

# Histologic findings of three-wall intrabony defects around dental implants using different grafting materials in beagle dogs

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## I. INTRODUCTION

Dental implants have been used for many years in the treatment of completely and partially edentulous patients with good long term predictability. The clinical and experimental findings indicate that fixation of endosseous implants may be dependent on qualities and quantities of the surrounding bone.<sup>1</sup>

Implants can easily be placed into sites with abundant bone. However, the problem of insufficient bone volume is encountered during implant placement.<sup>2,3</sup> As the implant dentistry has improved, attempts have been made to place implants in what may be considered less than ideal anatomic situations to proper prosthetic results. Patients who have been missing teeth for prolonged periods frequently have areas of compromised bone. Consequently, clinicians are faced with the situation of how to

manage the complicated case.<sup>4</sup>

Extraction socket defects or alveolar ridge defect may restrict placement of dental implant.<sup>5</sup> Even minor loss of bone may result in exposed threads at the alveolar crest or at bone fenestration. These problems will occur at failing or failing implant before or after placement of implant. The development of bone graft materials and techniques may give surgeons methods for solving of these problems.<sup>6,7</sup>

There are many graft materials and techniques that are used recently in attempt to repair osseous defects around implants.<sup>1,6,8,9,10,11,12,13</sup> One of the most common methods involves the harvesting and implantation of fresh autogenous bone graft.<sup>4,14,15</sup> Other methods is using demineralized bone powder implants or several commercially available allograft.<sup>4,16,17</sup> Mellonig<sup>18</sup> reported that the use of dem-

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ineralized freeze-dried bone allograft has a potential risk for disease transmission. Some investigators reported that demineralized freeze-dried bone allograft did not appear to induce bone formation.<sup>4,14</sup> Nevertheless, Demineralized freeze-dried bone (DFDB) is the most widely used allograft material.<sup>19,20</sup> Guided tissue regeneration concept has been applied to regenerate bone around exposed implant surfaces during osseointegrated implant placement.<sup>8,9,10,21,22</sup> Guided bone regeneration (GBR) with mechanical barriers has been shown to be effective in the treatment of bone defects around dental implants.<sup>14,21,23,24,25,26</sup> Such studies have reported different degrees of success of guided bone regeneration, depending upon the type of barrier selected, presence or absence of an underlying graft material,<sup>27</sup> types of graft material, feasibility of technique, and clinician's preference.<sup>2,6,12,13,15,28,29,30,31,32</sup> Demineralized bone matrix (DBM) is considered a transplantable tissue. Recently, several authors have evaluated the usage of DBM putty.<sup>33,34,35</sup> Conflicting reports concerning the osteoinductivity of demineralized bone matrix (DBM) and historical use of synthetic bone graft substitutes has limited the use of DBM in oral and maxillofacial applications.<sup>35</sup>

Alloplast, such as the bioactive glass, may be an effective alternative to DFDB.<sup>1,3,6,36</sup> Commonly used ceramic bioactive alloplastic bone grafting materials include hydroxyapatite and  $\beta$ -tri-calcium phosphate, which have been reported to form a chemical bond to bone tissue.<sup>37,38,39</sup> Bioceramic glasses are made from calcium salts and phosphate and there are controlled studies which support their clinical use.<sup>1,3,6</sup> The use of synthetic bone substitutes has increased in implant dentistry. These materials are readily available, easily manipulated, relatively economical, and have become increasingly predictable with improvements in clinical techniques.<sup>36</sup> Recently, Studies about the use of  $\beta$ -tri-calcium

phosphate with dental implant placement were reported.<sup>40-45</sup>

Recently Lee et al, fabricated calcium phosphate glass with Ca/P ratio of 0.6 using the system CaO-CaF<sub>2</sub>-P<sub>2</sub>O<sub>5</sub>-MgO-ZnO. This material can be expected to extend application field to biomaterials for hard tissue repair because of non-crystalline structure as well as low Ca/P ratio.<sup>46</sup> Low Ca/P ratio and amorphous states provide the great extent of dissolution and resorption that allows the fast ingrowth of surrounding bone. particle size was 200 to 500 $\mu$ m. Before new graft materials are used for general clinical purpose, basic biologic experiments should be performed to analyze the reaction of host tissues. However, there has been no investigation that deal with CaO-CaF<sub>2</sub>-P<sub>2</sub>O<sub>5</sub>-MgO-ZnO in GBR procedures adjacent to implant.

The purpose of this study was to histologically evaluate and compare the healing of the three-wall defects using xenogeneic DBM putty<sup>33-35</sup>, Porous  $\beta$ -tri-calcium phosphate ( $\beta$ TCP)<sup>40-45</sup>, newly developed non-crystalline calcium phosphate glass<sup>46</sup> around submerged SLA surface dental implant in beagle dogs. Histologic analysis provides the clinician with better understanding for selecting the most suitable graft material.

## II. MATERIALS AND METHODS

### 1. Animals & Materials

Five male, lab-bred beagle dogs were used. these animals were approximately 15-18 months old and weighted between 12kg and 15kg. xenogeneic DBM putty<sup>†</sup>, Porous  $\beta$ -tricalcium phosphate particles<sup>‡</sup>, newly developed non-crystalline calcium phosphate glass were used in defects around SLA surface dental implant (6mm in length, 3,4mm in diameter)<sup>†</sup>. Animal selection and management, surgical protocol

and procedures for this study were reviewed and approval given by the Institutional Animal Care and Use Committee, Yonsei Medical Center, Seoul, Korea.

## 2. Experimental design

The experimental group was treated with non-crystalline calcium phosphate glass, Porous  $\beta$ -tri-calcium phosphate, xenogeneic DBM putty, No treatment(control).

## 3. Surgical protocol

Tooth were extracted under general anesthesia and sterile conditions in an operating room using Atropine<sup>§</sup> 0.05mg/kg SQ., Rompun<sup>\*\*</sup> 2mg/kg, Ketamine<sup>††</sup> 10mg/kg IV as a premedication. The dogs were placed on a heating pad, intubated, and inhaled with 2% enflurane and monitored with an electrocardiogram. After disinfection of the surgical sites, 2% lidocaine HCl with epinephrine 1:100,000 was used by infiltration at the surgical sites. Creviceular incisions were made, and all premolar were carefully extracted. Prior to extraction, P2-P4 were sectioned to avoid tooth fracture. Flaps were sutured with vertical mattress 5-0 resorbable sutures. The day of surgery the dogs received antibiotics Cefazoline<sup>¶</sup> 10mg/kg IV.

The implants were placed under the same surgical conditions as the tooth extraction after a healing period of 8 weeks. A crestal incision was made preservation of keratinized tissue on each side of the

incision. Mucoperiosteal flaps were carefully reflected on the buccal and lingual aspect. The edentulous ridge was carefully flattened with an surgical bur and irrigation with sterile saline. Two implants were placed on each side of the mandible. The implant osteotomy was performed at 800 rpm under irrigation of chilled saline. Before placement, a standardized 3-wall intrabony defect(3mm buccolingual  $\times$  3mm apicocoronal  $\times$  5mm mesiodistal) was created at the mesial of the each implant site with a straight fissure bur. Modification of intrabony defects site preparation was completed as described by Hall et al.<sup>6</sup> Countersink was done, placement was made without tapping. The implants were positioned such that the most coronal portion of the implant body was level with the osseous crest and centered in a buccal - lingual position.

Graft materials were then inserted into the 3-wall defect sites, defects were grafted with either  $\beta$ -tri-calcium phosphate, xDBM putty, non-crystalline calcium phosphate glass or not filled(control)

The flap were closed with 5-0 resorbable sutures. Periosteal releasing incisions were performed to achieve tension free wound closure. Vertical mattress and interrupted sutures were used. The post-operative care was the same as the tooth extraction. Sutures were removed after 7 to 10 days. A soft diet was provided throughout the study period.

The dogs were sacrificed at 8 weeks following placement of the graft materials. Euthanasia was performed with an overdose of the drugs used in the process of anesthesia. Block sections including

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\* GrafTon Putty<sup>®</sup> Osteotech, Inc., Eatontown, NJ

† Cerasorb<sup>®</sup>, Curasan AG Germany

‡ Implantium<sup>®</sup>, for the experimental usage, manufactured by Dentium Co, Seoul, Korea.

§ Kwangmyung Pharm. Co., Ltd, Seoul, Korea

\*\* Bayer Korea Ltd, Seoul, Korea

†† Korea United Pharm, Seoul, Korea

¶ Yuhan Co, Seoul, Korea

segments with implants were preserved and fixed in 10 % neutral buffered formalin for histologic preparation and analysis.

#### 4. Histologic Preparation & Findings

48 hours after sacrifice, the specimens were cut into block sections on a low speed saw and placed in fresh 10% formalin for complete fixation before dehydration. The specimens were soaked for 3 days in Villaneuva bone stain solution before dehydration. The specimens were then dehydrated through graded alcohols of 70%, 80%, 95%, 95%, 100%, 100% at 2 hour intervals for 1 week. Infiltration was completed by using monomer and embedded in methyl-methacrylate resin. Polymerization of the specimens lasted seven days. Methyl-methacrylate blocks were trimmed with a band saw and mounted on a plastic mount with adhesive. Block was reduced with the grinding unit to approximately 40 $\mu$ m thickness.

Sections were analyzed under microscope for new bone formation and bone to implant contact and residual graft particle content. The sites from the top of the implant to the base of the created defect which was originally created to be 3mm and approximately 2.5mm(half of original defect M-D length) mesial of the defect was observed along the side of the implant.

### III. RESULTS

#### 1. Clinical Findings

During the postoperative healing periods, there was no exposure of the tissue covering the remaining implants.

#### 2. Histologic findings

Evaluation of the histologic sections revealed similar findings in all treatment group. There was no evidence of acute inflammatory reaction around any of the dental implants. Retentive grafted particles adjacent to the implant could be seen regardless of the type of graft. The treatment groups in this study showed histologic evidence of a little new bone formation from the base of the bone defects. Slightly bone loss of distal side of implant(no bony defect) was observed.

##### 1) non-crystalline calcium phosphate glass

Large amount of grafted particles were visible in a histologic section. Grafting particles were surrounded with connective tissue. New bone formation around graft materials was not present. Minimal newly formed bone originating from existing bone was found only in the proximity of the base of the bone defects. In contrast, Grafted particles were positioned at the upper portion of defects. Histologic sections demonstrate grafted particles throughout field. New bone-to-implant surface contact was not seen.

##### 2) Porous $\beta$ -phase tricalcium phosphate

Most of the  $\beta$ -TCP granule in the infrabony defects were surrounded with connective tissue. There was a large amount of newly formed bone among the  $\beta$ -TCP granules and an apparent "bone scaffolding" effect observed. Ingrowth of new bone from lateral wall was observed in  $\beta$ -TCP specimen. A little amount of new bone formation originating from the existing base of bone defects was observed at the surface of dental implant, new bone-to-implant surface contact was not revealed.

##### 3) xDBM putty

The biopsies from these sites consisted of grafted bone particles enmeshed in connective tissue. Most

of the xDBM putty was observed at the upper part of the defects. Two distinct part between the newly formed bone and xDBM putty scattered in the connective tissue was observed. New bone formation around graft materials was not present. Small amount of newly formed bone adjacent surface of the implants was observed, originating from the existing base of bone defects. Such findings were similar to those of the control. However, new bone-to-implant surface contact was not revealed.

#### 4) The control (No treatment)

Upper parts of bone defects were completely filled with connective tissue which consisted of some fibers, blood vessels, and inflammatory cells. Collapsed defect space were observed in this specimen. However, there was a little amount of newly formed bone adjacent surface of the implants near bone, originating from the existing base of the bone defects. Small amount of new bone-to-implant contact was revealed

## IV. DISCUSSION

Many previous investigations were performed in optimal bone condition with implant placed without major alveolar defect. However, clinically, it is often necessary to apply the principles of guided bone regeneration to improve bone regeneration with or without grafting materials because of bone defect such as dehiscence fenestration, circumferential bone defect.<sup>2,5</sup> There are many graft materials and technique that are used recently in attempt to repair osseous defects around implants.<sup>1,6,8,9,10,11,12,13</sup> Several authors reported histology of bone removed over the implant cover screw or where dehiscence or fenestration were "repaired", they did not address actual quality and quantity of bone at the implant interface.<sup>15,29</sup> Jovanovic reported that bone-to-

implant contact can be re-established by using graft materials.<sup>47</sup>

The purpose of this study was to evaluate and compare the healing of the three-wall intrabony defects using xDBM putty, Porous  $\beta$ -tri-calcium phosphate, newly developed non-crystalline calcium phosphate glass around submerged SLA surface dental implant in beagle dogs.

In this study, we used calcium phosphate glasses with Ca/P ratio 0,6 were prepared from the system CaO-CaF<sub>2</sub>-P<sub>2</sub>O<sub>5</sub>-MgO-ZnO. Determined particle size of the powdered sample was 200 to 500 $\mu$ m. Large amount of calcium phosphate glasses were visible and surrounded with connective tissue in this histologic specimen. A lesser newly formed bone was found only in the proximity of the base of bone defects, originating from the pre-existing bone. There was no evidence of osseointegration at the grafted area.

Recently, Several authors reported Studies about the use of  $\beta$ -TCP with dental implant placement.<sup>40-45</sup> Zerbo et al.<sup>40</sup> showed considerable replacement of the bone substitute by bone and bone marrow. In 9,5 months biopsy of the mandible, 34% of the biopsy consisted of mineralized bone tissue and 29% of remaining  $\beta$ -TCP, while the biopsy at 8 months after sinus floor augmentation consisted of 20% mineralized bone and 44% remaining  $\beta$ -TCP. This report suggested that this graft material, possibly by virtue of its porosity and chemical nature, may be a suitable bone substitute that can biodegrade and be replaced by new mineralizing bone tissue. Trisi et al.<sup>41</sup> reported that  $\beta$ -TCP was resorbed simultaneously with new bone formation, without interference with the bone matrix formation, harvested 6 months after placement in the posterior jaws of five volunteers. In nine adult Goettinger miniature pigs, Within 86 weeks, nearly 90% to 95% of the  $\beta$ -TCP granules were degraded.<sup>43</sup> Merten et al.<sup>43</sup> concluded that

because of the initially pronounced accumulation of macrophages, dental implants should not be inserted simultaneously with ceramic, but after further progress of ceramic degradation (5 to 6 months after  $\beta$ -TCP implantation). von Arx T et al.<sup>44</sup> investigated the Lateral ridge augmentation and implant placement in the canine mandible. In these study, Six months later, All implants demonstrated high percentages (59% to 75%) of bone-to-implant contact, with no significant differences across the various treatment groups. These previous study was designed to test the long term results in human or animal models. Schenk et al.<sup>48</sup> reported that bone regeneration is not complete within 4 months after a bone defect is made, and that a prolonged healing period might be required in large defects prior to functional loading of the regenerated bone.<sup>49</sup> Different study using rabbit showed that control defect had nearly filled by 6 weeks.<sup>8</sup> Hall et al reported healing after 4 months in canine.<sup>6</sup> Our experimental design was modified with previous study<sup>6</sup> and defects size was smaller than those of Hall et al.<sup>6</sup> New bone formation most likely occurred from apical and lateral wound margin in three-wall defect. Therefore, we expected that evaluation of rapid bone healing could be available within a 8 weeks healing period of 3-wall defects in beagle dogs. In this study, most  $\beta$ -TCP granule in the intrabony defects were surrounded with connective tissue. Significant amounts of newly formed bone tissue was observed at the base of the bone defects, originating from pre-existing bone. Such findings were similar to those of the xDBM putty. However, there was a large amounts of newly formed bone among the  $\beta$ -TCP granules in spite of the fact that most granules were circumscribed by the connective tissue. Ingrowth of new bone from lateral wall was observed in  $\beta$ -TCP specimen. These results corresponded with those reported by Zerbo et al.<sup>40</sup> who

showed considerable replacement of the bone substitute ( $\beta$ -TCP) by bone and bone marrow, possibly by virtue of its porosity and chemical nature. Therefore, we may suppose that difference between  $\beta$ -TCP and non-crystalline calcium phosphate glass might originated from its porosity.

Porosity and particle size are important because they have an effect on the rate of resorption and the ability of the graft to promote bone growth.<sup>50</sup> But, Hall et al reported that Particle size of bioactive glass granule is not significant.<sup>6</sup> Bioactive glass size range 300 to 355 $\mu$ m had significant residual graft particle content that encapsulated in soft tissue compared to particle of broad range 90 to 710 $\mu$ m and demineralized freeze-dried bone allograft.<sup>6</sup> It has been shown that a minimum pore size between graft particles of greater than 100 $\mu$ m is needed to allow proper vascularization and bone formation.<sup>6</sup> As the pore sizes become larger, the bone growth increases.<sup>51</sup> Some investigator examined the difference of demineralized freeze-dried bone allograft particle size. Shapoff et al. showed that particle of 100 to 300 $\mu$ m resulted in better than 1000 to 2000 $\mu$ m sized particle.<sup>50</sup> Fucini et al. showed that there was no significant difference between small particle group 250 to 500 $\mu$ m and large group 850 to 1000 $\mu$ m.<sup>52</sup> However, these studies of demineralized freeze-dried bone allograft particle size were based on periodontal defect and not defects around implant. In our study, Particles size of  $\beta$ -TCP was 150 to 500  $\mu$ m, calcium phosphate glass was 200 to 500  $\mu$ m and putty type human DBM was used. Widespread use of demineralized bone matrix (DBM) putty was seen for medical patients.<sup>33,34</sup> Implant placement after DBM putty bone grafting provides the rare opportunity to biopsy and histologically evaluate new bone formation. Callan et al.<sup>35</sup> reported that histologic analysis extensive new bone formation and minimal residual bone graft matrix putty were observed at an average of 5

months postoperative. The pattern of new bone maturity and remodeling varied by patient and the time in situ. Putty and Flex regenerated excellent bone height and width for the placement of dental implants, were easy to handle intraoperatively.<sup>35</sup> In contrast, there was apparently no evidence that xDBM putty induce a significant amounts of bone formation at the surface of the implant in our animal study. There was a significant amount of newly formed bone originating from the existing the base of bone defects. Furthermore, most xDBM putty without resorption was observed at the upper part of the defects. Two distinct part between the newly formed bone and xDBM putty scattered in the connective tissue was observed. Some authors reported similar results that demineralized freeze-dried bone allograft does not promote bone formation adjacent to dental implants or within extraction sockets.<sup>4,14,15,23,28,29,53,54</sup> Nishihori et al,<sup>53</sup> reported that retained demineralized freeze-dried bone allograft chip and poor bone quality after 8 months. Even Becker et al.<sup>4,14,15,23,28,29,54</sup> argued that grafting materials(DFBDA, HA) may actually interfere with the normal healing process. The use of xDBM did not appear to provide more bone to implant contact and new bone formation than did the synthetic materials. Within this study, xDBM putty as well as calcium phosphate glass were considered to be inert and well tolerated, we feel that only  $\beta$ -TCP had a necessity of additional evidence for new bone formation from grafting materials.

Sections were also analyzed bone and non-bone contact area in the grafted area. To determine the amount of new bone formation adjacent implant, bone-to-implant contact and bone height fill were examined by means has been described previously.<sup>6</sup> Others reported that an average of 55 to 61% of bone contact at Light microscopy level<sup>55,56,57,58,59</sup> Hall et al,<sup>6</sup> reported that the greatest

percentage of the bone to implant contact resulted when using demineralized freeze-dried bone allograft as a graft material in dogs. In our study, all grafted sites were seen rare bone-to-implant contact. Takeshita et al<sup>49</sup> reported that the grafting of dense HA into bone defects surrounding implants will result in fibrous healing during the early healing stage(28 day after surgery). Our histologic findings in this study also similar with their observations in spite of the fact that we had used different type graft. Porous  $\beta$ -tri-calcium phosphate, newly developed non-crystalline calcium phosphate glass and xDBM putty were completely surrounded with connective tissue.

The clinical significance of having exposed implant threads was evaluated in a retrospective study by Lekholm et al.<sup>60</sup> These authors reported that a few exposed threads would not have adverse effects on the overall long term prognosis of an implant.<sup>60</sup> Where bone gaps of 0.5mm existed between the bone wall and the implant, Surface treated implant were superior to Ti implants.<sup>48,64</sup> Stentz et al, reported that surface characteristics of the implant have a significant effect on the amount of bone to implant contact.<sup>65,66</sup> The width of the gap at the time implant placement had a significant effect on bone to implant contact.<sup>27,64,67</sup> In this study, It was difficult to see new bone to implant surface contact in spite of SLA surface implants. Becker et al.<sup>14</sup> reported that the bone-implant contacts between Ti implants and the newly formed bone were less than favorable in spite of various methods of augmentation.

Past studies indicated that the use of autogenous bone for grafting small defect adjacent to implants is highly predictable. Covani et al.<sup>27</sup> , Akimoto et al,<sup>67</sup> suggested that small circumferential defect not exceeding 2mm , could heal with good predictability without using a regenerative procedure clinically.

However, the width of the gap at the time of the implant placement had a significant impact on the histologic percentage and the height of bone-to-implant contact.<sup>67</sup> Clinically, The average initially exposed implant surface is larger, and incomplete wound closure is prevalent compared to the long term delayed implants.<sup>32</sup> Combination therapy using guided bone regeneration may be indicated in sites with larger bone gap.<sup>64</sup> Of course, the defects were surgically created intrabony defects which could exhibit a different wound healing than that seen in naturally occurring defects. We used the intrabony defects design that was surgically created around implant(3x 3x 5mm) to mimic small amount of exposed implant thread. Cho et al<sup>68</sup> suggested that bone formation peaked at 4 weeks to regress at week 8 through 12 under fluorescence microscopy observations. Our study was designed to test early healing at 8 weeks after treatment in beagle dogs.

In summary, Result from this limited animal study after 8 weeks healing period demonstrated that intrabony defects around implants treated with non-crystalline calcium phosphate glass showed minimal amount of new bone formation. But, A significant amounts of new bone formation in xenogeneic DBM putty,  $\beta$ -TCP were observed. However, there was no significant difference in related with control defects. Most of residual graft particles adjacent to the implant, embedded in connective tissue, were observed from all specimens regardless of graft type. Although bone fill was observed clinically, our histologic sections demonstrated regenerated tissue with fibrous consistency. These results are in agreement with previous findings.<sup>2</sup> The non-crystalline calcium phosphate glass to the bone defect might not promote active bone formation. Moreover, there is a possibility that the presence of non-crystalline calcium phosphate glass arrests bone formation such as dense HA in study of Takeshita et al<sup>49</sup>. The

non-crystalline calcium phosphate glass might be considered to be inert in this study. Our used graft materials apparently failed to induce new bone formation(oscoinduction) adjacent to the implant surface. There was a some difference about amount of new bone formation between non-crystalline calcium phosphate glass and  $\beta$ -TCP. There is a possibility that the difference in synthetic materials, namely dense or porous, might influence the bone formation in bone defects surrounding implants.<sup>49</sup> Large amounts of residual xDBM putty encapsulated in connective tissue without evidence of resorption were observed above the newly formed bone in the xDBM putty defects. The significant extent of new bone formation was observed in xDBM putty defects. A large proportion of the dental implant surface remained uncovered by bone. Application of xDBM putty does not appear to improve direct bone to implant contact in xDBM specimens. Such findings were in agreement with previous findings.<sup>68</sup> Cho et al reported that xDBM apparently delayed bone formation because their findings showed that bone activity was increased at week 8 compared to other observation intervals(peaked at 4 weeks in membrane alone defects).<sup>68</sup>

While results of this study were not excellent, it must be note that this was design to observe the relatively short term healing. The minimum time to regenerate new bone formation from graft materials is unknown. Different studies indicated that quality of new tissue was time dependent.<sup>2,3,8,32,48,58</sup> The new bone may be the result of dense connective tissue reinforced by the bone graft rather than replacement of the graft with true bone.<sup>30</sup> Past studies indicated that all guided bone regeneration procedures(GBR alone and GBR/graft combination) equally produced the greatest amount of clinical 'hard tissue fill' by bone graft alone.<sup>13,24</sup> Hurzeler et al reported that combination of GBR with either



DFDB or resorbable HA appears to be the treatment of choice for plaque-induced peri-implant defects in 5 months later study.<sup>13</sup> Due to these conflicting findings, there is a need of observation under different healing periods. The results in this study were obtained with three-wall defect morphology. Different result may occur if initial defect are larger or one-wall, two -wall defect. We feel that additional studies should be undertaken to examine the long term use of grafting materials adjacent to the implant surface which were used in this studies. Until more long term data on the stability of regenerated peri-implant bone using our experimental grafting materials are available, it seems reasonable to suggest the exposed implants treated with membrane technique with or without autogenous bone.<sup>2,13</sup>

## V. Conclusion

The aim of this study was to histologically evaluate and compare the healing of the three-wall defects using xenogeneic demineralized bone matrix putty(xDBM putty), porous  $\beta$ -tri-calcium phosphate( $\beta$ -TCP), newly developed non-crystalline calcium phosphate glass around submerged SLA surface dental implant. Twenty SLA surface dental implants were used. Defects were then grafted with either xDBM putty,  $\beta$ -tri-calcium phosphate, non-crystalline calcium phosphate glass or not filled(control). Experimental animals were sacrificed at 8 weeks later.

Result from this limited study demonstrated followings;

1. Intrabony defects around implants treated with  $\beta$ -TCP, xDBM showed a little amount of new bone formation originating from pre-existing bone.
2. All the treatment groups in this study showed

no histologic evidence of new bone formation and bone-to-implant contact originating from grafted materials.

3. Most residual graft particles adjacent to the implant were observed from all specimens regardless of graft type.

Therefore, there was no beneficial effects to osseointegration in intrabony defects around implants using these grafting materials

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## 사진부도 설명

- Figure 1. A, B Photograph of Surgically created infrabony defect adjacent dental implant.
- Figure 2. A, B Photograph of xDBM putty and the control(Left), Calcium-phosphate glass and  $\beta$ -TCP (Right)
- Figure 3. A Photomicrograph of non crystalline Calcium phosphate glass, showing large amount of calcium phosphate glasses were surrounded with connective tissue. A lesser newly formed bone was found only in the proximity of the base of bone defects, originating from the pre-existing bone(original magnification  $\times 20$ )
- B Photomicrograph of fig A, minimal new bone formation near the surface of dental implant. There was no evidence of osseointegration at the grafted area(original magnification  $\times 40$ )
- C Higher magnification of fig A, showing granules surrounded with connective tissue(original magnification  $\times 100$ )
- Figure 4. A Photomicrograph of  $\beta$ -TCP, showing granules in the connective tissue. There was a large amount of newly formed bone among the  $\beta$ -TCP granules(original magnification  $\times 20$ )
- B Photomicrograph of fig A, a little amount of new bone formation near the surface of dental implant(original magnification  $\times 40$ )
- C Higher magnification of fig A, showing granules surrounded with connective tissue and fibrous tissue between new bone and the surface of dental implant(original magnification  $\times 100$ )
- Figure 5. A Photomicrograph of xDBM putty, showing granules in the connective tissue. There was a little amount of newly formed bone near implant at the apical area of the defect(original magnification  $\times 20$ )
- B Photomicrograph of fig A, A little amount of new bone formation near the surface of dental implant. However, there was no bone-to-implant contact (original magnification  $\times 40$ )
- C Higher magnification of fig A, showing fibrous tissue between new bone and the surface of dental implant(original magnification  $\times 100$ )
- Figure 6. A Photomicrograph of Control(No treatment), Bone defect were completely filled with connective tissue. There was a little amount of newly formed bone near implant at the apical area of the defect(original magnification  $\times 20$ )
- B Photomicrograph of fig A, showing a little amount of new bone formation (original magnification  $\times 40$ )
- C Higher magnification of fig A, showing direct bone-to-implant contact at the bottom in spite of small amount(original magnification  $\times 100$ )

## 사진부도 (1)

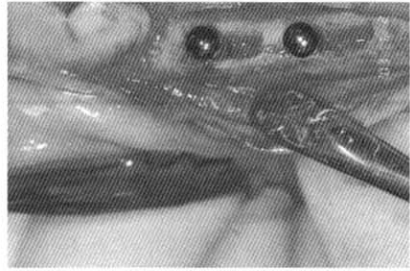
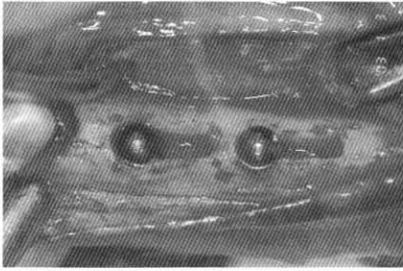


Figure 1-A , B : Photograph of surgically created intrabony defect adjacent dental implant.

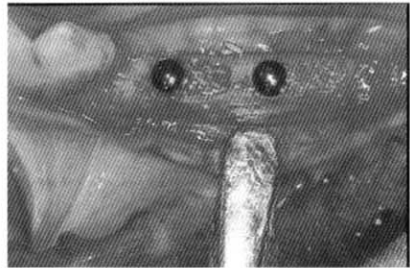
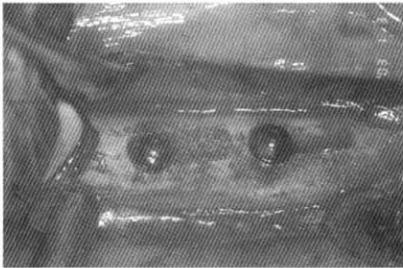


Figure 2-A , B : Photograph of xDBM putty and the control (Left), Calcium-phosphate glass and  $\beta$ -TCP(Right)

## Histologic findings

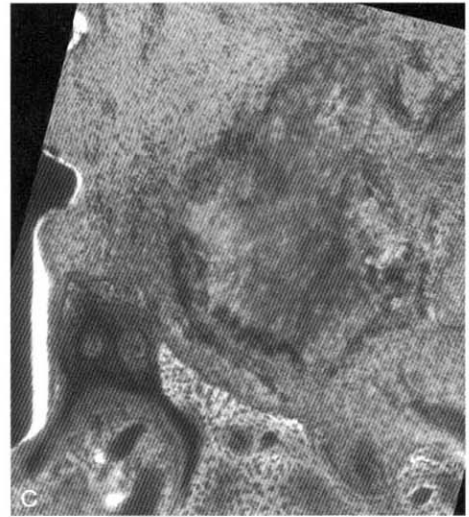
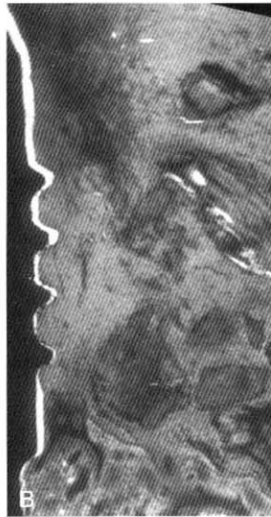


Figure 3 Photomicrograph of non crystalline Calcium phosphate glass

사진부도 ( II )

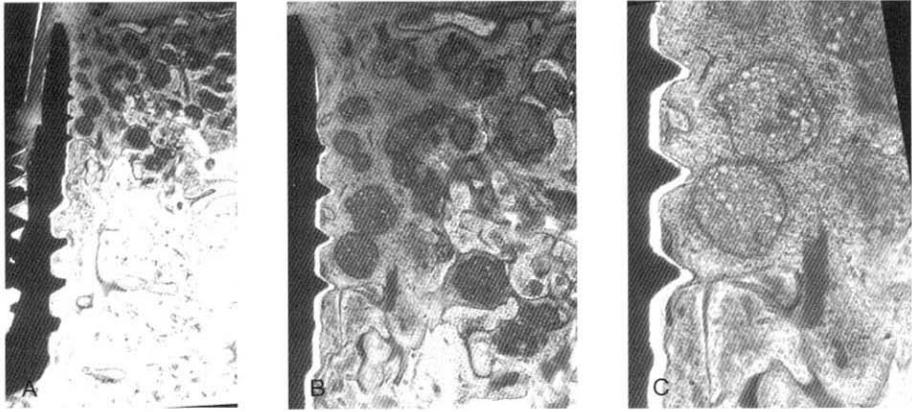


Figure 4. Photomicrograph of  $\beta$ -TCP

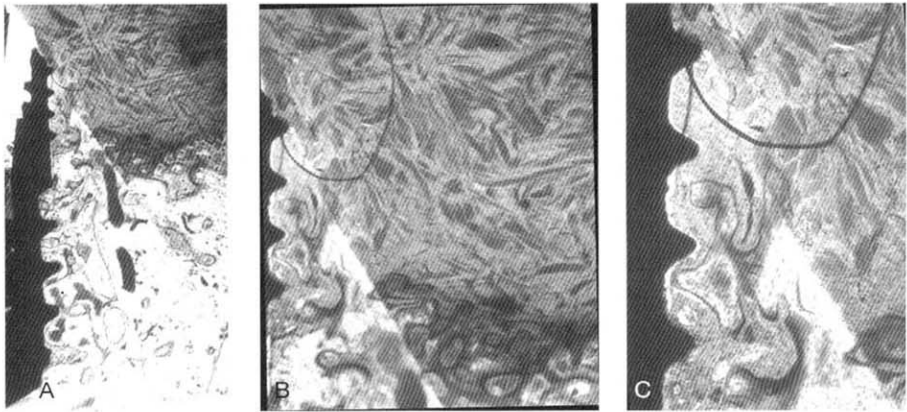


Figure 5 Photomicrograph of xDBM putty

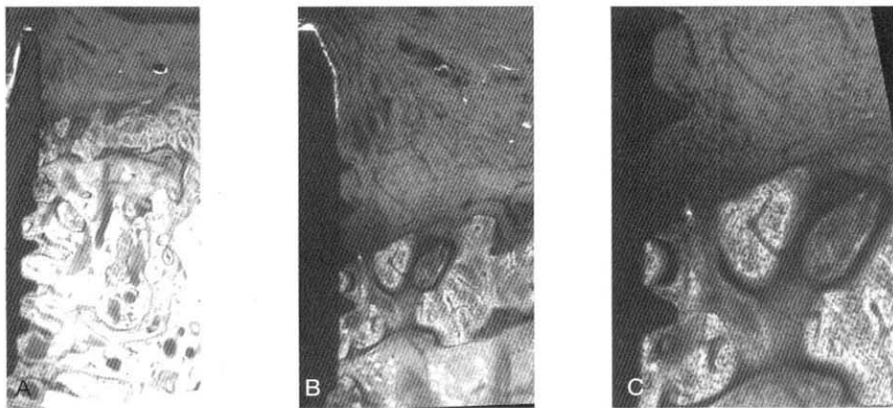


Figure 6 Photomicrograph of Control(No treatment)



## 수종의 골이식재를 이용한 성견의 임플란트 주위 3면 골내낭의 조직학적 관찰

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**연구목적** : SLA surface dental implant 주위의 3면 골내낭에서 xenogeneic demineralized bone matrix putty, porous  $\beta$ -tri-calcium phosphate, 새로이 개발된 non-crystalline calcium phosphate glass를 사용한 치료를 조직학적으로 비교 평가하기 위한 것이다.

**연구방법** : 실험동물로는 15개월에서 18개월 사이의 12kg에서 15kg 정도되는 성견을 사용하였다. 20개의 SLA surface implant가 사용되었으며, 성견 하악의 양측에 각각 2개씩 사용되었다. 임플란트 식립 전에, 각각의 임플란트 근심면에 straight fissure bur를 이용하여 표준화된 3면 골내낭(근원심 5mm × 협설 3mm × 깊이 3mm)을 형성하였다. 형성된 골 결손부에는 demineralized bone matrix putty, porous  $\beta$ -tri-calcium phosphate, non-crystalline calcium phosphate glass를 넣은 것을 각각 실험군으로, 이식재를 넣지 않은 것을 대조군으로 사용하였다. 8주 후에 실험 동물을 희생 시키고 조직학적 관찰을 하였다.

**결 과** : 조직학적 소견상 임플란트 주위에 급성 염증 소견은 보이지 않았으며, non-crystalline calcium phosphate glass은 매우 적은량의 신생골을,  $\beta$ -TCP을 이용한 골내낭에서는 약간의 기저부에서 유래된 신생골이 관찰된다.  $\beta$ -TCP granules 가운데로 상당량의 측면의 골에서 유래된 신생골 형성이 보인다. xenogeneic DBM putty에서는 많은 량의 신생골이 기저부에 형성된 것을 볼수 있으나 대조군과의 차이는 크지 않다. 이식재의 종류와 상관없이 흡수되지 않은 이식재를 임플란트 주위에서 관찰할 수 있었다. 골내낭 안의 이식재들은 모두 connective tissue로 둘러 싸여 있었다. 모든 실험군에서 이식재에서 기인한 신생골 형성과 임플란트 표면에 신생 골유착의 조직학적 증거는 발견되지 않았다.

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**주요어** : demineralized bone matrix putty, porous  $\beta$ -tri-calcium phosphate, non-crystalline calcium phosphate glass, SLA surface Dental implant, 3면 골내낭