation (Tb.Sp), and trabecular number (Tb.N), as well as nonmetric parameters like connective density (Conn.D), and structure model index(SMI) for shape. These parameters describing the microarchitecture of bone have been shown to be important.

Few studies used cone beam CT to evaluate dimension change of intraoral bone block graft in ridge augmentation.[36-40] Most studies used direct measurement of ridge dimension by using a veneer caliper to measure at the site of augmentation intraorally.[36-40] Therefore the location and method of measurements were not accurate and precisely repeatable. Those studies were mostly done in Caucasian patients and Indian patients but not in Asian ethnic that the body structure and bone structure are not the same.

The statement of the problems can be summarized as follows**:**

1. Direct measurement is not accurate and precise.
2. There was no study using cone beam CT combine with cast –based measurement to assess graft dimension.
3. Intraoral graft dimension, graft remodeling and microstructure in Thai ethnic are still unknown.

Objective of the Study

General objectives

The purpose of this study was to evaluate the dimensional change and microstructure of intraoral bone block graft in ridge augmentation compared to extraoral source.

Specific objective

1. To compare dimensional change clinically both ridge width gained and remodel by using cast-based measurement and cone beam CT after healing of bone block graft from various sources
2. To compare bone formation of grafted bone from intraoral source by using micro CT and histomorphometry evaluation

Patients and Methods

This study was a prospective clinical study and conducted at Oral & Maxillofacial Surgery Clinic, Prince of Songkla University, Hatyai, Songkhla, Thailand.

The experimental protocol was approved by the Human Research Ethics Committee, Faculty of Dentistry, Prince of Songkla University. Patients conditioned ASA I or ASA II classification with these conditions were included in the study, pre implant condition of partial edentulous ridge with alveolar bone defects in a bucco-lingual direction resulting from prior extractions and require bone graft augmentation, crestal width of $\leq$ 4 mm, crestal height of $\geq$ 10 mm, controlled oral hygiene (fair and good oral hygiene) and absence of any lesions in the oral cavity. Patients were excluded on the basis of these criteria: a smoker, a bruxism, a head and neck irradiated patient, a pregnant woman, a bisphosphonate taken person, a patient who has blood, liver, kidney and autoimmune disease and a poor oral hygiene patient.

Patients satisfying the above criteria were consent and enrolled in the study. The edentulous ridges were augmented with autogenous ramus, symphysis, iliac bone block graft, fixed with 1-2 screws, covering with resorbable membrane.

1. Procedures

1.1 Pre-operative Preparations

Dental model records and standardized dental radiographs including periapical and orthopantomogram were taken. Dental study models were simulated at the augmented area and an individualized acrylic stent was fabricated with perforated line at implant site as a reference line for measuring of dimensional change after ridge augmentation (Figure 1).

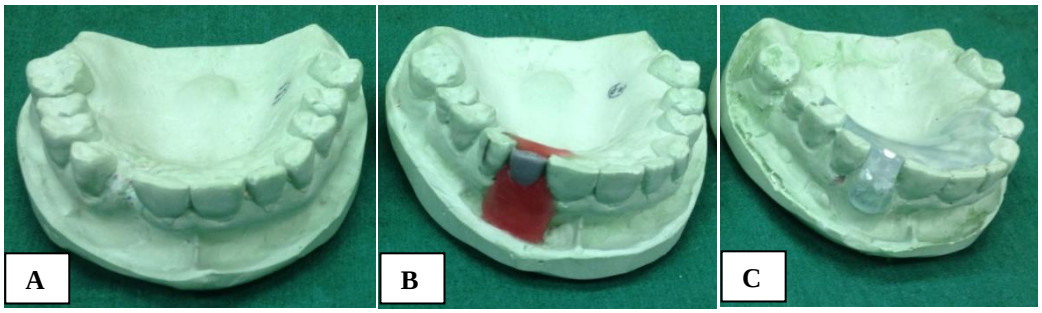


Figure 1. (A) dental study model (B) dental study models were simulated at the augmented area (C) an individualized acrylic stent was fabricated with perforated line at implant site

1.2 Bone harvesting

A bone block was harvested from either the anterior ramus or the symphysis of mandible under local anesthesia with intravenous sedation or the anterior iliac crest under general anesthesia where appropriate. Procedures were done followed the standard procedures and by an experienced oral and maxillofacial surgeon. The bone block was then fixed to the perforated recipient site with 1-2 micro screws. PRF membrane was used to cover the block graft. Flap was closed and suture with 3-0 Vicryl. Antibiotics, analgesic and antiseptic mouth rinse were prescribed as a standard treatment elsewhere. Removable denture was relieved at least 2 mm. out of contact to the grafted tissue. Sutures were removed 10-14 days after the surgery (Figure 2).

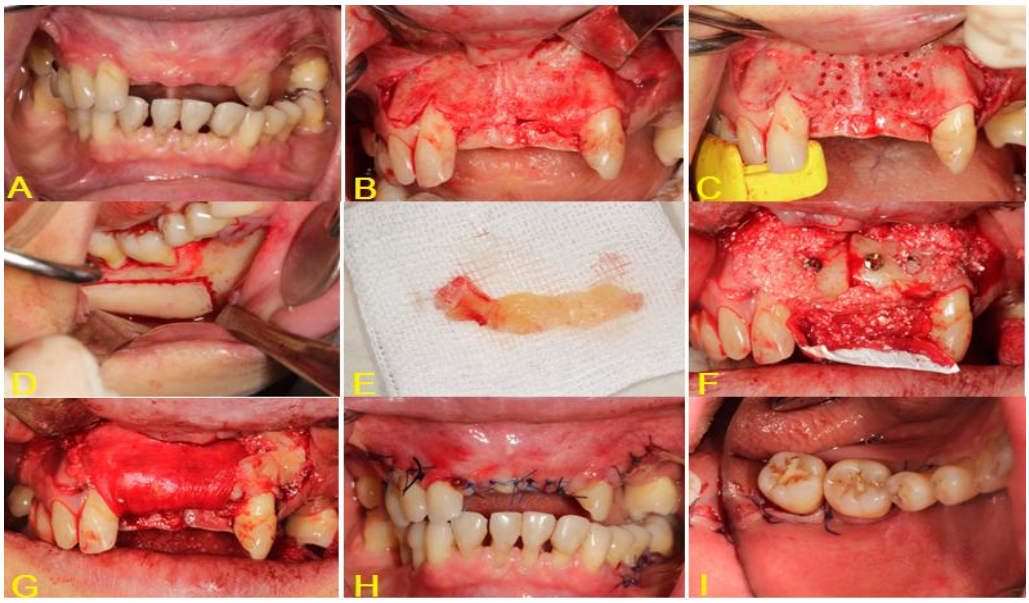


Figure 2.Procedure of bone augmentation (A) atrophic ridge at anterior maxilla (B) alveolar ridge deficiency (C) complete decorticate at recipient site (D) harvesting of bone block from the ramus (E) platelet rich fibrin (F) the bone block fixation with screws (G) covering with resorbable membrane (H, I) primary closure at donor and recipient sites

2. Clinical Examination & Data Collection

1.1 Cast-based measurements

Cast-based measurements were made to evaluate ridge width gained after bone augmentation. Preoperative and postoperative dental casts at 4 months were measured as immediate width gained and final width gained respectively.

Impression of the grafted jaw was taken with a custom tray with irreversible hydrocolloid (Coe Alginate; GC American Inc, Alsip, Ill). The impressions were made before operation and 4 months after the bone grafting at the time of implant insertion. The impressions were poured with dental stone plaster.

The pre- and postoperative stone casts were used to quantitatively assess the volume of alveolar ridge augmentation by using the following technique. An impression of the postoperative stone cast was made using putty silicone (blue), covered at least 2 adjacent teeth next to the grafted area. Light body silicone (orange) was lined in the internal surface of silicone impression which was then placed on the 4-month postoperative stone cast. The light body silicone represented the final width gained of the augmented portion. The excess material was trimmed. Linear measurements

were made by evaluating the buccal/labial thickness of the inner layer of the material by using a digital veneer caliper (Figure 3 D) at the depth 3mm and 5mm from the alveolar crest

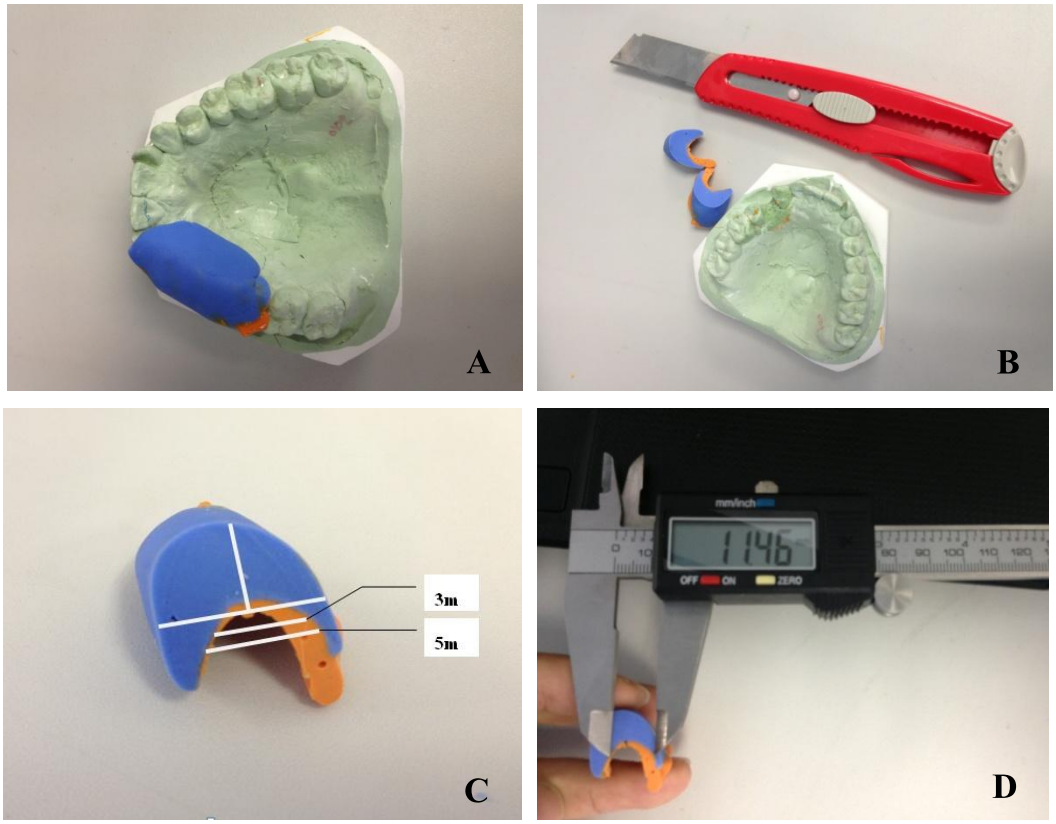


Figure 3. Cast-based measurement of bone graft area

1.2 Cone beam CT evaluation

Cone beam CT (3D Accuitomo 170, J Morita, Kyoto, Japan)(Figure 4) with 90 kvp, 5 mA, 30.8 s, 4x4 cm FOV, 0.08 mm isotropic voxel size at the grafted area was taken within 2 weeks and 4 months postoperative and used for measuring grafted dimension of ridge width at the depth 1mm, 3mm, 5mm and 10mm from the alveolar crest and for measuring the ridge height (Figure 5).

Figure 4. 3D Accuitomo 170, J Morita, Kyoto, Japan

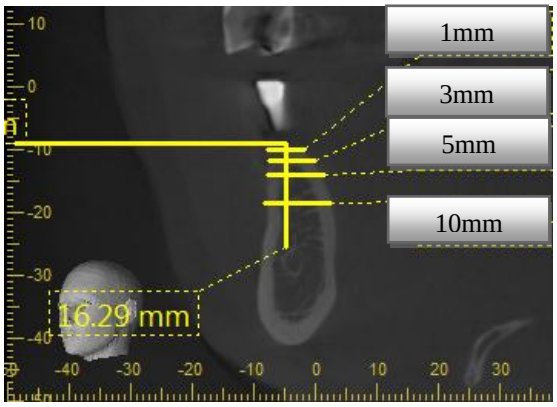


Figure 5. Cone beam CT measurement

At the stage of implant placement in the intraoral source of graft, a core biopsy of bone was taken by using a trephine bur with 2-mm in a diameter and 6mm in length.

Bone biopsy was processed for micro-computed tomography analysis (Figure 6).

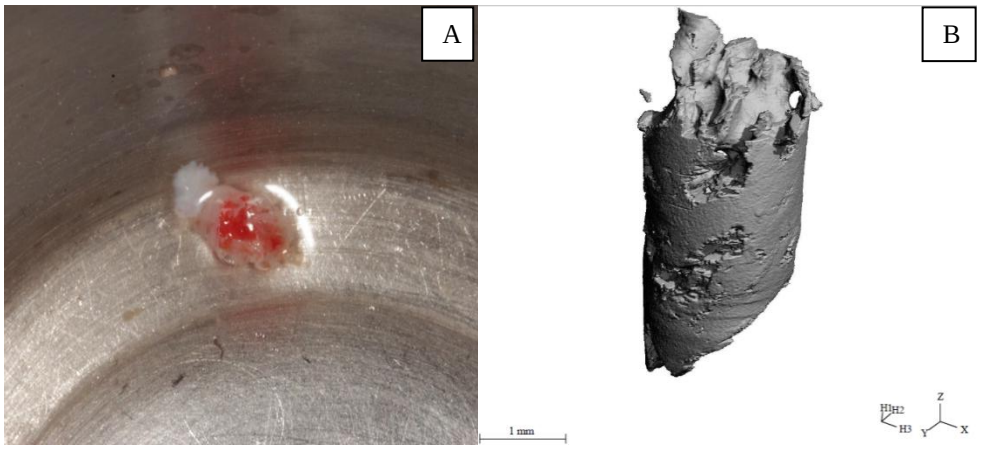


Figure 6. (A) bone core biopsy (B) 3-D structure of bone core from micro CT

2. Micro-computed tomography

Trephined and formalin-fixed bone cores were used for micro-CT analysis (μCT 35, SCANCO Medical AG, Brüttisellen, Switzerland) at 70 kVp, 114 μA and 8W (Figure 7). The specimens were placed in a sample holder and scanned through 180˚ at a spatial resolution of 20 μm, which allows for evaluation of the tissue architecture. The image data were reconstructed to create 3-D images for quantitative percent of bone volume analysis.

Before analysis, the grayscale threshold values were determined to discriminate bone from soft tissue[1]. The threshold value of "bone" was specified. The threshold was selected by identifying the threshold of bone voxels within the total bone area.

After determination of the threshold values, the margins were traced to specify ROI the total bone area. The percent of bone volume fraction (BVF, BV/TV), percentage of radio-opaque voxels (as bone threshold range) divided by the total bone volume, and the data from micro-CT used to calculate histomorphometric parameters[2] including bone surface (BS), bone volume (BV), mean trabecular thickness (Tb.Th), trabecular separation (Tb.Sp), and trabecular number (Tb.N), divided by the total bone volume, were determined.

Figure 7. Micro-CT (µCT 35, SCANCO Medical AG, Brüttisellen, Switzerland)

3. Histology Processing

After finished the micro-CT analysis, the specimens were processed to obtain thin ground sections using undecalcified techniques, according to the technique of Donath and Breuner[3] with minor modifications. Briefly, the specimens were dehydrated in an ascending series of alcohol rinses and embedded in a glycolmethacrylate resin (Technovit 7200 VLC, Kulzer, Wehrheim, Germany). After polymerization the specimens were serial sectioned along their longitudinal axis with a high-precision diamond disc at approximately 150 µm and ground down to approximately 30µm with a specially designed grinding machine (EXAKT® cutting and grinding system, EXAKT® Apparatebau, Norderstedt, Hamburg, Germany) (Figure 8). Three sections contained the central portion were selected and stained with hematoxylin and eosin. All slides were examined descriptively before histomorphometric analysis.

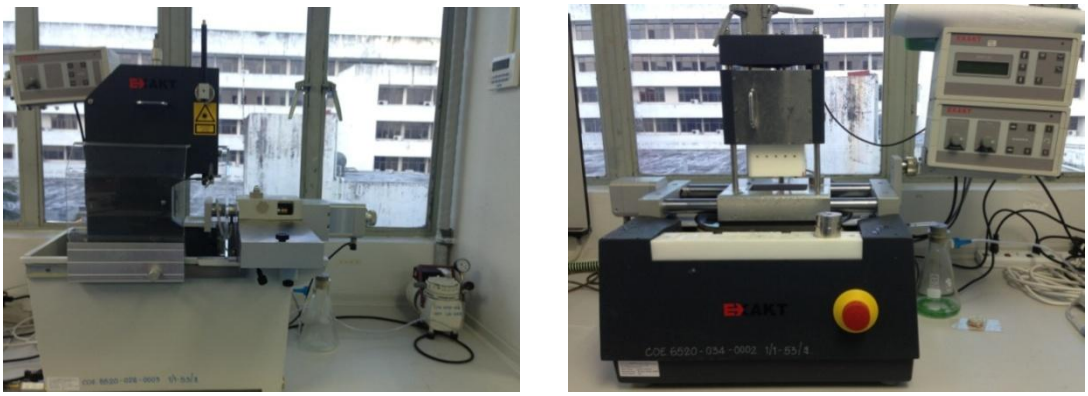


Figure 8. EXAKT® cutting and grinding system, EXAKT® Apparatebau, Norderstedt, Hamburg, Germany

4. Histomorphometric Analysis

Digital histologic images were captured at X5 magnification using a light microscope (Axiostar, Carl Zeiss, Göttingen, Germany) coupled to a high resolution digital camera (AxiocammRC, Carl Zeiss) connected to a PC computer, and analyzed by Image Pro Plus 5.0 (Media Cybernetics, MD, USA). (The quantity of new bone formation was calculated as the percentage of total bone area to the total bone graft area using Image Pro Plus 7.0 (Media Cybernetics, MD, USA) (Figure 9).

$$\text{Percentage of total bone area} = \frac{\text{new bone area}}{\text{total area}} \text{ x } 100$$

Figure 9. A microscope (Axiostar, Carl Zeiss, Göttingen, Germany) coupled to a high resolution digital camera (AxiocammRC, Carl Zeiss)

5. Statistical Analysis

Statistical analysis was performed using statistical analysis software (SPSS ver16.0, SPSS Inc., Chicago, USA). Data were tested for normality and presented as means ± SD. One-way analysis of variance and multiple comparison by Scheffé's post-hoc test ($P<0.05$) were used to compare the differences between the mean of immediate width and height gained, final width and height gained, the ridge width and height reduction, the percentage of newly formed bone in each groups.

Result

Ten patients aged 41.84±12.82 year olds with 32 implant sites participated in the study. The mean healing period was 5.31±0.70 months. One case of upper anterior region grafted with ramus block graft was failed; therefore total implant placement was 31 implants. There were 16 sites in the maxilla and 16 sites in the mandible. Donor sites comprised of 11 sites from the anterior ramus, 8 sites from the symphysis and 13 sites from the anterior iliac crest. Demographic data were presented in Table 1. Pre-width of the ridge, final width after grafting and implant diameter were presented in Table 2. Most of implant diameter were more than 4.0 mm in diameter (20/31 implants).

Table 1. Demographic data

Source of grafts	Patient (n)	Gender M	Gender F	Period of healing	Implant (n)	Age	Recipient Anterior maxilla(n)	Recipient Posterior maxilla(n)	Recipient Anterior mandible(n)	Recipient Posterior mandible(n)
Anterior ramus	5	2	3	5.02±0.22	11	52.27±8.39	4(2)	1(1)	0	6(3)
Symphysis	3	1	2	4.47±0.66	8	25.38±10.33	1(1)	0	3(2)	4(1)
Anterior iliac crest	2	0	2	5.38±0.98	13	43.15±4.67	10(2)	0	0	3(1)
Total	10	3	7	5.03±0.79	32	41.84±12.82	15(5)	1(1)	3(2)	13(5)

Table 2. Baseline data of each patient and implant placement

Pts	Missing teeth	Donor	Pre width	Post width	Implants (n)	Diameter 3.25-3.5	Diameter 3.75-4.0	Diameter 4.1-5.0
1	36,37	Ramus	3.65±0.33	6.94±1.33	2			2
2	41	Symphysis	1.75	2.53(4)	1	1		
3	13-23	Iliac	4.19±1.48	8.31±0.81	6	2	4	
4	14	Ramus	4.39±1.04	6.91±0.41	1		1	
	46				1			1
5	12	Ramus	3.46	7.62	1	1		
6	11-22	Ramus	2.42±1.08	4.87±0.52	3	1		2
7	45-47	Ramus	3.68±1.29	7.36±1.58	3			3
8	11	Symphysis	3.79	5.70	1			1
9	33-35	Symphysis	3.57	8.7±0.76	3			3
	43-45				3			3
10	12-22	Iliac	2.86±1.15	7.37±1.78	4	2		2
	36				1			1
	46-47				2			2
Total			3.4±1.28	6.96±1.79	32	7	5	20

Clinical evaluation

There were some complications at the donor and recipient sites in 5 patients. There were 1 case (Patient 1) developed temporary hypoesthesia at the donor site (chin area). Bone graft exposure developed at the recipient site in 4 cases (Patients 2, 3, 5 and 9, Figure 10) and 3 cases were healed completely except one case (Patient 5, Figure 10 E, F) was failed due to infection and graft had to be removed (Table 3).

Before **After healed**

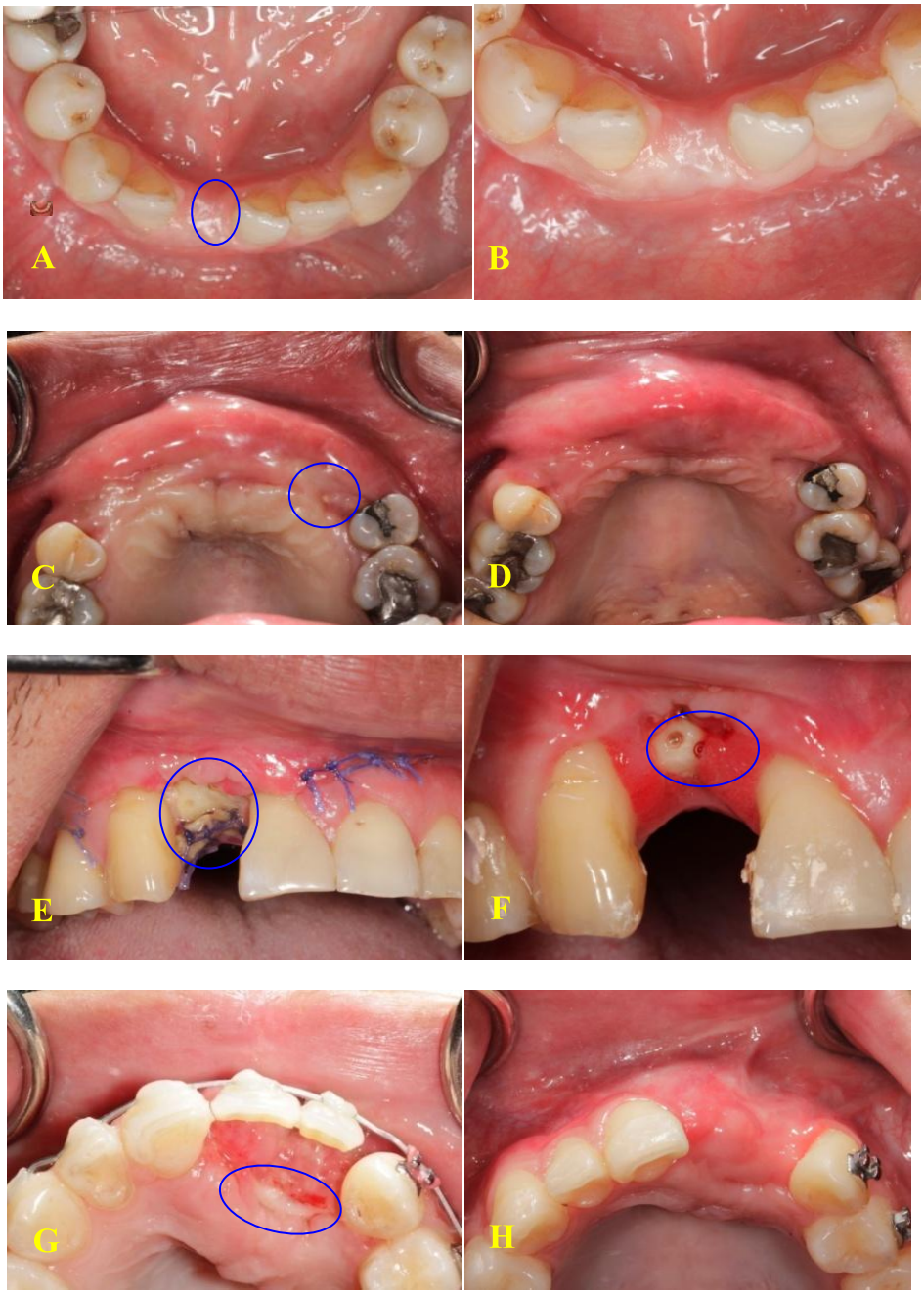


Figure 10. Complication at recipient sites A, B Patient No.2 Bone exposure of symphysis graft and completely healed after bone recontour, C, D, Patient No.3 Bone exposure of iliac graft and completely healed after bone recontour, E, F Patient No.5 Bone and screw exposure of ramus graft resulted graft failure G, H Patient No.9 Bone exposure of symphysis graft and completely healed after bone recontour.

Bone graft exposure developed at the recipient site in 4 cases (Patients 2, 3, 5 and 9, Figure 10). The first case Patient No. 2 (Figure 10 A, B) showed symphysis graft exposure and complete healing after graft recontour by a surgical blade. The second case Patient No. 3 (Figure 10 C, D) showed iliac graft exposure and complete healing after graft recontour by using a rotary bur. Patient No. 5 (Figure 10 E, F) showed ramus graft and screw exposure and was failed due to secondary infection and graft had to be removed eventually. Patient No. 9 (Figure 10 G, H) showed iliac graft exposure and completely healed after graft recontouring by using a rotary bur.

Table 3.Clinical assessment

Pts (n)	Donor	Recipient	Complications -donor site	Complications -recipient site	Time of occurrence	Outcome
1	Ramus	Posterior mandible	Temporary hypoesthesia	None	1wk-3mo	Success
2	Symphysis	Anterior mandible	None	Graft exposed	2wks	Success
3	Iliac	Anterior maxilla	None	Graft exposed	3mo	Success
4	Ramus	Posterior maxilla and mandible	None	None		Success
5	Ramus	Anterior maxilla	None	Graft exposed	2wks	Block graft removed
6	Ramus	Anterior maxilla	None	None		Success
7	Ramus	Posterior mandible	None	None		Success
8	Symphysis	Anterior maxilla	None	Graft exposed	2wks	Success
9	Symphysis	Anterior, posterior mandible	None	None		Success
10	Iliac	Anterior maxilla and posterior mandible	None	None		Success

Evaluation of Graft dimension change

Cast-based evaluation

The morphological ridge width from cast-based measurements revealed that the average final width gained from the iliac group was highest (4±0.76 mm), then the ramus (3.6±1.1 mm) and the symphysis group (2.56±0.79 mm). The width gained from the iliac crest was more than the symphysis significantly ($p<0.05$) as shown in the Table 4.1

Table 4. Clinical measurements of ridge width gained after bone augmentation

Table 4.1. Cast-based measurement of final width gained at 3, 5 mm depth level of recipient site from each type of graft

Level	Ramus	Symphysis	Iliac
3mm	3.82±0.39	2.33±1.16	3.71±0.69
5mm	3.47±1.39	2.79±0.57	4.29±0.76
Average	3.60±1.10	2.56±0.79	4.00±0.76*

* Statistically significant difference from symphysis at $p<0.05$

Table 4.2. Final width gained at 3, 5 mm depth level of recipient site at each region of grafting

Level	Anterior maxilla	Posterior maxilla	Anterior mandible	Posterior mandible
3mm	3.61±0.94	3.66	3.16	3.49±0.80
5mm	4.33±0.85	3.66	3.20	3.12±1.35
Average	3.97±0.94	3.66	3.18±0.028	3.26±1.15

Cone beam CT evaluation

The morphological ridge width and height from the cone beam CT were presented in Table 5 and Figure 11. Immediate width and height gain represented the width and height gained after augmentation within 2 weeks and final width and height gain represented the width and height gained after augmentation within 4 months. The average of immediate width gained at all levels of measurements from the iliac group was highest (4.86±2.51 mm), then the ramus (3.85±1.49 mm) and the symphysis group (3.15±1.45 mm). The width gained from the iliac crest was more than the ramus and symphysis significantly ($p<0.05$) at 1 mm depth level of measurements. The final ridge width gain of the iliac group was highest (3.21±2.16 mm) but not different from the ramus (2.9±1.56 mm) and the symphysis group (2.80±1.69 mm). The ridge width remodel from the iliac graft (-1.64±1.53 mm, -34.79±28.30 %) was more than the ramus (-0.65±0.75 mm, -18.64±17.28 %) and the symphysis (-0.35±0.38 mm, -16.07±20.09 %). There was significantly ($p<0.05$) different in the ridge width remodel only between the iliac and the ramus. After bone remodeling the iliac graft gained bone width at 1mm depth level more than intraoral graft from both the ramus and the symphysis but not significant (Figure 11).

The immediate height gain was also highest in the iliac group (4.72±1.75 mm) and significantly ($p<0.05$) different from the ramus (1.01±0.53 mm) but no significantly different from the symphysis group (1.49±0.96 mm). The final height gain of the iliac group (3.38±1.8 mm) was still highest and significantly ($p<0.05$) higher than the ramus (0.79±0.46 mm) but not the symphysis group (1.16±0.74 mm). The ridge height reduction from the iliac group was highest (-1.34±1.25 mm, -29.59±28.92 %), then the ramus (-0.2±0.13mm, -23.50±16.05 %) and the symphysis group (-0.33±0.22 mm, -21.73±1.05 %) according to the percentage of reduction.

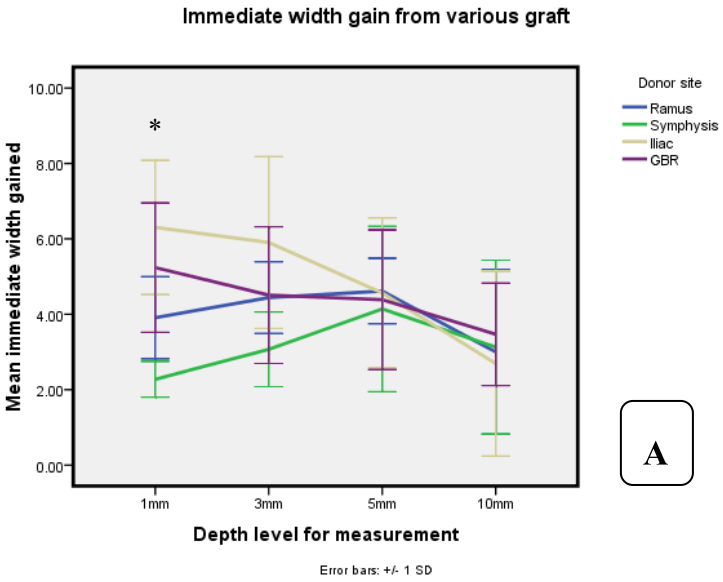
Table 5. Dimensional change of each type of graft according to immediate, final width and height gain and graft remodel

Level	Ramus	Symphysis	Iliac
Immediate width gain:			
1mm	3.72±0.99	2.27±0.47	6.30±1.77**
3mm	4.41±1.01	3.07±0.98	5.90±2.27
5mm	4.56±0.91	4.14±2.19	4.56±1.99
10mm	2.72±2.16	3.13±2.30	2.69±2.45
Average	3.85±1.49	3.15±1.45	4.86±2.51
Final width gain:			
1mm	3.00±1.09	1.34±0.79	4.33±1.70
3mm	3.65±1.33	2.92±0.94	3.60±2.24
5mm	3.61±1.50	3.96±2.22	2.86±2.13
10mm	1.33±1.19	2.97±2.54	2.08±2.07
Average	2.90±1.56	2.80±1.69	3.21±2.16
Ridge width remodel:			
1mm	-0.60±0.46	-0.93±0.32	-1.96±1.63
3mm	-0.46±0.44	-0.15±0.04	-2.30±1.66[a]
5mm	-0.39±0.18	-0.17±0.03	-1.70±1.37[a]
10mm	-1.14±1.29	-0.16±0.24	-0.60±0.98
Average	-0.65±0.75	-0.35±0.38	-1.64±1.53[a]
(% width reduction)	(-18.64±17.28)	(-16.07±20.09)	(-34.79±28.30)*
Immediate height gain	1.01±0.53	1.49±0.96	4.72±1.75*
Final height gain	0.79±0.46	1.16±0.74	3.38±1.80*
Ridge height remodel	-0.20±0.13	-0.33±0.22	-1.34±1.25
(% height reduction)	(-23.50±16.05)	(-21.73±1.05)	(-29.59±28.92)

* statistically significant difference from ramus at $p<0.05$

** statistically significant difference from ramus and symphysis at $p<0.05$

[a] statistically significant difference from other groups at $p<0.05$



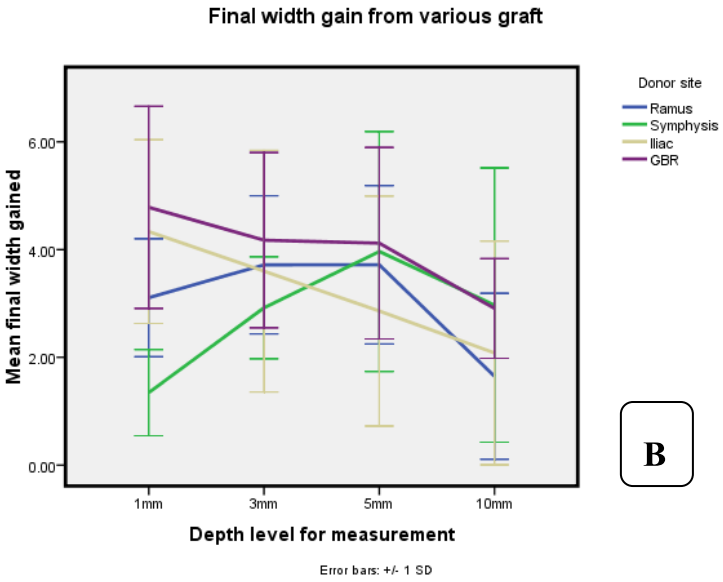


Figure 11. (A) Immediate width gain from various sources of graft at each level of measurement, (B) Final width gain

Microstructure of intraoral source

Micro-computed tomography and Histomorphometry analysis

Micro CT was done in the group of intraoral grafts from ramus and symphysis which showed that the percentages of bone volume fraction (%BV/TV) from ramus (84.66±8.36 %) and symphysis (83.13±8.10 %) were not different. The trabecular thickness (Tb.Th micron) from ramus (0.24±0.08) and symphysis (0.23±0.07) were also not different. The trabecular number (Tb.Number) from ramus (5.95±1.26) and symphysis (6.14±1.35) were also not different. The trabecular separation (Tb.Separation) from ramus (0.06±0.02) and symphysis (0.07±0.02) were also not different (Table 6).

Table 6. Micro CT evaluation of bone microstructure and bone mineral density from the ramus and the symphysis bone block graft.

Donor site	**Ramus**	**Symphysis**
BV/TV (Micro CT)%	84.66±8.36	83.13±8.1
Trabecular Number(1/mm)	5.95±1.26	6.14±1.35
Trabecular Thickness(mm)	0.24±0.08	0.23±0.07
Trabecular Separation(mm)	0.06±0.02	0.07±0.02
Total bone area(Histo)%	80.29±12.03	84.98±14.50

Regarding the recipient site, the BV/TV of anterior maxilla (78.72±4.21) was the least and was highest in the posterior mandible (87.15±7.54). The trabecular thickness of the mandible either anterior (5.82±1.24) or posterior (5.42±0.80) was comparable (Table 7).

Table 7. Micro CT evaluation of bone microstructure and bone mineral density from the ramus and the symphysis bone block graft at each region of recipient sites.

Location	**anterior maxilla**	**posterior maxilla**	**anterior mandible**	**posterior mandible**
BV/TV (Bone fraction)%	78.72±4.21	84.15	80.3±11.92	87.15±7.54
Trabecular Number(1/mm)	7.77±0.92	5.88	5.82±1.24	5.42±0.80
Trabecular Thickness(mm)	0.16±0.02	0.21	0.26±0.11	0.26±0.06
Trabecular Separation(mm)	0.05±0.01	0.05	0.07±0.01	0.06±0.03
Total bone area (Histo)%	82.70±16.34	90.64	70.63±8.36	87.26±11.33

Histology

Microscopic examination revealed that at 4 months period both ramus and symphysis block graft were successfully healed with the recipient sites. The bone pattern from the ramus and symphysis were not different, it varied upon the recipient area. The core bone biopsy from the maxilla showed loose pattern of the bone trabeculae while the mandible regions shown dense bone pattern regardless of the donor origin (Figure 12-17).

Histomorphometry was done in the group of intraoral grafts from ramus and symphysis and showed no difference in the percentages of total bone area from the ramus (80.29±12.03 %) and the symphysis (84.98±14.5 %). The result of from Micro CT and histomorphometry were similar as shown in Table 6.

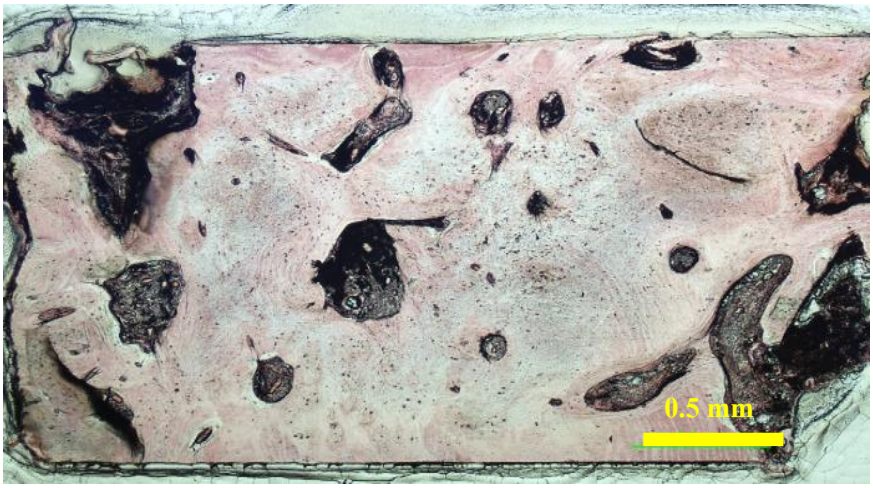


Figure 12. Core biopsy of ramus block graft to the posterior mandibular region showed dense bone pattern.

Figure 13. Core biopsy of symphysis block graft to the posterior mandibular region showed dense bone pattern.

Figure 14. Core biopsy of ramus block graft to the anterior maxillary region showed loose bone pattern.

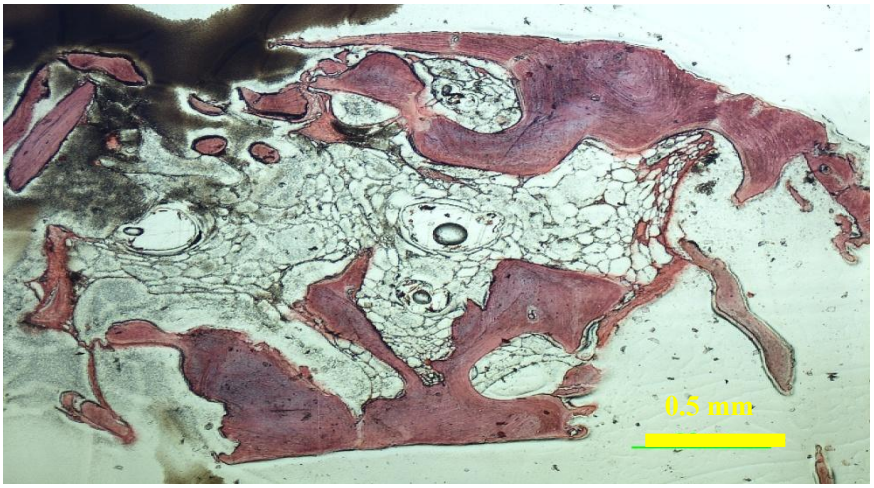


Figure 15. Core biopsy of ramus block graft to the anterior maxillary region showed loose bone pattern.

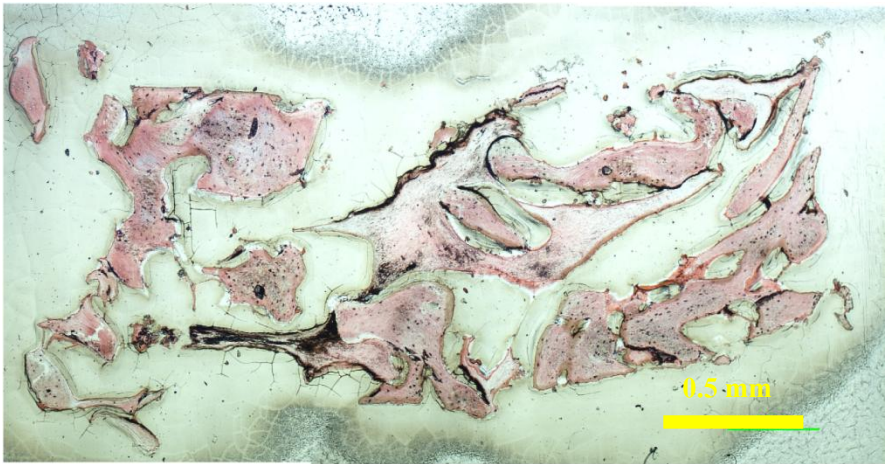


Figure 16. Core biopsy of symphysis block graft to the anterior maxillary region showed loose bone pattern.

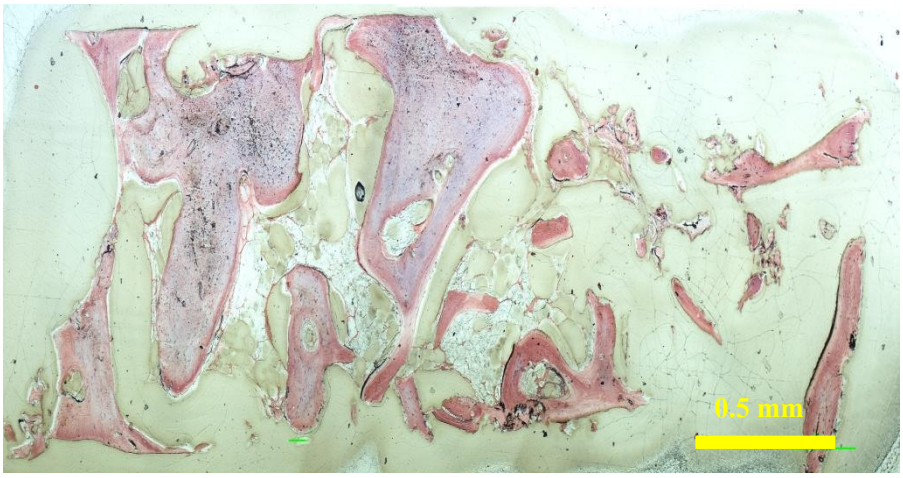


Figure 17. Core biopsy of ramus block graft to the anterior maxillary region showed loose bone pattern.

Discussion and Conclusion

Ridge augmentation is a common procedure to correct ridge deficiency before implantation. Cortico-cancellous block harvested from anterior iliac crest give much more volume than intra oral sources, however it undergoes more remodeling and faster resorption.[1, 2] The average of ridge width gained in this study from intra oral site was in the range of 3.15 to 3.85 mm immediately after augmentation then underwent remodeling and gained final width only 2.8-2.9 mm. While the iliac crest gained more width (4.86±2.51 mm) and height (4.72±1.75 mm) immediately after augmentation and after remodeling the width (3.21±2.16 mm) and height (3.38±1.8 mm) were still higher than augmentation with intra oral graft even though it's percentage of resorption was higher than the intraoral graft. Since the iliac site has more volume of bone than the intraoral site, it can be used in case of large defect or severe ridge atrophy in the long span of edentulous ridge. Over contour of the graft is necessary in the iliac group to compensate the volume reduction nearly at 35 % or 2 times of intraoral source.

However when compared with previous study[3] using mandibular block graft conducted in Italy, lateral augmentation obtained at the time of bone grafting was 5.5±1.3 mm, and reduced during healing from graft resorption to 4.3±1.1 mm. The other study using ramus block graft gained mean lateral augmentation at the time of augmentation 4.6 ±0.73 mm, then later, at the time of implant insertion, reduced to 4±0.77 mm.[4] Those studies measured direct ridge dimension by using a caliper at the augmented site so that a location and method of measurements differed from the present study and those method were not accurate because the measurement point before and after grafting might not be precise. Although the width gained from those studies was higher than this present study, remodeling of the ramus was 21.8 and the symphysis was 13 % which was comparable to our study (18.64 %, 16.07 %).

Buser et al. 1996[5] reported data on bone gain in the case of lateral ridge augmentation using autograft harvest from intraoral source, either from the retromolar region of mandible or from the chin and barrier membranes. The mean gain measured by direct ridge dimension measurement with a caliper was 3.53 mm at the time of implant placement (7–13 months after ridge augmentation), which differed from our study a little.

Another study by the Chiapasco et al[6] provided data on the reconstruction of atrophic mandibles by means of bone blocks harvested from the mandible ramus. The mean bone gain after the procedure was 4.6 mm and the mean bone resorption (4–5 months after the augmentation

procedure) was 0.6 mm. Again that study gained more bone width than this study but underwent similar bone resorptionto our study.

The other study[7] used autogenous block grafts covered with anorganicbovine bone mineral (ABBM) and bioabsorbable collagen membrane. A bone block graft for lateral ridge augmentation was harvested from the symphysis or retromolar region in Swiss patients and the re-entry period was 5.8 months (range 4.5-13.5 months), the mean gain was 4.59±1.05 mm, the overall surface resorption of block grafts was 0.36±0.52 mm (7.2 %), which showed more bone gained and less resorption. The technique of using combination of bone block graft and bovine bone mineral together with bioabsorbable membrane could increase graft volume and decrease volume reduction because anorganic bovine bone is slowly resorbed.

The other study by Monje et al. 2013[8] using micro CT and histomorphometric analyses compared architectural metric parameters between grafted with blocks harvested from the mandibular ramus and cavarium for horizontal bone augmentation in maxilla. After 4-6 months of healing, micro CT analysed showed that the mean of BV/TV from ramus grafted sites was 49.65±22.17 %, the trabecular thickness (Tb.Th micron) was 0.23±0.08, the trabecular separation (Tb.Separation) was 0.24±0.12, the trabecular number (Tb.Number) was 2.38±0.80. In our study, the BV/TV and the trabecular number (Tb.Number) of ramus graft was higher (84.66±8.36 % and 5.95±1.26) respectively and in the maxilla (78.72±4.2) it was still higher than Monje's study. It is interesting that intraoral graft in our study could contain mainly the cortical bone, therefore it yield less volume and less resorption but high in trabecular number and bone volume with dense pattern.

For the failed case of upper anterior region graft with ramus block graft, the recipient site was very thin and concave therefore there was a space between the graft and the host bone which was filled with bone collected from bone collector. The fixation after grafting was stable but it might be loosen later from resorption of the bone in between the graft and the recipient and led to infection and soft tissue interface eventually.

If the graft volume is sufficient for the planned reconstruction and the thickness required is less than 3 mm, the mandibular bone is a good source of bone graft. The mandibular ramus provides larger volume, thickness and less remodeling than the symphysis. In a condition that needs larger volume for both horizontal and vertical augmentation, bone thickness is more than 3 mm, the iliac source is recommended. In our study only the iliac group provided good vertical height (3.38±1.8 mm) and more than the ramus and symphysis group. In case of vertical augmentation, bone block alone might be not enough and could be combined with particulate bone from cortico-

cancellous chips or bone substitutes plus GBR. Intraoral graft has limited source of particulate bone and bone thickness, therefore it is suitable for a case that need minor to moderate bone augmentation that limit to the thickness not more than 3 mm and the recipient should have sufficient height.

It can be concluded that dimensional change of intraoral bone block graft is less than the iliac bone and microstructure of ramus and symphysis are comparable. Intraoral bone block is suitable for moderate ridge deficiency that width gained was not more than 3 mm.

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Appendix 1

Journal Paper

Prisana Pripatnanont, DDS, Phetsamone Thanakone, DDS, Narit Leepong, DDS. The Dimensional Change and the Microstructure of Intraoral Bone Block Graft in Ridge Augmentation, Preliminary Report. ***Int J Periodontics Restorative Dent.***

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The Dimensional Change and the Microstructure of Intraoral Bone Block Graft in Ridge Augmentation, Preliminary Report.

Abstract

This study investigated the dimensional change and the microstructure of intraoral bone block graft in ridge augmentation by using cast-based measurement, cone beam computed tomography (CT), micro CT and histomorphometry. There were 7 patients with 10 sites from the ramus and 8 sites from the symphysis. The final ridge width gained at 4 month postoperative from case-based and cone beam CT measurement of the ramus (4.08±0.50, 4.48±0.93 mm) was higher than the symphysis (2.56±0.79, 3.60±1.51 mm) and the remodeling of the ramus was also higher (-10.46±10.55 %) than the symphysis (-5.04±2.08 %). Bone volume fraction from Micro CT and the percentage of bone area from histomorphometry of the ramus (84.668.36%, 80.29±12.03%) and the symphysis (83.138.1%, 84.98±14.50%) showed no difference. In conclusion, the dimensional change of the symphysis graft is less than the ramus and their microstructure are comparable.

Keywords: autogenous bone, bone augmentation, bone block graft, bone remodeling, graft dimension, histomorphometry, micro-CT, microstructure

Introduction

The use of bone block graft to augment atrophic ridge has been the gold standard for both horizontal and vertical bone augmentation. The common donor sites for a limited area of augmentation, obtained from intra oral site are the ramus and the symphysis.[1-4] After bone block graft, a waiting period for implantation is 4-6 months to ensure bone integration but not too long for a graft to be resorbed.[4] The fate of bone block graft remodeling and the morphology of bone graft healing are still important for later implantation.

Although assessment of bone block remodeling has usually been done by many studies,[5-10] the technique of measurement was either a direct measurement intraorally at the grafted site or an indirect measurement on a cast-based measurement.[11, 12] Most studies used a direct measurement of ridge dimension by using a vernier caliper to measure the augmented site, the reference points in those techniques were not precise and might change during the follow-up period. Although a conventional computed tomography (CT) scan or a Cone beam CT has been used to evaluate ridge dimensions and bone quality for planning of implant placement and bone augmentation, there were only a few studies used a cone beam CT[5-9] to detect dimensional change after bone grafting even though a CT gives more accurate dimension and better precision than the direct measurement.

A micro-Computed Tomography (Micro-CT) is a well–documented method and widely used to study bone microstructure because it provides accurate three-dimensional (3D) images and is time efficient[13] compared with conventional histomorphometry.[14, 15] The Micro-CT data can be used to calculate histomorphometric parameters[16] including bone surface (BS), bone volume (BV), mean trabecular thickness (Tb.Th), trabecular separation (Tb.Sp), and trabecular number (Tb.N).

The dimensional change and the microstructure of intraoral bone block graft either the ramus or the symphysis are still a question that need an accurate answer to determine of a graft volume harvested and the final outcome after remodeling. This study

aimed to evaluate the dimensional change and the microstructure of intraoral bone block graft in ridge augmentation.

Patients and Methods

This study was a prospective clinical study, conducted at Oral & Maxillofacial Surgery Clinic, Prince of Songkla University, Hatyai, Songkhla, Thailand.

The experimental protocol was approved by the Human Research Ethics Committee, Faculty of Dentistry, Prince of Songkla University (No: EC5506-25-P). Seven patients conditioned ASA I or ASA II classification with these conditions were included in the study, pre implant condition of partial edentulous ridge with alveolar bone defects in a bucco-lingual direction resulting from prior extractions and require bone augmentation, controlled oral hygiene (fair and good oral hygiene) and absence of any lesions in the oral cavity. Patients were excluded if they are: a smoker, a bruxism, a head and neck irradiated patient, a pregnant woman, a bisphosphonate taken person, a patient who has blood, liver, kidney and autoimmune disease and a poor oral hygiene patient.

Patients satisfying the above criteria were consented and enrolled in the study. The edentulous ridges were augmented with the autogenous ramus orthe symphysis bone block graft, fixed with 1-2 screws, covered with platelet rich fibrin (PRF) and a resorbable membrane.

1. Procedures

.1 Platelet rich fibrin preparing

Platelet rich fibrin (PRF) was prepared by using 10 ml of patient's own venous blood from antecubital vein and immediately centrifuged at 3000 rpm for 10 minutes (Labofuge 400R® centrifuge, Hereus, Hanau, Germany), according to the PRF protocol.[17] After centrifugation, there are 3 layers of blood products acellular plasma at the top a fibrin clot in the middle of the tube, and the red corpuscles at the bottom. A fibrin clot was pressed to make it a PRF membrane to be used to cover the bone block graft (Figure 1).

.2 Bone harvesting

A bone block was harvested from either the anterior ramus or the symphysis of the mandible under local anesthesia with intravenous sedation. Procedures were done

followed the standard procedures and by an experienced oral and maxillofacial surgeon. The bone block was then fixed to the perforated recipient site with 1-2 micro screws. A PRF membrane was used to cover the block graft. A flap was closed and sutured with 3-0 Vicryl. Antibiotics, analgesic and antiseptic mouth rinse were prescribed as a standard treatment elsewhere. A removable denture was relieved at least 2 mm. out of contact to the grafted tissue. Sutures were removed 10-14 days after the surgery (Figure 1)

2. Clinical Evaluation and Data Collection

a. Cast-based measurements

Preoperative and postoperative stone dental casts at 4 months were used for an evaluation of ridge width gained after bone augmentation and recorded as final width gained.

The measurement of final width gained on pre- and postoperative dental casts were performed by using the following techniques. An impression of the postoperative stone cast was made by using blue color putty silicone (Silagum®, DMG Chemisch-Phamazeutische Fabrik GmbH, Hamburg, Germany), covering at least 2 adjacent teeth next to the grafted area. Orange color light body silicone (Silagum®, DMG Chemisch-Phamazeutische Fabrik GmbH, Hamburg, Germany) was lined over the internal surface of a silicone impression which was then placed on the 4-month postoperative stone cast. The light body silicone represented the final width gained of the augmented portion. The excess material was trimmed. Linear measurements were made by measuring the buccal/labial thickness of the inner layer of the material by using a digital vernier caliper (Figure 2 D) at the depth 3, 5 mm from the alveolar crest.

b. Cone beam CT evaluation

A cone beam CT (3D Accuitomo 170, J Morita, Kyoto, Japan) with 90 kvp, 5 mA, 30.8 s, 4x4 cm FOV, 0.08 mm isotropic voxel size at the grafted area was taken within 2 weeks and 4 months postoperative and used for measuring grafted dimension of ridge width at the depth 3 mm and 5 mm from the alveolar crest (Figure 3).

At the stage of implant placement between4-6 months after grafting, a core biopsy of bone was taken by using a trephine bur with 2-mm in diameter and 6mm in length. The bone biopsy was processed for a micro-computed tomography analysis (Figure 4).

2. Micro-computed tomography

Trephined and formalin-fixed bone cores were used for micro-CT analysis (μCT 35, SCANCO Medical AG, Brüttisellen, Switzerland) at 70 kVp, 114 μA and 8W. The specimens were placed in a sample holder and scanned through 180° at a spatial resolution of 20 μm, which allowed for an evaluation of the tissue architecture. The image data were reconstructed to create 3-D images for quantitative percent of bone volume analysis.

3. Histology Processing

After the micro-CT process, the specimens were processed to obtain thin ground sections using undecalcified techniques, according to the technique of Donath and Breuner[18] with minor modifications. Briefly, the specimens were dehydrated in an ascending series of alcohol rinses and embedded in a glycolmethacrylate resin (Technovit 7200 VLC, Kulzer, Wehrheim, Germany). After polymerization the specimens were serial sectioned along their longitudinal axis with a high-precision diamond disc at approximately 150 μm and ground down to approximately 30μm with a grinding machine (EXAKT® cutting and grinding system, EXAKT® Apparatebau, Norderstedt, Hamburg, Germany). The section contained the central portion was selected and stained with hematoxylin and eosin. All slides were examined descriptively before histomorphometric analysis.

4. Histomorphometric Analysis

Digital histologic images were captured at X5 magnification using a light microscope (Axiostar, Carl Zeiss, Göttingen, Germany) coupled to a high resolution digital camera (AxiocammRC, Carl Zeiss) connected to a PC computer, and analyzed by Image Pro Plus 7.0 (Media Cybernetics, MD, USA). The quantity of new bone formation was calculated as the percentage of total bone area to the total area.

5. Statistical Analysis

Statistical analysis was performed using statistical analysis software (SPSS ver16.0, SPSS Inc., Chicago, USA). Data were tested for normality and presented as means ± SD. Independent T –Test were used to compare the differences between groups, a significant level was set at $P<0.05$.

Result

Seven patients aged 49.58±13.05 years old with 18 implant sites participated in the study. The mean healing period was 5.09±0.40 months. There were 5 sites in the maxilla and 13 sites in the mandible. Donor sites comprised of 10 sites from the anterior ramus and 8 sites from the symphysis. Demographic data were presented in Table 1. Pre-width of the ridge, final width after grafting and implant diameter were presented in Table 2. Most of implants' diameter were more than 4.0 mm in diameter (15/18 implants).

Clinical evaluation

There were some complications at the donor and recipient sites in 3 patients. There was 1 patient (Patient 1) developed temporary hypoesthesia for 3 months at the donor site (chin area). Bone graft exposure developed at the recipient sites in 2 patients (Patients 2 and 6, Figure 5) and both were healed completely.

Patient 2 (Figure 10 A, B) showed symphysis graft exposure at 2 weeks postoperatively and completely healed within 1 month after graft recontouring by a surgical blade. Patient (Figure 10 C, D) showed symphysis graft exposure at 2 weeks postoperatively and completely healed within 1 month after graft recontouring by a rotary bur.

Evaluation of dimensional change of the graft

Cast-based evaluation

The morphological ridge width from cast-based measurements revealed higher final width gained in the ramus group (4.08±0.50 mm)than the symphysis group (2.56±0.79 mm) and statistically significant difference ($p<0.05$) at the 3-mm depth level from the crest (3.82±0.39, 2.33±1.16 mm) as shown in Table 3.

Cone beam CT evaluation

The morphological ridge width data from the cone beam CT were presented in Table 3 and Figure 6. Immediate width gain represented the width gained after augmentation within 2 weeks and final width gain represented the width gained after augmentation within 4 months. The average of immediate width gained from both depth levels of measurements from the ramus (4.48±0.93 mm) was higher than the symphysis group (3.60±1.51 mm) and statistically different ($p<0.05$) at the 5-mm depth level of measurement (4.56±0.91, 4.14±2.19 mm).The final ridge width gain of the ramus group (3.63±1.38 mm) was also higher than the

symphysis group (3.44±1.52 mm) but not statistically different. In the mean time ridge width remodel from the ramus still was higher (-0.42±0.33 mm,-10.46±10.55 %), than the symphysis (-0.16±0.03 mm,-5.04±2.08 %), and statistically different ($p<0.05$) at the 5-mm depth level of measurement (-0.39±0.18, -0.17±0.03 mm) (Table 3).

Micro-computed tomography and Histomorphometry analysis

Micro CT and histomorphometery parameters are presented in Table 5. The percentages of bone volume fraction (%BV/TV) from the ramus (84.66±8.36 %) and the symphysis (83.13±8.10 %) were comparable and were not different, including other parameters such as trabecular thickness (Tb.Th micron, 0.24±0.08, 0.23±0.07), trabecular separation (Tb.Separation, 0.06±0.02, 0.07±0.02) and trabecular number (Tb.Number, 5.95±1.26, 6.14±1.35) (Table 4).

However the BV/TV of the graft at the recipient sites showed that the posterior mandible (87.15±7.54) was higher than the anterior maxilla (78.72±4.21) regardless of the source of the graft and the trabecular thickness from the posterior mandible (0.27±0.06) was more than the anterior maxilla (0.16±0.02) significantly($p<0.05$). However the trabecular number from the anterior maxilla was highest (7.77±0.92), then the posterior maxilla (5.88), the anterior mandible (5.82±1.24), and the posterior mandible (5.42±0.80) (Table 4).

Histology

Microscopic examination revealed that both ramus and symphysis block graft were successfully healed with the recipient sites. The bone pattern from the ramus and symphysis were not different, it varied upon the recipient area. The core bone biopsy from the maxilla showed loose pattern of the bone trabeculae while the mandibular regions showed dense bone pattern regardless of the donor origin (Figure 7).

Histomorphometry showed no difference in the percentages of total bone area from the ramus (80.29±12.03 %) and the symphysis (84.98±14.5 %). The result of from Micro CT and histomorphometry were similar as shown in Table 4.

Discussion and Conclusion

Ridge augmentation is a common procedure to correct ridge deficiency before implantation. In this study the dimensional change of bone block graft at the augmented site

was based on the cast-based measurement and the indirect measurement on a sagittal view of a cone beam CT, therefore a point of measurement was accurate and repeatable. Most other studies[5-8, 10, 12] used direct measurement intraorally at the augmented site with or without cast-based or CT, therefore the measurements might not be precise and repeatable.

The average of ridge width gained in this study was in the range of 3.6 to 4.48 mm immediately after the augmentation then the augmented ridge underwent remodeling and gained final width of 3.44-3.63 mm. However when compared with previous studies,[5, 7, 10] using mandibular block graft for ridge augmentation, the ridge width gained at the time of implant placement was in the range of 4-4.6 mm which was more than our study. Those studies measured direct ridge dimension by using a caliper at the augmented site so that a location and method of measurements differed from the present study and those methods were not accurate because the measurement point before and after grafting might not be the same point. Although the width gained from those studies was higher than this present study, the graft resorption of the range 7.2 - 13.1 % was also higher than our study (range 5.04 – 10.46 %. When compared with the study using particulate bone combined with Titanium mesh, the percentage of bone resorption (36.65 -43.62%) was much higher than bone block graft in previous studies and also our study.[5, 7, 9, 10] It could be implied that bone block graft remodeling at 4-5 months period was not more than 15 % particularly with a barrier membrane and the remodeling process continued further with time.

Buser et al. 1996[6] reported data on bone gained in lateral ridge augmentation using autograft harvested from an intraoral source, either from the retromolar region of the mandible or from the chin with barrier membranes. The mean ridge gain measured directly at the augmented sites with a caliper was 3.53 mm at 7–13 months after ridge augmentation. The final ridge gained was comparable to the present study but the healing period was longer, therefore a period of 4to 5 months could better prevent further resorption of bone block graft than waiting a long period of time for bone healing.

The other study by Monje et al. 2013[19] used micro CT and histomorphometric analyses compared architectural metric parameters of the ramus block graft to the cavarium for horizontal bone augmentation in the maxilla. After 4-6 months of follow-up, micro CT analyses showed that the mean of BV/TV from ramus grafted sites was 49.65±22.17 %, which was much lower than the ramus graft at the maxilla site in the present study (78.72±4.2). The other parameters showed the same direction such as the Tb.Number

(2.38±0.80) of the ramus graft was much lower than of the present study (5.95±1.26) while the trabecular thickness (0.23±0.08, 0.24± 0.08) was comparable, and the trabecular separation was much higher (0.24±0.12,0.06±0.02)than our study. It could be postulated that the bone architecture with high BV/TV and Tb. Number with low trabecular separation contains mainly with the cortical bone and composed with dense pattern bone then it might undergo less resorption than the loose pattern of the bone.

In the case of limited area of ridge augmentation not more than 4-tooth area and the thickness required is less than 3 mm, the mandibular bone is a good source of bone graft. The evidence from this study showed that the mandibular ramus provides larger volume, thickness and less complication at the donor site than the symphysis. The symphysis graft provided less remodeling than the ramus graft. The bone architecture and microstructure of the two intraoral sources were comparable and tended to be influenced by the recipient area that the posterior mandible showed denser bone pattern than the maxilla. Although this study was a preliminary study of a small sample and more cases are needed to confirm the outcomes, it presented key answers for clinicians.

It can be concluded that dimensional change of ramus bone block graft is more than the symphysis bone, and the microstructure of ramus and symphysis are comparable. Intraoral bone block is suitable for moderate ridge deficiency that width gained was not greater than 3 mm.

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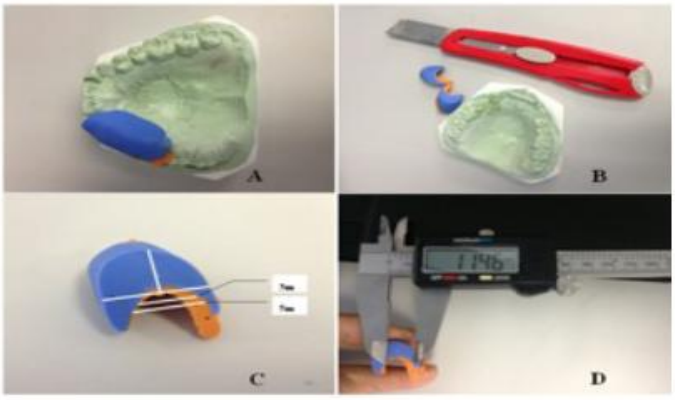

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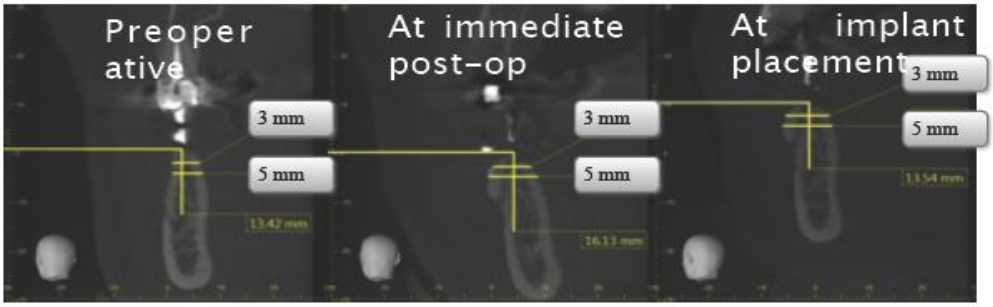

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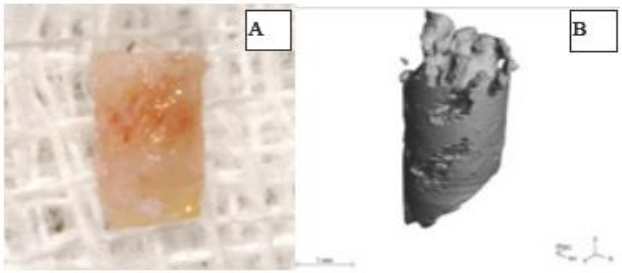

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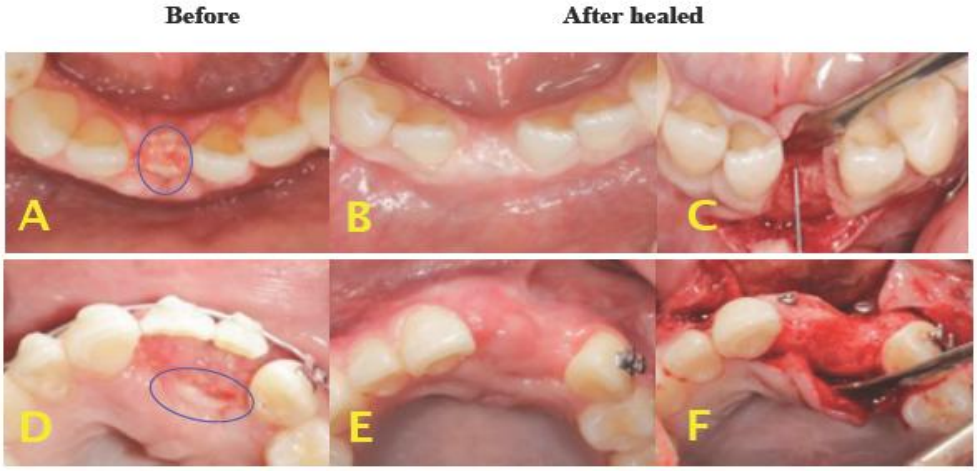

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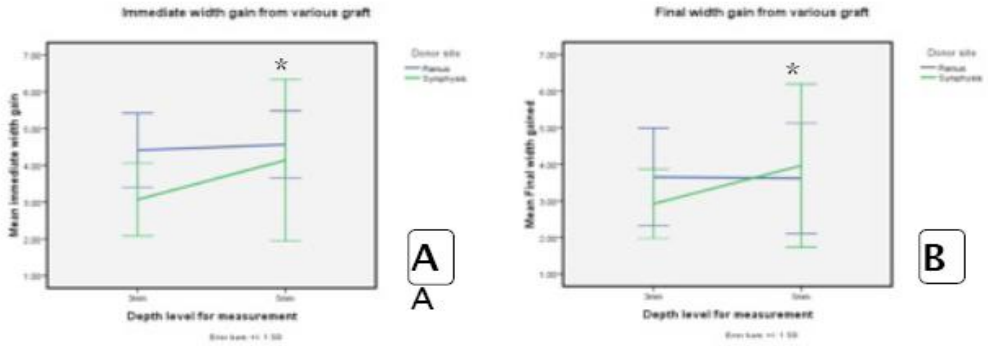

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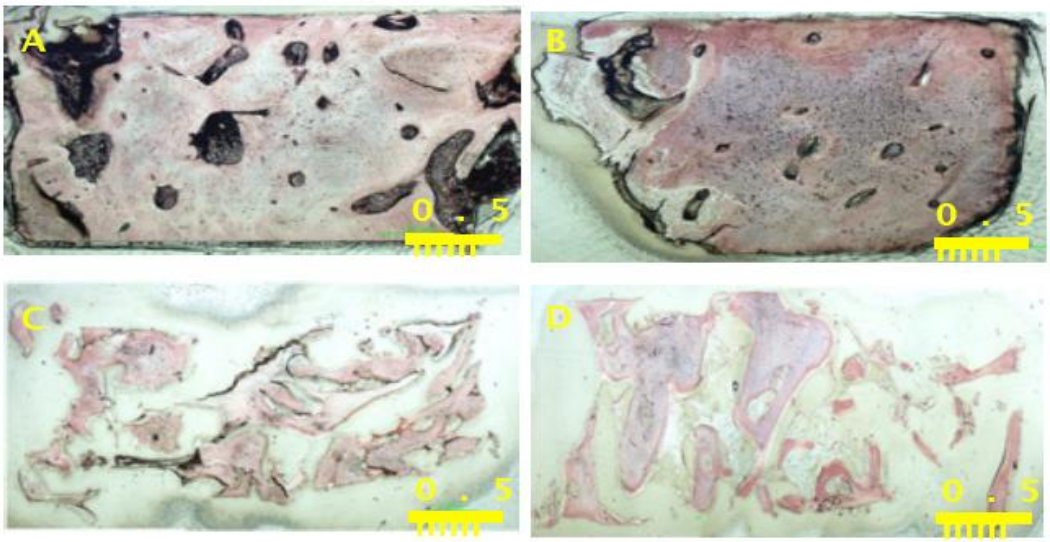

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graft (C) and a core biopsy of the symphysis block graft (D) taken from the anterior maxillary region showed loose bone pattern.

Table 1. Demographic data

Source of graft	Patient (n)	Gender M	F	Age	Period of healing	Implant (n)	Recipient Anterior maxilla	Recipient Posterior maxilla	Recipient Anterior mandible	Recipient Posterior mandible
Ramus	4	1	3	53.00±8.24	5.06±0.19	10	3	1	0	6
Symphysis	3	1	2	32.50±20.20	5.28±1.15	8	1	0	3	4
Total	7	2	5	49.58±13.05	5.09±0.40	18	4	1	3	10

Table 2. Baseline data and implant placement

Patient	Missing teeth	Donor sites	Pre width	Final width	Implant (n)	Diameter 3.25-3.5	Diameter 3.75-4.0	Diameter 4.1-5.0
1	36,37	Ramus	5.83±0.80	9.33±0.72	2			2
2	41	Symphysis	2.08±0.47	4.40±0.57	1	1		
3	14 46	Ramus	6.62±1.17	8.56±2.01	1 1		1	 1
4	11-22	Ramus	3.45±0.77	7.05±0.96	3	1		2
5	45-47	Ramus	5.27±0.98	10.16±0.79	3			3
6	11	Symphysis	4.43±0.04	8.99±1.33	1			1
7	33-35 43-45	Symphysis	3.57±0.94	8.7±0.76	3 3			3 3
Total			4.79±1.60	8.40±1.97	18	2	1	15

Table 3. The dimensional change of each type of grafts according to immediate, final width gain and graft remodel

Depth level	Ramus (n=10)	Symphysis (n=8)
Cone beam CT measurement:		
Immediate width gain:		
3mm	4.41±1.01	3.07±0.98
5mm	4.56±0.91*	4.14±2.19
Average	4.48±0.93	3.60±1.51
Final width gain:		
3mm	3.65±1.33	2.92±0.94
5mm	3.61±1.50	3.96±2.22
Average	3.63±1.38	3.44±1.52
Ridge width remodel:		
3mm	-0.46±0.44	-0.15±0.04
5mm	-0.39±0.18*	-0.17±0.03
Average	-0.42±0.33	-0.16±0.03
(% width reduction)	-10.46±10.55	-5.04±2.08
Cast-based measurement:		
Final width gain:		
3mm	3.82±0.39*	2.33±1.16
5mm	4.34±0.49	2.79±0.57
Average	4.08±0.50	2.56±0.79

* statistically significant difference from the symphysis at $p<0.05$

Table 4. Micro CT evaluation of bone microstructure and bone mineral density and the percentage of total bone area from histomorphometry of the ramus and the symphysis bone block graft at each region of recipient sites.

	Donor site		Location			
	Ramus (n=7)	Symphysis (n=7)	anterior maxilla (n=3)	posterior maxilla (n=1)	anterior mandible (n=3)	posterior mandible (n=7)
BV/TV (Bone fraction)%	84.66±8.36	83.13±8.1	78.72±4.21	84.15	80.3±11.92	87.15±7.54
Trabecular Number(1/mm)	5.95±1.26	6.14±1.35	7.77±0.92*	5.88	5.82±1.24	5.42±0.80
Trabecular Thickness(mm)	0.24±0.08	0.23±0.07	0.16±0.02	0.21	0.26±0.11	0.27±0.06**
Trabecular Separation(mm)	0.06±0.02	0.07±0.02	0.05±0.01	0.05	0.07±0.01	0.06±0.03
Total bone area (Histo)%	80.29±12.03	84.98±14.50	82.70±16.34	90.64	70.63±8.36	87.26±11.33

* statistically significant difference from other regions at $p<0.05$

** statistically significant difference from the anterior maxilla region at $p<0.05$

Appendix 2

Conference Paper

Phetsamone Thanakone, Prisana Pripatnanont, Narit Leepong. The effectiveness of intraoral bone block graft in bone augmentation. ***The 2nd ASEAN Plus Three Graduate Research Congress,*** 5-7 Feb 2014, Bangkok, Thailand.


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THE EFFECTIVENESS OF INTRAORAL BONE BLOCK GRAFT IN BONE AUGMENTATION

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Abstract

This study aimed to evaluate the efficacy of autogenous bone block in maintaining bony dimension after ridge augmentation in an edentulous area. Thirteen patients with 36 tooth-sites were included in the study. There were 18 sites in the maxilla and 18 sites in the mandible. Donor sites comprised of 11 sites from the anterior ramus, 8 sites from the symphysis, 13 sites from the anterior iliac crest and 4 sites from the guided bone regeneration (GBR) with bone substitutes. Evaluation had been done by using cone beam computed tomography (CT) at immediate and 4 months postoperatively. Bone biopsy had been done before implantation, micro CT had been analyzed. Results from cone beam CT measurements showed that the average width gained immediately from the iliac (4.64±1.74 mm) was highest, then the GBR (4.29±1.24 mm), the ramus (3.31±1.41mm) and the symphysis (2.09±1.71mm) respectively. The immediate width gain from the iliac was statistically significant difference from the symphysis ($p<0.05$). The average final width gained of all groups were less than immediate width gained and the average width reduction from the symphysis was highest (-1.21±1.48 mm), then the ramus (-0.71±0.66 mm), the iliac (-0.42±2.23 mm) and the GBR (-0.15±0.40 mm), respectively. The ridge height reduction was also maximum in the iliac group (-0.99±1.45 mm), then the symphysis (-0.83±0.72 mm), the ramus (-0.78±0.69 mm), and the GBR (-0.08±0.23 mm) respectively. Micro CT showed no difference in the percentages of bone volume fraction (%BV/TV) from the ramus (84.52±8.93%) and the symphysis (82.78±8.11%). It can be concluded that the iliac bone graft gained more bone width and height than other sources of the bone, bone remodeling of either sources were not difference.

Keywords: autogenous bone, bone augmentation, bone block graft, bone remodeling, micro-CT

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Abstract

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Keywords: autogenous bone, bone augmentation, bone block graft, bone remodeling, micro-CT

Introduction

The goal of pre-implant bone augmentation of the deficient alveolar ridge is reconstruction of the proper alveolar anatomy through the techniques of socket preservation, horizontal and vertical ridge augmentation, sinus bone grafting, and others. Autogenous bone grafts are considered "the gold standard" due to their compatibility and osteogenic potentials to form the new bone by processes of osteogenesis, osteoinduction, and osteoconduction. A particulate and block autogenous bone has been used for correction of alveolar ridge deficiency. Extraoral site of autogenous block grafts particularly ilium provides a good source of bone material when compares to intra-oral site such as symphysis and retromolar-ramus areas that have limited bone not more than 4 tooth-sites[1].

Although bone graft harvesting from iliac crest give a large amount of bone for reconstruction, it still possesses some drawbacks of donor site morbidity and faster rate of bone resorption than intra oral sites[2, 3]. After bone block graft, timing for implantation should be not more than 4 months to maintain volume of graft and wait for bone integration[4, 5].

Several studies have been proposed to achieve alveolar ridge augmentation in partially edentulous patients using bone blocks harvested from the mandible[6]. Mandibular bone either from the ramus or the symphysis is the ideal choice for limited area of surgical field[7-9].

The purpose of this study was to evaluate the effectiveness of alveolar ridge augmentation with bone block grafts harvested from the extra or intraoral sources in partially edentulous patients. The width and height gained after augmentation from cone beam CT were evaluated. The quality of bone formed from various sources was analyzed by using micro CT.

Patients and Methods

This study is a prospective clinical study and was conducted at Oral & Maxillofacial Surgery Clinic, Prince of Songkla University, Hatyai, Thailand.

The experimental protocol was approved by the Human Research Ethics Committee, Faculty of Dentistry, Prince of Songkla University. Patients condition ASA I or ASA II classification with these conditions were included in the study, pre implant condition of partial edentulous ridge with alveolar bone defects in a bucco-lingual direction resulting from prior extractionsand require bone graft augmentation, crestal width of ≤4 mm, crestal height of ≥ 10 mm, controlled oral hygiene (fair and good oral hygiene) and absence of any lesions in the oral cavity. Patients were excluded on the basis of these criteria: a smoker, a bruxism, a head and neck irradiated patient, a pregnant woman, a bisphosphonate taken person, a patient who has blood, liver, kidney and autoimmune disease and a poor oral hygiene patient.

Patients satisfying the above criteria were consent and enrolled in the study.The edentulous ridgeswere augmented withautogenous ramus, symphysis, iliac bone block graft, fixed with 1-2 screws, or particulate deproteinized bovine bone (Bio-Oss; Geistlich AG, Wolhusen, Switzerland)covering with resorbable membrane.

1. Procedures

1.1 Pre-operative Preparations

Dental model records and standardized dental radiographs including periapical and orthopantomogram were taken. Dental study models were simulated at the augmented area and an individualized acrylic stent was fabricated with perforated line at implant site as a reference line for measuring of dimensional change after ridge augmentation (Fig.1).

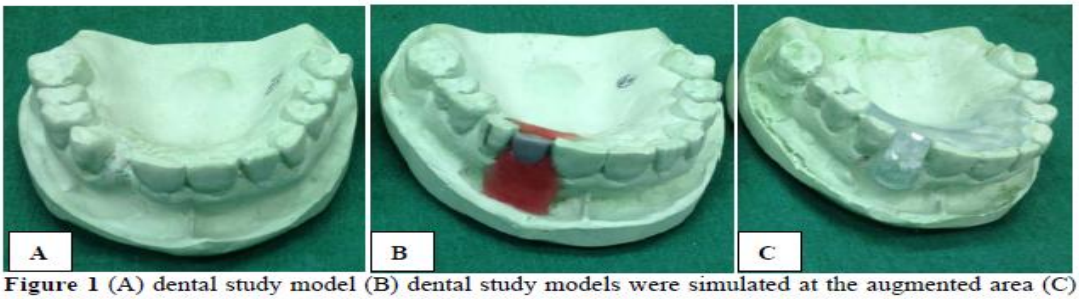

Figure 1 (A) dental study model (B) dental study models were simulated at the augmented area (C) an individualized acrylic stent was fabricated with perforated line at implant site

1.2 Bone harvesting

A bone block was harvested from either the anterior ramus or the symphysis of mandible under local anesthesia with intravenous sedation or the anterior iliac crest under general anesthesia

where appropriate. Procedures were done followed the standard procedures and by an experienced oral and maxillofacial surgeon. The bone block was then fixed to the perforated recipient site with 1-2 micro screws. PRF membrane was used to cover the block graft. Flap was closed and suture with 3-0 Vicryl. Antibiotics, analgesic and antiseptic mouth rinse were prescribed as a standard treatment elsewhere. Removable denture was relieved at least 2 mm. out of contact to the grafted tissue. Sutures were removed 10-14 days after the surgery (Fig.2).

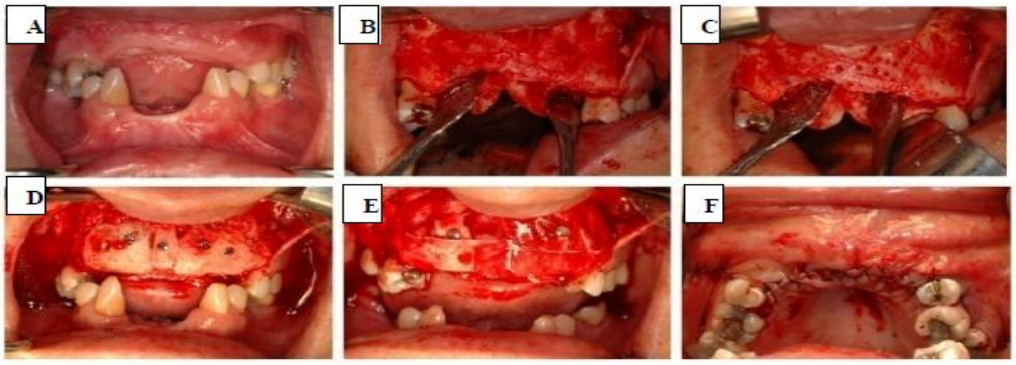

Figure 2. Procedure of bone augmentation (A) atrophic ridge at anterior maxilla (B) alveolar ridge deficiency (C) complete decorticate at recipient site (D) the bone block fixed with screw (E) covering with resorbable membrane (E) primary closure

1.3 Clinical Examination & Data Collection

Cone beam CT (3D Accuitomo 170, J Morita, Kyoto,Japan) with 90 kvp, 5 mA, 30.8 s, 4x4 cm FOV, 0.08 mm isotropic voxel size at the grafted area was taken within 2 weeks and 4 months postoperative and used for measuring grafted dimension of ridge width at the depth 1mm, 3mm, 5mm and 10mm from the alveolar crest and for measuring the ridge height (Fig.3)

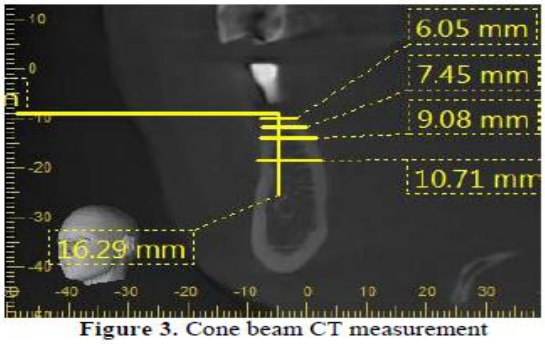

Figure 3. Cone beam CT measurement

At the stage of implant placement in the intraoral source of graft, a core biopsy of bone was taken by using a trephine bur with 2-mm in diameter and 6mm in length.

Bone biopsy was processed for micro-computed tomography analysis (Fig.4).

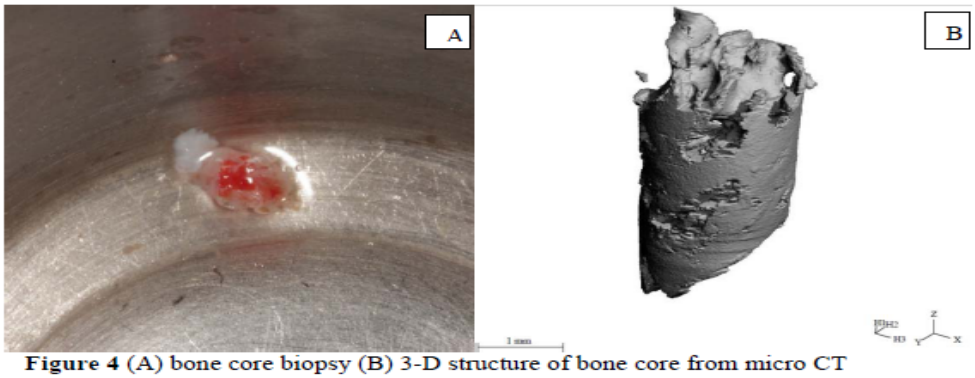

Figure 4 (A) bone core biopsy (B) 3-D structure of bone core from micro CT

2. Micro-computed tomography

Trephined and formalin-fixed bone cores were used for micro-CT analysis (µCT 35, SCANCO Medical AG, Brüttisellen, Switzerland). The specimens were placed in a sample holder and scanned through 180° at a spatial resolution of 20 µm, which allows for evaluation of the tissue architecture. The image data were reconstructed to create 3-D images for quantitative percent of bone volume analysis.

Results

Thirteen patients aged 43.46±13.08 year olds with 36 implant sites participated in the study. There were 18 sites in the maxilla and 18 sites in the mandible. Donor sites comprised of 11 sites from the anterior ramus, 8 sites from the symphysis, 13 sites from the anterior iliac crest and 4 sites from the GBR. Demographic data were presented in **Table 1**.

Table 1.Demographic data

Source of grafts	No of patient	Gender M	F	No of implant site	Age	Recipient Anterior maxilla	Recipient posterior maxilla	Recipient Anterior mandible	Recipient posterior mandible
Anterior ramus	5	2	3	11	50.8±9.06	4	1	0	6
Symphysis	3	1	2	8	29.33±18.34	1	0	3	4
Anterior iliac crest	2	0	2	13	43.50±6.36	6	4	0	3
GBR	3	1	2	4	45.33±8.15	2	0	0	2
Total	13	4	9	36	43.46±13.08	13	5	3	15

The morphological ridge width and height from the cone beam CT were presented in **Table 2 and Figure 5**. Immediate width and height gain represented the width and height gained after augmentation within 2 weeks and final width and height gain representedthe width and height gained after augmentation within 4 months. The immediatewidth gained at all levels of measurementsfrom the iliac group was highest (4.64±1.74 mm), then the GBR (4.29±1.24 mm), the ramus(3.31±1.41mm)and the symphysisgroup(2.09±1.71mm). The width gained from the iliac crest

was more than the symphysis significantly ($p<0.05$) at all levels of measurements. The final ridge width gain of the iliac group was still highest (4.21±2.04 mm) but not different from the GBR (4.14±1.33mm) and the ramus (2.91±1.06 mm) but different from the symphysisgroup (0.89±2.54 mm) significantly ($p<0.05$). There was no difference among each source of bone in the ridge width remodel but the symphysis(-1.21±1.48 mm) underwent most resorption while the GBR(-0.15±0.40 mm) got least resorption. After bone remodeling iliac graft and GBR gained similar bone width at each level and more than intraoral graft from both the ramus and the symphysis (**Figure5**).

Table 2: Immediate, final width and height gain and remodel

Level	Ramus	Symphysis	Iliac	GBR
Immediate width gain:				
1mm	3.31±1.36	2.35±1.74	6.04±1.99*	5.19±1.63
3mm	3.74±1.49	2.38±2.67	5.57±2.47*	4.35±1.65
5mm	3.87±1.67	2.19±2.21	4.26±2.07*	4.23±1.77
10mm	2.29±2.54	1.46±1.74	2.67±2.46*	3.41±1.41
Average	3.31±1.41	2.09±1.71	4.64±1.74*	4.29±1.24
Final width gain:				
1mm	2.29±1.19	1.12±2.53	5.33±1.84*	3.51±2.59
3mm	2.79±1.46	0.92±3.31	4.81±2.38*	4.50±1.51
5mm	3.08±1.62	1.14±3.24	4.27±1.87*	4.27±1.87
10mm	1.33±1.88	0.37±2.36	2.68±2.49*	2.96±0.88
Average	2.91±1.07	0.89±2.54	4.21±2.04*	4.14±1.33
Ridge width remodel:				
1mm	-0.85±0.50	-1.23±1.35	-0.69±2.88	-0.35±0.38
3mm	-0.34±0.75	-1.50±1.78	-0.75±3.01	-0.74±2.18
5mm	-0.26±0.37	-1.05±1.96	-0.25±2.91	0.05±0.43
10mm	-1.39±1.43	-1.09±2.15	0.01±1.54	-0.45±0.67
Average	-0.71±0.66	-1.21±1.48	-0.42±2.23	-0.15±0.40
Immediate height gain	0.71±0.84	-1.01±2.55	4.73±1.75[a]	1.69±1.38
Final height gain	-0.05±0.84	-1.84±2.35	3.74±2.14[b]	1.60±1.27
Ridge height remodel	-0.78±0.69	-0.83±0.72	-0.99±1.45	-0.08±0.23

*statistically significant difference from symphysis at $p<0.05$

[a]statistically significant difference from other groups at $p<0.05$

[b] statistically significant difference from ramus and symphysis at $p<0.05$

The immediate height gain was also highest in the iliac group (4.73±1.75 mm) and significantly ($p<0.05$) different from the GBR (1.69±1.38mm), the ramus (0.71±0.84 mm) andthe symphysis group (-1.01±2.55 mm). The final height gain of the iliac group (3.74±2.14 mm) was still highest and significantly ($p<0.05$) higher than the ramus (-0.05±0.84mm) and the symphysis group (-1.84±2.35 mm) but not the GBRgroup(1.60±1.27 mm). The ridge height reduction from the iliac group (-0.99±1.45 mm) was reduced most, the GBR group reduced least (-0.08±0.23mm) but not different from other 2 groups (ramus -0.78±0.69mm, symphysis-0.83±0.72mm)

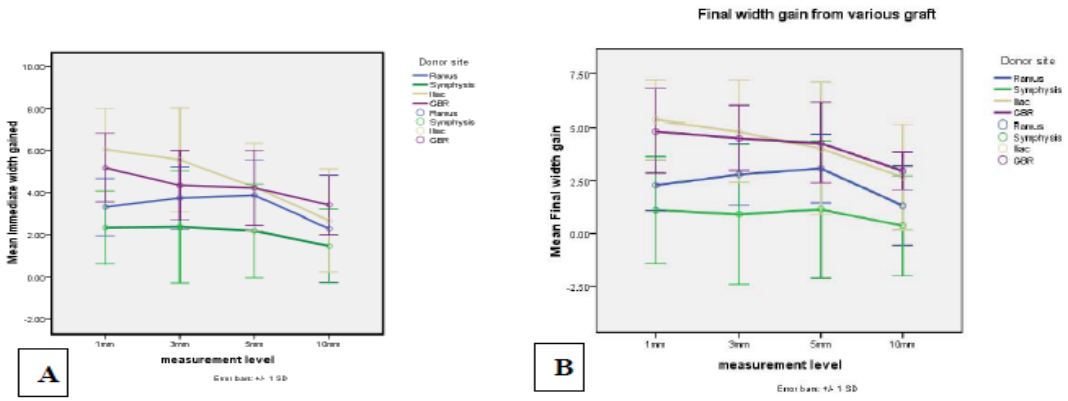

Figure 5(A) Immediate height gain from various sources of graft at each level of measurement , (B) Final width gain

Micro CT was done only in the group of intraoral grafts from ramus and symphysis which showed that the percentages of bone volume fraction (%BV/TV) from ramus (84.52±8.93%)and symphysis(82.78±8.11%) were not different (**Table 3**). The trabecular thickness (Tb.Thmicron) from ramus (24.02±4.26) and symphysis (23.04±7.94) were also not different.

Table 3: Micro CT evaluation of bone microstructure and bone mineral density from the ramus and the symphysis bone block graft.

Donor site	Ramus	Symphysis
Bone volume fraction	84.52±8.93	82.78±8.11
Trabecular bone thickness	24.02±4.26	23.04±7.94

Discussion and Conclusion

Ridge augmentation is a common procedure to correct ridge deficiency before implantation. Cortico-cancellous block harvested from anterior iliac crest give much more volume than intra oral sources, however it undergoes more remodeling and faster resorption[2, 3].The average of ridge width gained in this study from intra oral site was in the range of 2.09 to 3.31mm immediately after augmentation then underwent remodeling and gained final width only 0.89-2.91mm. While the iliac crest gained more width (4.64±1.74 mm) and height (4.73 ±1.75mm) immediately after augmentation and after remodeling the width (4.21±2.04 mm) and height (3.74±2.14 mm) were still higher than augmentation with intra oral graft. This study the iliac site gained maximum width and height while the symphysisgained least width and height. Ridge width reduction was maximum in the symphysis group and ridge height reduction was maximum in the iliac group.

However when compared with previous study[10] using mandibular block graft conducted in Italy, lateral augmentation obtained at the time of bone grafting was 5.5±1.3mm, and reduced during healing from graft resorption to 4.3±1.1mm. The other study using ramus block graft gained mean lateral augmentation at the time of augmentation 4.6 ±0.73 mm, then later, at the time of implant insertion, reduced to 4±0.77 mm[11]. Those studies measured direct ridge dimension by using a caliper that a location and method of measurements were not as same as the present study.

The width gained from those studies was higher than this present study. Remodeling was 21.8 and 13 %, while our study was 12.12% in the ramus and 41.5 % in the symphysis. The symphysis in this study underwent much resorption because the bone used was thin. The other study [12] used particulate bone fromsymphysis bone together with titanium mesh and compared with mixed particulate bone and deproteinzed bovine bone in Indian patientsand found that the horizontal bone gain was 3.44±0.54 mm and 2.88±0.57 mm, which was more than our study but the method used is different.The dimension of the bone in European patients are larger than Asian people from those three studies, however the dimension in our study was less than others, which may be come from the race,the gender of the patients and the structure of the bone.

If the graft volume is sufficient for the planned reconstruction such as thickness required is less than 3 mm, the mandibular bone is a good choice for graft and the mandibular ramus provided better volume, thickness and less remodeling than the symphysis. In a condition that needs bone thickness more than 3 mm, the iliac source is recommended. Only the iliac and the GBR group provided vertical augmentation and the iliac group (3.74±2.14 mm) gained more height and width than the GBR (1.60±1.27 mm). In case of vertical augmentation, bone block alone might be not enough and could be combined with particulate bone from cortico-cancellous chips or bone substitutes plus GBR. Intraoral graft has limited source of particulate bone and bone thickness, therefore it is suitable for a case that need minor to moderate bone augmentation that limit to the thickness not more than 3 mm and the recipient should have sufficient height.

In conclusion, the iliac bone graft gained more bone width and height than other sources of the bone, bone remodeling of either sources were not difference.

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P_MS060

The effectiveness of intraoral bone block graft in bone augmentation

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Introduction

The use of bone block graft to augment atrophic ridge has been the gold standard for both in horizontal and vertical bone augmentation. The common donor sites can be obtained from intra oral site such as ramus and symphysis or extraoral site such as calvaria, and iliac crest . Although bone graft harvesting from iliac crest give a large amount of bone for reconstruction, it still possesses some drawbacks of donor site morbidity and faster rate of bone resorption than intra oral sites (1). After bone block graft, timing for implantation should not be more than 4 months for bone integration and to maintain volume of graft not to be resorbed (2). The fate of bone block graft remodeling and the pattern of bone graft healing is still important for later implantation.

Aim

The purpose of this study was to evaluate the effectiveness of alveolar ridge augmentation with bone block grafts harvested from the extra or intraoral sources in partially edentulous patients in terms of width and height reduction after augmentation from cone beam computerized tomogram (Cone beam CT) and bone structure from micro CT

Materials and Methods

This study is a prospective clinical study, conducted at Oral & Maxillofacial Surgery Clinic, Prince of Songkla University, Hatyai, Thailand.

Healthy patients with edentulous atrophic ridge were consent and enrolled in the study. The edentulous ridges were augmented with autogenous ramus, or symphysis, or iliac bone block graft, fixed with 1-2 screws, or particulate deproteinized bovine bone (Bio-Oss; Geistlich AG, Wolhusen, Switzerland) covering with resorbable membrane.

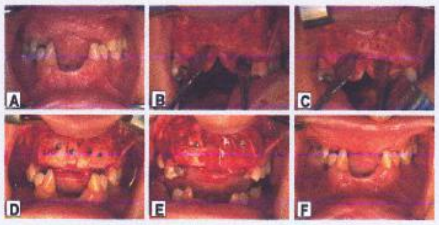

Figure 1. Procedure of bone augmentation (A) atrophic ridge at anterior maxilla (B) alveolar ridge deficiency (C) complete decorticate at recipient site (D) the bone block fixed with screw (E) covering with resorbable membrane (F) primary closure

Cone beam CT (3D Accuitomo 170, J Morita, Kyoto,Japan) was taken within 2 weeks and 4 months postoperative and used for measuring grafted dimension of ridge width at the depth 1mm, 3mm, 5mm and 10mm from the alveolar crest and for measuring the ridge height

For intra oral graft of symphysis and ramus graft, at the stage of implant placement, a core biopsy of bone was taken by using a trephine bur with 2-mm in a diameter and 6mm in length.

Bone biopsy was processed for micro-computed tomography analysis (μCT 35, SCANCO Medical AG, Brüttisellen, Switzerland).

Result

Thirteen patients aged 43.46±13.08 years, with 36 implant sites participated in the study. There were 18 sites in the maxilla and 18 sites in the mandible. Donor sites comprised of 11 sites from the anterior ramus, 8 sites from the symphysis, 13 sites from the anterior iliac crest and 4 sites from the GBR.

The morphological ridge width and height from the cone beam CT were presented in **Table 1 and Figure 2**

Table 1: Immediate, final width and height gain and remodel

Level	Ramus	Symphysis	Iliac	GBR
Immediate width gain:				
Average	3.31±1.41	2.09±1.71	4.64±1.74*	4.29±1.24
Final width gain:				
Average	2.91±1.07	0.89±2.54	4.21±2.04*	4.14±1.33
Ridge width remodel:				
Average	-0.71±0.66	-1.21±1.48	-0.42±2.23	-0.15±0.40
Immediate height gain	0.71±0.84	-1.01±2.55	4.73±1.75[a]	1.69±1.38
Final height gain	-0.05±0.84	-1.84±2.35	3.74±2.14[b]	1.60±1.27
Ridge height remodel	-0.78±0.69	-0.83±0.72	-0.99±1.45	-0.08±0.23

* significant difference from symphysis at $p<0.05$
[a] significant difference from other groups at $p<0.05$
[b] significant difference from ramus and symphysis at $p<0.05$

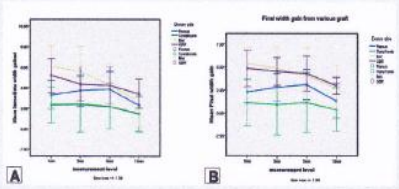

Figure 2(A) Immediate height gain from various sources of graft at each level of measurement , (B) Final width gain

Table 2: Micro CT evaluation of bone microstructure and bone mineral density from the ramus and the symphysis bone block graft.

Donor site	Ramus	Symphysis
Bone volume fraction	84.52±8.93	82.78±8.11
Trabecular bone thickness	24.02±4.26	23.04±7.94

Discussion

Cortico-cancellous block harvested from anterior iliac crest give much more volume than intra oral sources. The average of ridge width gained from intra oral site was in the range of 2.09 to 3.31 mm after augmentation then underwent remodeling and gained final width only 0.89-2.91 mm. The iliac site gained maximum width (4.21±2.04 mm) and height (3.74±2.14 mm) while the symphysis gained least width (0.89±2.54) and height(-1.84±2.35).

Conclusions

The iliac bone graft gained more bone width and height than other sources of the bone, bone remodeling of either sources were not different

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คณะทันตแพทยศาสตร์
มหาวิทยาลัยสงขลานครินทร์
ตู้ไปรษณีย์เลขที่ 17
ที่ทำการไปรษณีย์โทรเลขคอหงส์
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หนังสือฉบับนี้ให้ไว้เพื่อรับรองว่า

โครงการวิจัยเรื่อง "ผลการหายของกระดูก และ เสถียรภาพของรากฟันเทียมในตำแหน่งที่เสริมกระดูกในแนวนอนด้วยชิ้นกระดูกสกัดจากกระดูกม้า ในสันกระดูกที่สูญเสียฟัน"

รหัสโครงการ EC5506 25 P

หัวหน้าโครงการ ทันตแพทย์เพชรสมร ธนาการ

สังกัดหน่วยงาน นักศึกษาหลังปริญญา ภาควิชาศัลยศาสตร์ คณะทันตแพทยศาสตร์ มหาวิทยาลัยสงขลานครินทร์

ได้ผ่านการพิจารณาและได้รับความเห็นชอบจากคณะกรรมการจริยธรรมในการวิจัย (Research Ethics Committee) ซึ่งเป็นคณะกรรมการพิจารณาศึกษาการวิจัยในคนของคณะทันตแพทยศาสตร์ มหาวิทยาลัยสงขลานครินทร์ ดำเนินการให้การรับรองโครงการวิจัยตามแนวทางหลักจริยธรรมการวิจัยในคนที่เป็นสากล ได้แก่ Declaration of Helsinki, the Belmont Report, CIOMS Guidelines และ the International Conference on Harmonization in Good Clinical Practice (ICH-GCP)

ในคราวประชุมครั้งที่ 7/2555 **เมื่อวันที่** 18 ตุลาคม 2555

ให้ไว้ ณ วันที่ 25 ธ.ค. 2555

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Documentary Proof of Ethical Clearance

Research Ethics Committee (REC)

Faculty of Dentistry, Prince of Songkla University

The Project Entitled Bone healing and implant stability in a horizontal bone augmentation with an equine bone block in the edentulous area

REC Project No. : EC5506-26-P

Principal Investigator : Mr. Phetsamone Thanakone

Approved by Research Ethics Committee (REC), Faculty of Dentistry, Prince of Songkla University.

This is to certify that REC is in full Compliance with International Guidelines for Human Research Protection such as the Declaration of Helsinki, the Belmont Report, CIOMS Guidelines and the International Conference on Harmonization in Good Clinical Practice (ICH-GCP).

Date of Approval : 25 DECEMBER 2012

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List of Publication and Proceedings

1. Prisana Pripatnanont, DDS, Phetsamone Thanakone, DDS, Narit Leepong, DDS. The Dimensional Change and the Microstructure of Intraoral Bone Block Graft in Ridge Augmentation, Preliminary Report. ***Int J Periodontics Restorative Dent.***
2. Phetsamone Thanakone, Prisana Pripatnanont, Narit Leepong. The effectiveness of intraoral bone block graft in bone augmentation. ***The 2nd ASEAN Plus Three Graduate Research Congress,*** 5-7 Feb 2014, Bangkok, Thailand.