Alveolar Ridge Preservation with Hydroxyapatite/beta-tricalcium phosphate-Collagen Composite in Maxillary Anterior Teeth

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Abstract **- The purpose of this study was to compare the dimensional changes (width and height) and healing of alveolar ridge following tooth extraction, with and without placement of hydroxyapatite, beta-tricalcium phosphate collagen (HA/β-TCP-collagen) composite plug. The twenty-four extracted sockets of maxillary anterior teeth were randomly allocated to experimental group with HA/β-TCP-collagen composite plug and control group with extraction alone. The extractions and grafting were performed at the same time without raising a flap nor being covered with barrier membranes. The dimensional changes in width of the ridge were measured clinically by using the alveolar ridge mapper and the changes in height were detected radiographically at before tooth extraction, immediately after tooth extraction and 3 months after the extraction. The healing of the ridge was assessed by Gray Scale and Modified Landry and Turnbull healing index. The greater reduction in width of the alveolar ridge was observed at the control sites (3.67±1.16 mm) compared to the experimental sites (5.83±1.12 mm) during the 3 month follow up period. But the comparison of changes in height of the alveolar ridge between two groups was not statistically significant (*p*=0.551). In comparison of the healing of the ridge between these two groups, the better outcomes were seen in the experimental group with significance level (*p*<0.005). There were no foreign body reactions or complications in this study. In conclusion, the placement of HA/β-TCP-collagen socket plug into the freshly extracted socket could prevent the reduction of the alveolar ridge with the least surgical morbidity and the most promising result.**

Keywords; alveolar ridge preservation, HA/β-TCP-collagen composite, socket grafting

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Introduction

Alveolar ridge resorption is a chronic, irreversible phenomenon which continues to resorb throughout life after the extractions (Kotaski *et al*., 2014). If no actions are employed for prevention of this phenomenon, 40%-60% of total alveolar bone volume is lost during the first 2-3 years post extraction, the vast majority of these changes occur during the first 3 months after tooth extraction and this phenomenon continues with a rate of 0.25%-0.5% loss per year (Ashman, 2000).

When immediate dental implant placement is not planned, alveolar socket preservation is a method of choice used to minimize the dimensional changes in soft and hard tissues after extraction (Sadeghi *et al*., 2016). Atraumatic extraction and further protection of alveolus are important to reduce need of additional complex bone and/or soft tissue augmentation procedures

during later dental implant placement procedure (Kubilius *et al*., 2012).

The type of maxillary anterior bone is type III bone, mostly spongy, less cortical and the labial bone is also very thin, which leads to high risk of ridge resorption after tooth extraction. The volumetric reduction and loss of favourable architecture of the alveolar ridge may negatively affect the placement of dental implant and influence the treatment success of a fixed or removable prosthesis in regard to function and aesthetics (Schroop *et al*., 2003). Thus, it would be advisable to protect reduction of the ridge.

The methods to preserve alveolar ridge include guided bone regeneration-GBR (with or without grafting material), grafting with bone substitutes (with or without flaps), and socket seal surgery without primary flap closure (BioCol technique, modified BioCol technique and Nu-men technique with alloplast) (Kotsakis *et al*., 2014).

In GBR, the augmented site needs to be covered with a barrier membrane or an advanced buccal flap. Barrier membranes have drawbacks of primary soft tissue closure, membrane exposure, surgical site infection and second surgery is needed to be removed. It also requires reflection of flap which disturbs the blood supply and causes negative effect on bone remodeling (Mezzomo *et al*., 2011). But the use of synthetic bone plug technique is a flapless procedure and it does not need primary closure, membrane or flap - providing patients with more comfort, no alteration of mucogingival junction and adequate zone of keratinized gingiva which are needed for aesthetics of future dental implant (Kotsakis *et al*., 2014).

Biphasic calcium phosphate ceramics (BCP) consisting of HA and β-TCP (homogenous 60/40 mixture) have the advantage of the different resorption rates of the two materials, achieving a balance between long term stability and support (HA) and more rapid dissolution and bone ingrowth (β-TCP) (Legeros *et al*., 2003). As HA and β-TCP are completely synthetic, they do not require donor sites (available in unlimited quantities) and do not pose a risk of disease transmission although they cannot provide osteogenesis (Jamjoom and Cohen, 2015). But it can also readily be identified on X-ray, being much denser than the adjacent bone, for the radiographic assessment for bone healing (Von Doernberg *et al*., 2006).

The present study was made to compare the dimensional changes and healing of the alveolar ridge, with and without placement of HA/β-TCP-collagen plug, in freshly extracted sockets.

Materials and Methods

Study Population

Twenty-four subjects were selected based on the need of tooth extraction at Department of Oral and Maxillofacial Surgery, University of Dental Medicine, Yangon. The inclusion criteria were both genders with age group between 20-55 years, mentally sound subjects with ASA I and II, non-restorable, maxillary anterior teeth with adjacent teeth present on both sides, and freshly extracted sockets with intact four wall bone after tooth extraction.

Exclusion criteria were medically compromised subjects, pregnant and lactating mothers, use of systemic corticosteroids within 2 weeks, previous head and neck radiation therapy, use of bisphosphonates and immunosuppressants, smokers and betel nut chewers, tooth with severe periodontitis (with a remaining bone height ≤ 6 mm) and tooth associated with presence of acute infection and underlying bony pathology (for example-cysts).

Study Material

The material used in this study was maxresorb® flexbone/collacone® max, a product of Botiss Company, Germany (Figure 1). It is a resorbable synthetic bone plug containing biphasic calcium phosphate (60% hydroxyapatite and 40% beta-tricalcium phosphate) and porcine type I collagen. The macropore size is 200 µm – 800 µm and the porosity is 80%. The diameter of plug is 11 mm and its height is 16 mm.

Preoperative Assessment

At first, the clinical assessment was done to patients with non-restorable maxillary anterior teeth, who attended to Department of Oral and Maxillofacial Surgery from September 2017 to August 2018. The patients entitled to the study according to inclusion criteria were explained about the procedures, outcomes, benefits and complications of the current research. Then, informed consent was taken. Patient's bio-data such as age, gender and past medical history were recorded. Each patient received a diagnostic workup including digital periapical radiographs, study casts, and clinical photographs. Customized vaccum assisted thermoplastic stents were fabricated on study casts to serve as fixed reference points for measurement of width of alveolar ridge. Two holes (at mid-buccal and mid-palatal) as references to measure the width of alveolar ridge were made on the stents at 5mm below the line connecting the cementoenamel junction (CEJ) of the two adjacent teeth.

Operative Procedure

Routine standard operative procedures were performed in both groups. The whole mouth was cleaned with 0.12 percent chlorhexidine solution. The extraction of tooth was performed under local anaesthesia, using lignocaine with adrenaline (1:100,000). All the procedures were performed by the same surgeon. The extraction of the tooth was performed as atraumatically as possible. Care was given to not raise a flap in order to maintain the vascularization of the socket walls. After removal of the tooth, thorough debridement of the extracted socket was made. A Michigan-O-periodontal probe was utilized to explore the buccal plate which had to be intact four-wall post-extraction sockets after tooth extraction. The subjects were divided into two groups according to randomization table. In study group, the synthetic bone plug was inserted into an extraction socket, trimmed to completely occupy the space from the crest of the alveolus to the apex of the socket and stabilized with a figure of eight suture (3/0 vicryl) to prevent it from falling out. In control group, the extracted socket was left open and was not given any pressure to contact the socket walls. Both groups were prescribed postoperative medications- per oral amoxicillin 500 mg for 5 days, per oral acetaminophen 500 mg for 3 days and 0.2 percent chlorhexidine mouth rinse twice a day for 2 weeks. The patients were asked to follow post-operative instructions and medications strictly. After 6^{th} week, the placement of a provisional temporary restoration was made with least trauma to healing ridge, only for optimal aesthetics.

Study Method

The custom-made vaccum-formed thermoplastic stents were placed into the mouth. The width of alveolar ridge was measured at reference holes on these stents (under local anaesthesia) clinically by using the ridge mapper (Figure 2) at baseline, immediate postoperative period and 3 months after tooth extraction (Figure 3). The height of the alveolar ridge was also detected on intraoral digital periapical

X-ray with parallel technique by drawing two lines (first line connecting the cementoenamel junction (CEJ) of two adjacent teeth on each side, second line drawn from the lowest position on alveolar ridge defect perpendicular to the first one). This perpendicular distance was measured at baseline, immediate postoperative period and 3 months after extraction. To detect the alveolar bone healing, gray scale-relative alveolar bone density (mean gray value of the defect region/ mean gray value of the surrounding bone) was analyzed by using image J software (Geiger *et al*., 2016). The soft tissue healing was assessed by the Modified Landry and Turnbull healing index, as shown in Table 1. This study was approved by Research and Ethical Committee of University of Dental Medicine, Yangon.

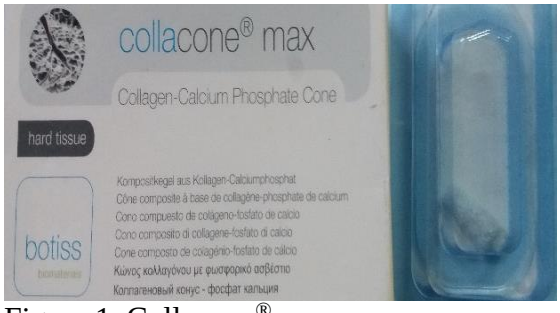

Figure 1. Collacone® max


Figure 2. Alveolar ridge mapper


Figure 3. Measurement of width of alveolar ridge with ridge mapper

Table 1. Modified Landry and Turnbull healing index (Balse & Baliga 2018)

Healing score	Characteristics
1-Very poor	Tissue color: ≥ 50% of gingiva red Response to palpation: bleeding Granulation tissue: present Suppuration: present Presence of Alveolar osteitis
2- Poor	Tissue color: ≥ 50% of gingiva red Response to palpation: bleeding Granulation tissue: present
3- Good	Tissue color: ≥ 25% and ≤ 50% of gingiva red Response to palpation: no bleeding Granulation tissue: none
4-Very good	Tissue color: < 25% gingiva red Response to palpation: no bleeding Granulation tissue: none
5-Excellent	Tissue color: all tissues pink Response to palpation: no bleeding Granulation tissue: none

Statistical Analysis

Statistical Package for Social Sciences (SPSS) 20.0 version Statistical Software was used for data analysis. The data were expressed as in mean and standard deviation (SD) for continuous variables and count and percent for categorical variable. To test the hypothesis of difference between two groups, Fisher's

exact test, Mann-Whitney U-test and paired '*t*' test were used. Statistical significant level was determined at *p*-value <0.05.

Results

Twenty-four subjects were involved in this study and half of them were in the age group 47-55 years. The causes of tooth extractions were dental caries (62.5%), endodontic failure (25%) and traumatic crown fracture (12.5%). The extracted teeth were 21 incisors and 3 canines.

Table 2. Comparison of width (mm) of alveolar ridge at different interval between two groups (n=24)

Time	Alveolar ridge width (in mm) (Mean±SD)		*p*-value*
	Study	Control	
Baseline	5.92±1.08	5.08±0.99	0.101
Immediate	5.92±1.08	5.08±0.99	0.101
3 months	5.83±1.12	3.67±1.16	0.000*
p-value*	0.339	0.000*	

*Mann-Whitney U-test

The mean width of alveolar ridge reduced in both groups at 3 month. The mean width of alveolar ridge decreased from 5.92±1.08 mm to 5.83±1.12 mm in the study group while the mean width of alveolar ridge decreased from 5.08±0.99 mm to 3.67±1.16 mm in control group. The reduction in width of alveolar bone in conventional group was statistically significant in comparison with synthetic bone plug group (*p*=0.000), as shown in Table 2. The reduction of bone width was 27.75% in control group and only 1.52% in study group.

Table 3. Comparison of height (mm) of alveolar ridge at different interval between two groups (n=24)

Time	Alveolar ridge width (in mm) (Mean±SD)		*p*-value*
	Study	Control	
Baseline	3.37±1.26	3.67±1.03	0.443
Immediate	3.37±1.26	3.67±1.03	0.443
3 months	2.67±0.93	2.78±1.18	0.551
p-value*	0.002*	0.000*	

*Mann-Whitney U-test

Reduction in the mean height of alveolar ridge was noted in both groups at 3 month. The mean height of alveolar ridge decreased from 3.367±1.26 mm to 2.667±0.93 mm in study group and from 3.667±1.03 mm to 2.783±1.18 mm in control group. The comparison of height of alveolar ridge at 3 month between groups was not significantly different (*p*=0.551), as shown in Table 3.

Table 4. Comparison of alveolar bone healing (gray scale for relative alveolar bone density) between two groups (n=24)

Time	Relative radiodensity (Mean±SD)		*p*-value*
	Study	Control	
Immediate	0.9696 ±0.15	0.6934 ±0.20	0.001*
3 months	0.8677 ±0.14	0.8334 ±0.144	0.713

* Mann-Whitney U-test

The relative radiodensity (Gray scale) in study group (0.9696±0.15) was significantly higher than control group (0.6934±0.20) at immediate postop, showing that the density of grafted

biphasic calcium phosphate was higher than of the surrounding bone. But at 3 month, it was observed that the radiodensity in study group gradually reduced from 0.9696±0.15 to 0.8677±0.14, indicating that some of the grafted material has resorbed. But the radiodensity of conventional group gradually increased from 0.6934±0.20 to 0.8334±0.14 at 3 month, showing that the radiodensity of naturally healing socket gradually increased with time, as shown in Table 4.

Table 5. Comparison of soft tissue healing between two groups

Soft tissue healing	Study		Control		Total	
	n	%	n	%	n	%
Very poor	-	-	-	-	-	-
Poor	-	-	-	-	-	-
Good	-	-	-	-	-	-
Very good	1	8.3	9	75	10	41.7
Excellent	11	91.7	3	25	14	58.3
Total	12	100	12	100	24	100

*Fisher's exact test

The comparison soft tissue healing between two groups was shown in table 5. According to Fisher's exact test, the comparison of soft tissue healing between these two groups was significant (p=0.003). The results of some of the cases were shown in following photographs.

Figure 4. Grafted socket at 3 months

Figure 5. Comparison of soft tissue healing between control (Right) and study (Left) at 3 months

Figure 6. X-ray of grafted socket at immediate (Right) and 3 months (Left)

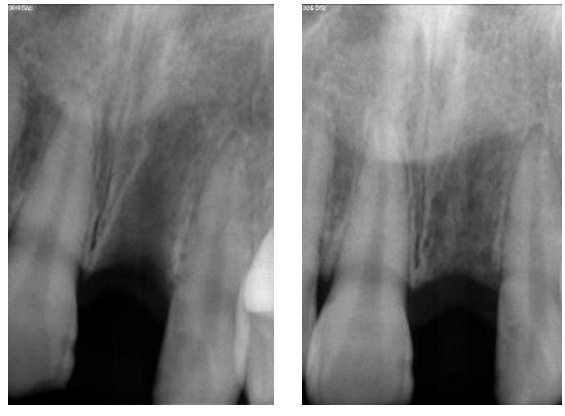

Figure 7. X-ray of control group at immediate (Right) and 3 months (Left)

Discussion

Post-extraction alveolar ridge resorption is an inevitable physiologic process. The alveolar socket wall commonly decreases in volume and changes morphologically following tooth extraction. To

prevent this, the alveolar ridge preservation (socket grafting) techniques have been adopted by dentists throughout the world.

The alveolar ridge preservation (ARP) via socket grafting with HA/β-TCP-collagen composite was chosen in this study due to its biocompatibility, osteoconductive 3D scaffolding, angiogenic abilities of collagen, cell-mediated resorbability. This method was supported by Ho *et al*., (2016) who conducted a comparative study of 4 groups- HA/β-TCP-collagen composite, collagen alone, purified fibrillar collagen and bovine xenograft-collagen into 80 extracted sockets. The smallest width reduction (19.9±8.81%) was observed in HA/β-TCP-collagen composite group.

Moreover, barrier membranes were not used in the present study according to Brkovic *et al.*, (2011) who stated that combination of β-TCP and type I collagen used for simple preservation of a maxillary extraction socket without a barrier membrane resulted in new bone formation (62.6% of mineralized bone and 21.1% of bone marrow) 9 months after the procedure. This was due to inhibition of fibroblastic proliferation into the bone marrow by β-TCP particle metabolites and a local decrease in pH during the chemical dissolution process.

But there is no ideal technique and bone graft material that is suitable in all situations and can provide hundred percent bone preservation. This technique is not appropriate in the presence of acute infection and flaps may need to be raised in cases of severe bone loss, ridge irregularities or socket wall defects (Darby *et al*., 2008).

According to Araújo and Lindhe (2009), Schroop *et al*., (2003) and Moya-Villaescusa and Sanchez-Perez, (2010), the vast majority of alveolar bone volume changes occured first 3 months after tooth extraction although the overall changes may not yet be completed by this time. Thus, the study period was selected for 3 months in the current study and it was found that significant changes in horizontal dimension of ridge occurred in comparison between conventional group and synthetic bone plug group ($p<0.005$).

The alveolar ridge mapping technique used in the present study had sensitivity 59%, specificity 91%, positive predictive value 71% and negative predictive value 90% according to Castro-Ruiz *et al.*, (2015). To assess the changes of alveolar ridge height, cone beam computed tomography (CBCT) is the best and alveolar width can also be measured simultaneously.

The current study revealed that the comparison of reduction in width of alveolar ridge between two groups was significant ($p<0.005$). The amount of reduction of bone width was 27.75% in the control group and only 1.52% in the study group at 3 months after tooth extraction. In regard with height changes, reduction in height of the ridge was found in both groups at 3 months after tooth extraction, but these changes were not significant at inter-group comparison ($p=0.551$).

These findings were in agreement with a similar study conducted by Sachdev *et al.*, (2015) which showed that the amount of loss in bone width in control site was 31.6% after 3 months and a significantly greater alveolar ridge width reduction was noted in control sites (4.0-1.5 mm) compared to experimental sites (2.5-1.0 mm) although the ridge height reduction was not significant. Therefore, ARP with HA/β-TCP-collagen composite plug was effective in limiting physiologic ridge reduction in horizontal dimension as compared with tooth extraction alone although it had no significant effect on

height of the ridge.

In the present study, it was found that the loss in width of the ridge (5.08±0.99 mm to 3.67±1.16 mm) was greater than loss in height (3.667±1.03 mm to 2.783± 1.18 mm) in control group at 3 months after the tooth extraction. These results were in accordance with a systematic review of alveolar bone dimensional changes of post-extraction sockets in humans by Van der Weijden *et al.,* (2009) which stated that the clinical loss of thickness (3.87 mm) was greater than the loss in height when evaluated both clinically (1.67-2.03 mm) and radio-graphically (1.53 mm) at 6 months after tooth extraction and also consistent with Lekovic *et al.,* (1997) who reported that loss of width was three times greater than loss of height following tooth extraction. Thus, to protect the width loss is more necessary than to protect the height.

In this study, the densitinometric analysis of extracted sockets was done by using software on digital intraoral periapical X-ray. In synthetic bone plug group, the decrease in relative radiodensity (from 0.9696±0.15 to 0.8677±0.14) was noted at 3 months after the procedure, indicating that some of the grafted material has resorbed. The result was in accordance with the studies conducted by Von Doerberg *et al.,* (2006), Horowitz *et al.,* (2009) and Pe'rez A'lvarezn *et al.,* (2016). As the grafted material had resorbed and preserved the dimension of alveolar ridge, it would provide favourable conditions for placement of dental implant with subsequent loading in the 4 to 6 month period.

In the current study, the soft tissue healing was assessed by Modified Landry and Turnbull healing index. The difference of soft tissue healing between the two groups was statistically significant (p= 0.003). Moreover, one patient in the present study had two maxillary anterior teeth which were indicated for extraction. These two teeth were simultaneously extracted and these two extracted sockets were compared, with and without grafting. At 3 months, it was found that healing of grafted socket were better than naturally healed socket, even in the same patient.

Girard *et al*., (2000) reported a case of a foreign body granuloma with pain and sensation disturbance following placement of a graft into an extraction socket, already compromised by the previous infection. In the present study, the teeth without acute infection have been selected and the extracted sockets were made thorough debridement before grafting to prevent presence of granulation tissues and foreign bodies. So, there were no foreign body reactions and complications in this study.

Conclusion

The alveolar ridge preservation (ARP) concepts are well accepted throughout the world and there are many still ongoing researches about ARP. The results of this study showed that ARP via socket grafting with HA/β-TCP-collagen composite plug can be a minimally invasive and effective method to prevent post-extraction physio-logic ridge resorption in horizontal dimension although it has less effect on vertical dimension. But there is also a necessity for long term study in large number of population to assess changes of the ridge following preservation and the success rate of osteointegration of dental implant within the grafted socket.

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The authors declare there is no potential conflict of interest.

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