Efficacy of biphasic calcium phosphate and cyanoacrylate-calcium phosphate bone substitute on the circumferential defects around implants in dogs

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감사의 글

본 박사 논문을 완상하기까지 부족한 제게 많은 지도와 격려, 가르침을 주신 최성호 교수님께 진심으로 감사를 드립니다. 부족한 논문에 많은 관심과 조언을 해주신 김종관 교수님, 김창성 교수님, 그리고 세심한 조언을 아끼지 않으신 정의원 교수님, 논문의 심사 과정에서 세심하게 관심을 가져주신 이용근 교수님께도 깊은 감사를 드립니다. 그리고 항상 진심 어린 조언과 따뜻한 관심으로 지켜봐 주신 채중규 교수님과 조규성 교수님께 감사드립니다. 또한, 박정철 교수님, 이중석 교수님께도 고마움을 전하고 싶습니다.

연구 내내 많은 도움을 주신 일산병원 치과의 김만용 교수님, 윤태철 교수님, 김문기 교수님, 강상훈 교수님, 이지연 교수님, 이명희 교수님, 김정훈 교수님, 박민옥 교수님과 치주과 전공의로 저를 도와준 정동열 선생과 박세진 선생, 윤재민 선생, 박정임 선생에게도 이 자리를 빌어 감사의 마음을 전합니다.

마지막으로 제가 이 자리까지 올 수 있도록 돌봐주시고 아낌없는 사랑과 조언을 주신 아버지, 어머니, 그리고 물심양면으로 응원해주는 동생과 누나에게 감사의 마음을 전합니다. 결혼과 논문을 동시에 준비하느라 많이 챙겨주지 못했음에도, 아무 불평없이 논문 진행에 차질이 없도록 도와준 박혜림 양에게도 진심어린 사랑과 감사의 마음을 전하고 싶습니다. 이 지면을 통해 인사드리지 못한 다른 모든 분들께도 짐심으로 감사드립니다.

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Abstract

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In many cases, there is no enough space of edentulous ridges for the implant installation. Circumferential gap defects around implants are easily made in case of immediate implantation. Additional surgical procedures are needed such as bone grafting and guided bone regeneration. Biphasic calcium phosphate (BCP) is one of the alloplast bone graft materials, which shows excellent biocompatibility and space maintaining properties. The newly developed cyanoacrylate-calcium phosphate bone substitute (CCP) was considered as a potential to serve as a graft material due to the plasticity and the bacteriostatic property.

The aim of this study is to identify the efficacy of the animal experimental model with critical circumferential gap defects over 2mm around implants, and to determine the efficacy of BCP and CCP on the defect around implant.

5 male mongrel dogs were prepared. In each side of mandible, 4 SLA surface implants with 3.8mm width and 10mm length were inserted and the circumferential gap defect with 2mm width, 5mm depth were prepared around implants in 3 implants. One gap was left empty (negative control group). The gap around the other implant was filled with BCP (BCP group). The another gap was filled with CCP (CCP group).

The implants without gaps were the positive control group. After implant placement, 16 weeks of healing period was given in the one side of mandible. 8 weeks of healing period was given in the other side of mandible. The dogs were sacrificed. Histological and histometrical analysis were performed and statistically analyzed in each groups.

In 8 weeks healing groups, Bone regeneration of the experimental groups with circumferential gap defects was limited. Bone height and BIC were relatively low in all the experimental groups with 8 weeks healing periods. In 16 weeks healing groups, the negative control group also showed as high BIC, bone height and bone volume as the BCP group, while the CCP group showed relatively low BIC and bone height. The BCP group showed excellent bone regeneration in both 8 weeks and 16 weeks healing period.

It is suggested that BCP can be a good candidate for circumferential gap defects around implants without any barrier membrane, whereas CCP might not be appropriate for bone grafting around implants and further studies are needed for improving the cyanoacrylate bone substitutes. It is concluded that the healing around circumferential gap defects is determined by the time of healing period and bone grafting materials.

Key words : dog model, implants, circumferential gap defect, cyanoacrylate, biphasic calcium phosphate, healing period

Efficacy of biphasic calcium phosphate and cyanoacrylate-calcium phosphate bone substitute on the circumferential defects around implants in dogs

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Ⅰ. INTRODUCTION

In many cases, it seems to be no enough space of edentulous ridges for the implant installation. After the extraction of teeth, alveolar ridge will undergo bone modeling and remodeling[1, 2]. It is shown that the bundle bone will be resorbed and result in pronounced buccal and lingual alveolar bone resorption[3, 4]. The alveolar ridge reduction is approximately up to 50% during the first 12 months after extraction[5]. In addition, the edentulous ridge, which has undergone periodontitis previously, can show more excessive bone loss[6].

Immediate implantation has been suggested as one of the methods to prevent the ridge reduction. Immediate implantation had been supposed to prevent the alveolar bone resorption by maintaining the bony crest structure[7-9]. However, Araujo et al.[10, 11] reported that immediate implantation could not prevent alveolar bony crest structures, which is considered as a recent general consensus. Nevertheless, the advantages, such as esthetic superiority, needlessness of second surgery and short overall period, make many clinicians practice the immediate implantation[6, 9].

Many researches have been carried out to solve the problems of immediate implantation[6, 7, 12]. Coronal gaps around implants have been the main issue of the immediate implantation. Bone grafts and guided bone regenerations have been performed with immediate implantation in the circumferential gap defects[12-15]. Autogeonus bone, allograft, xenograft and alloplast are used for bone regeneration graft materials. Although autogenous bone has been considered as the gold standard of bone graft, demerits like limited amounts, secondary surgical site, donor-site morbidity and complications make researchers to find out other graft materials[16].

Biphasic calcium phosphate (BCP) is one of alloplasts, which shows excellent biocompatibility and space maintaining properties[17, 18]. It consists of β-tricalcium phosphate (β-TCP) and hydroxyapatite (HA). β-TCP degrades faster than HA. Combination of these materials shows better stability and biocompatibility than HA alone and leads higher stability and lower degradability[17]. BCP is already used as potent alternatives to autogenous bone[17]. BCP can support the space of the defect sites during the healing periods and can help implants to be osseointegrated with bone.

In the present study, BCP was studied to examine if it could be a good candidate for the implants gap defects.

N-butyl-2-cyanoacrylate has been used as skin closure adhesive for years[19, 20]. It is known that it acts as effective hemostasis, promotes rapid adhesion of soft tissue and has bacteriostatic properties[19]. Cyanoacrylate has been limited to superficial wound due to its property of low-bioactivity by which it can induce a little inflammation to surrounding tissues[19]. However, recently studies reveal that cyanoacrylate could be served as a bone substitute. Park et al.[21] reported that cyanoacrylate combined with β-TCP particles could have a potential to serve as a filling materials for bony defects. It is described that the temperature change of the cyanoacrylate-calcium phosphate compounds during polymerization decreased compared to that of the cyanoacrylate. Cyanoacrylate-calcium phosphate bone substitute (CCP) was appeared to have osteoconductive properties in the rat calvarial defects[22]. CCP was suggested to have another crucial advantages. Cyanoacrylate binds to calcium phosphate and immobilizes graft particles within defects. The property can prevent loss of graft particles from the defect sites. CCP can be also plasticized to the forms of defects. Despite of these advantages, it was not yet studied the efficacy of CCP as a bone graft materials in the gap defects around implants. In this study, CCP were studied for the biocompatibilities and possibilities of osseointegration around implants.

Following consensus reports, osseointegration could be established within 4 weeks around the implants with recently developed surfaces[23]. In case of bone grafting or bone regeneration procedures, the longer period might be needed for complete bone healing and osseointegration. In the present study, by comparing two healing periods, 8 weeks and 16 weeks, bone healing period has been studied to examine bone graft materials to identify circumferential gap healing around implants.

The present paper was studied to identify the efficacy of bone substitutes in the critical circumferential gap defect. The first aim is to determine the efficacy of BCP and CCP as bone substitutes. The second aim is to identify the effects of healing periods to bone regeneration of each graft materials by comparing 8 weeks and 16 weeks healing periods.

Ⅱ. MATERIALS AND METHODS

1. Animals

Five male mongrel dogs, 12 ~ 15 months old and weighting about 30kg, were chosen for this experiment. Animal selection, management, preparation and the surgical protocols were performed according to the routine procedure approved by the Institutional Animal Care and Use Committee, Yonsei Medical Center, Seoul, Korea (09-067). The animals had *ad libitum* access to water and a pelleted laboratory diet with the exception of one week immediately post-surgery when they were fed a canned soft dog food diet (Prescription Diet Canine i/d, Hill's Pet Nutrition, Inc., Topeka, Kansas, USA).

2. Materials

Dental implants are sandblasted with large grits and acid-etched (SLA) with 3.8 mm in diameter and 10 mm in length (Dentium™, Seoul, Korea).

Biphasic calcium phosphate (BCP) is a synthetic calcium phosphate alloplast which consists of 70% hydroxyapatite and 30% β-tricalcium phosphate (Osteon™, Dentium™, Seoul, Korea).

Cyanoacrylate-calcium phosphate bone substitute (CCP) is the newly developed alloplast[21, 22]. It was prepared by mixing two pastes: one containing 0.1 g of liquid cyanoacrylate and solid inorganic materials, the other containing 0.22 g of β-TCP with a particle size of 10~50 μm and 0.14 g of glycerin. Inorganic materials in the first paste comprised 0.23 g of monocalcium phosphate (particle size 50~100 μm) and 0.03 g of dicalcium phosphate (particle size 10~20 μm).

3. Study Design

Four groups were prepared. Implants were placed in all groups, and circumferential gap defects around implants were prepared in 3 groups (Fig. 1).

a. Negative control group : gap without any bone grafting.

b. BCP group : gap filling with BCP

c. CCP group : gap filling with CCP

d. Positive control group : no gap

Following the healing period, 2 groups were organized.

At one side of mandible, 16 weeks healing period was given. At the other side of mandible, 8 weeks healing period was given. Each group consisted of 4 sub-groups (Fig. 2).

4. Surgical Protocol

All surgical procedures including extraction and experiments were performed under general anesthesia. Induction by intravenous injection of atropine (0.04 mg/kg; Kwangmyung Pharmaceutical Ind. Co. Ltd., Seoul, Korea) and intramuscular injection of a combination of xylazine (Rompun, Bayer Korea Co., Seoul, Korea) and ketamin (Ketara, Yuhan Co., Seoul, Korea) were performed and the general anesthesia was maintained with inhalation anesthesia (Gerolan, Choongwae Pharmaceutical Co., Seoul, Korea).

All mandibular premolars and 1st molars were extracted. After 8 weeks of healing period, animals were prepared for the experiments. The edentulous ridges for the experiment were prepared flattened with ridge contouring bur. In one side of mandible, a crestal incision was made and a full mucoperiosteal flap was raised. Four implant sites were identified and surgical procedures for implants installation were performed according to the manufacturer's instructions. After the implant preparation, except for the one site for the positive control, specially designed gap drill was used for making the 5mm depth, 2mm width bony defects (fig. 1). Four dental implants were placed at each site (fig. 2, 3). In one of the defect sites, BCP was grafted. In another site, CCP was grafted (fig. 4). In the other defect site, nothing was grafted for the negative control group. The flap was closed and sutured with resorbable suture materials (4-0 monosyn®, B.Braun, Melsungen, Germany). The sutures were removed after 7 days.

After eight weeks, same surgical procedures were performed in the other side of mandible.

Another eight weeks were given for healing after the last experiment. The dogs were sacrificed by potassium chloride under general anesthesia. Mandibles of experimented sites were separated. The block sections, including the segments with implants, were preserved and fixed in 10% neutral buffered formalin. The central sections from each implant site were reduced to a final thickness of 50μm by microgrinding and polishing with a cutting-grinding device (Exakt, Apparatebau, Norderstedt, Germany). The ground sections, representing the mid-buccal-lingual plane, were prepared for the histologic analysis. The sections were stained with Goldner trichrome stains. The histological slides were magnified with 10 and 40 times under light microscopy and images were captured.

The analysis was evaluated histologically and histometrically.

5. Evaluation Methods

Linear measurement for bone regeneration height was performed at both buccal and lingual side. Regenerated bone height was measured from the margin of defect to the most coronal part of bone to implant contacts. Percentage of bone to implant contact (BIC) on the surface of regenerated bone surface was measured. The volumes of bone regenerated in the defect were also measured.

The histometrical measurements were performed with Image-pro® (MediaCybernetics inc., Bethesda, Maryland, USA).

6. Statistics

The mean and standard deviation of values for each group were calculated. The significant differences between four groups were determined using the Kruskal-Wallis test ($p < 0.05$). The Mann-Whitney test was used to analyze the differences between values of 8 and 16 weeks groups and to compare each two groups ($p < 0.05$).

The Bonferroni correction was applied to analyze differences that were significant at the 5% level ($p < 0.05$).

Ⅲ. RESULTS

1. Clinical observations

Healing of all surgical sites was uneventful during the postoperative period. There was no exposure of dental implants or graft materials and was no clinical sign of inflammation in the surgical sites.

2. Histological observations

In 8 weeks groups, new bone was not regenerated to cover all implant surfaces and defect sites, except for the BCP group and the positive control group (Fig. 5 ~ 7).

In BCP group, defect site was filled with new bone and calcium phosphate particles (Fig. 6).

In 16 weeks group, bone regeneration showed remarkable improvements for supporting the implants except for the CCP group (Fig. 8). Some slides of the CCP group have even shown the inflammatory reaction above the defect sites.

The negative group showed remarkable bone regeneration as much as the BCP group or the positive control group. The BCP group showed complete bone filling like those in 8 weeks group. Calcium phosphate particles were still left not so much as in the 8 weeks group.

3. Histometric Analysis

A. Bone regeneration height (Table 1.)

In the negative control group, the BCP group and the CCP group, there showed little or no bone regeneration after eight weeks healing. The negative control group, the BCP group and the CCP group showed 0.86±1.24 mm, 1.00±1.05 mm, 0.47±0.41 mm of regenerated bone height. After 16 weeks healing, the negative control group and the BCP group showed apparent bone regeneration height, 3.55±1.86 mm and 3.63±1.63 mm each, otherwise the CCP group showed minimum bone healing, 1.14±1.41 mm, which had significant differences compared to the other two groups ($p < 0.05$).

B. Bone to implant contact (BIC) (Table 2.)

These results showed similar results as the bone regeneration height. In 8 weeks group, 3 groups all showed low BIC, less than 15% BIC. After sixteen weeks, the BCP group recovered BIC up to 45% BIC. BIC in the negative control group was markedly improved, whereas BIC in CCP group showed low BIC.

C. Bone regeneration volume (Table 3.)

In 8 weeks groups, bone volume regenerated in BCP group was 13.99±3.08mm^2 respectively. It had statistically significant differences compared to the other two groups.

After 16 weeks, the negative control group and the BCP group showed better results than the CCP group.

Residual materials were left only in BCP group (Fig. 6, Fig. 8), otherwise small amount of materials seemed to be left in CCP group (Fig. 7). Between 8 weeks group and 16 weeks group, there was no statistical difference in residual materials.

Ⅳ. DISCUSSION

Implants studied in the present experiments had rough surfaces which had been processed sand-blasting with large-grits and acid-etching (SLA). Implants with SLA surfaces are documented with excellent clinical and biomechanical results[24-26]. Cochran et al.[27] reported the reduced healing time of SLA surface implants. Botticelli et al.[28] studied osseointegration of SLA implants with self-contained defect and reported that osseointegration in less than 1.5mm defect sites depends on the surface characteristics of implants. It is assumed that the SLA surface implants would help the convincing evidences of the present study model.

In the present study, clinical situations like dimensional ridge alteration after extraction or immediate implantation were considered. Many treatments like placement of bone grafting materials and guided bone regeneration with or without bone grafting have been suggested to prevent dimensional ridge reductions[4, 13, 29-32].

We evaluated the surgically prepared circumferential gap defects with two synthetic grafting materials in 8 weeks and 16 weeks healing periods. Regenerated bone height, BIC and bone volume regenerated in the defect area were measured for evaluating the reliability of this animal model and the efficacy of the grafting materials. It is appeared that circumferential gap defects used in this study was applicable to the animal experimental model for examining the bone regeneration ability of bone grafting materials. Carlsson et al.[33] studied this issue by creating 0.35 mm and 0.85 mm gap defect in rabbit models and concluded that coronal gap to achieve full osseointegration was approximately 0 mm. However, Botticelli et al. suggested that circumferential gap defect with 1.25 mm width and 5 mm depth might heal with newly formed bone and there was no significant difference compared to control group in the series of papers[34-37]. Jung et al.[38] also reported that circumferential gap defect within 2 mm width, which studied as a cone-shape defect in dog models, did not need any additional regenerating procedures although there was tendency of increasing unfilled area with increasing width (1.0, 1.5, 2.0 mm). It could be concluded that 2.0 mm would be the critical width of bone healing in the box-type circumferential gap defect. Three experimental groups including the negative control group, the BCP group and the CCP group showed little regenerated bone height and BIC in 8 weeks healing period groups. Unlike the three experimental groups, the positive group showed complete bone healing with osseointegration to the top of the implants. Our results confirmed that over 2mm defects might need additional regenerating procedures in short term healing period. Regenerated bone volumes of the BCP group were higher than regenerated bone volumes of the negative control group and the CCP group. The bone volume regenerated in the BCP group was enough to maintain the space and prevent the alveolar ridge reduction. Regenerated bone height and BIC were relatively lower than regenerated bone volume. This results came from the distance osteogenesis followed by the contact osteogenesis[39]. This phenomenon might have made healing pattern in the defect site wedge-shaped[40].

After another 8 weeks healing period, regenerated bone heights in the BCP group and the negative control group were close to fill the defects. It was an enough time that contact osteogenesis could follow the complete bone healing of the defect. In 16 weeks healing groups, regenerated bone height and BIC did not show statistically significant differences between the negative control group and the BCP group. It can be concluded that defects can be filled with regenerated bone in 16 weeks healing periods without any additional regenerating procedures. It is proposed that in over 2mm gap defects, additional regenerating procedures in short-term healing period cases or long-term healing period might be needed.

The BCP group showed more bone regeneration than other groups in both 8 weeks and 16 weeks healing groups. Particles of BCP consist of HA and β-TCP. β-TCP has faster solubility and lower mechanical stability than HA[18]. Combination of these two materials leads BCP higher stability and lower degradability than β-TCP alone[17]. In 8 weeks healing groups, regenerated bone volume in the BCP group was measured higher than that in the negative control group. It might have occurred due to the space maintaining potential of BCP. BCP could have supported the space with remaining calcium phosphate particles compared to the negative control group with no grafting materials. BCP in this study also showed the excellent biocompatibility and osteoconductive property. In histological view, calcium phosphate particles were in contacts with new bone. It could be concluded that BCP could be a potent bone substitute for the autogenous bone graft or guided bone regeneration in the gap defects around implants.

Materials used for bone regeneration should not only have these properties; osetoconductive property, biocompatibility, space maintaining ability, but they also should be easy to handle and easy to form as bone grafting materials. Traditional graft materials are not easy to handle due to scattered particles. It has been studied that CCP would be easy to handle and easy to manipulate[21, 22]. CCP has been reported that it could bind particles together and makes it easy to mold to fit the defect forms. CCP also has another positive effects like antimicrobial properties and homeostatic effects[41]. CCP is the mixture of liquid cyanoacrylate and β-TCP. It had been suggested that the combination could have lowered the toxicity of cyanoacrylate and improved bioactivity according to the previous '*in vitro*' study[21]. However, the CCP group showed limited bone regeneration in the present study. It is postulated that cyanoacrylate could have induced a significant inflammation. This result demonstrates that the combination of liquid cyanoacrylate and β-TCP could not lower the toxicity of cyanoacrylate to tissues. In the 16 weeks healing period group, there was no residual materials of CCP. It could be assumed that the temperature increase caused by polymerization of cyanoacrylate might have affected the surrounding tissue or cyanoacrylate itself has interrupted the bone regeneration in the defect sites. Future studies should be focusing on improving the newly developed CCP bone substitutes.

Although the experimental model had the standard pattern with critical size of the circumferential gap defect, some limitations were existed. One of the limitations of this study model was that there was no concern of rapid resorption after extraction. Araujo et al.[3] explained that the resorption of alveolar bone after extraction came out with the bundle bone resorption. Surgically prepared circumferential gap defects might not fulfill all the clinical situations of immediate implant. The animal models for future studies should be designed to consider the bundle bone resorption with the critical defect size.

Another limitation was that only circumferential gap defects around implants were studied. Immediate implants can produce various types of defects around implants like dehiscence defects. In the future study, various defect forms should be replenished.

Ⅴ. CONCLUSION

It is suggested that BCP can be a good candidate for circumferential gap defects around implants without any barrier membrane, whereas CCP bone substitutes might not be appropriate for bone grafting around implants. Further studies are needed for improving the CCP bone substitutes.

In conclusion, this study demonstrated that bone regeneration procedures in short-term healing period or sufficient healing period would be needed in case of gap size over 2mm for complete defect healing.

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FIGURES

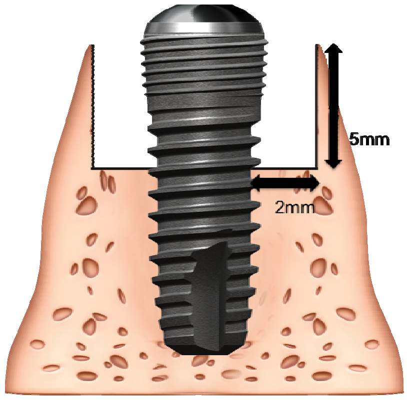

Figure 1. Schematic drawing illustrating the dimension of defect site

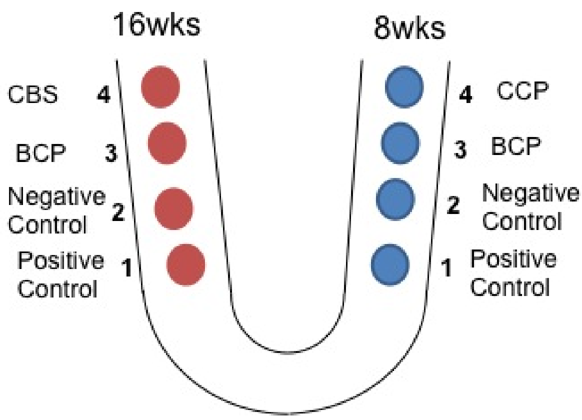

Figure 2. Schematic drawing illustrating the site of experimental groups

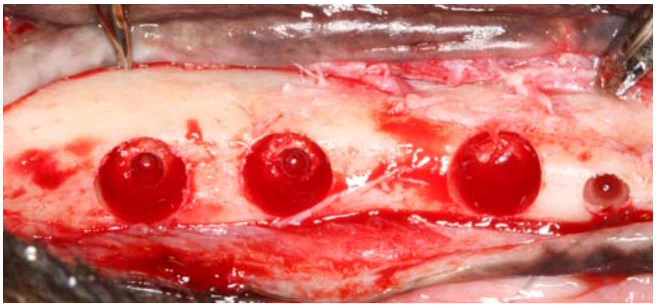

Figure 3. Clinical Photograph illustrating the surgical preparation site

Figure 4. Clinical photograph illustrating the site after the experiments. The positive control group, the negative control group, BCP group and CCP group were prepared in order from the most right side.

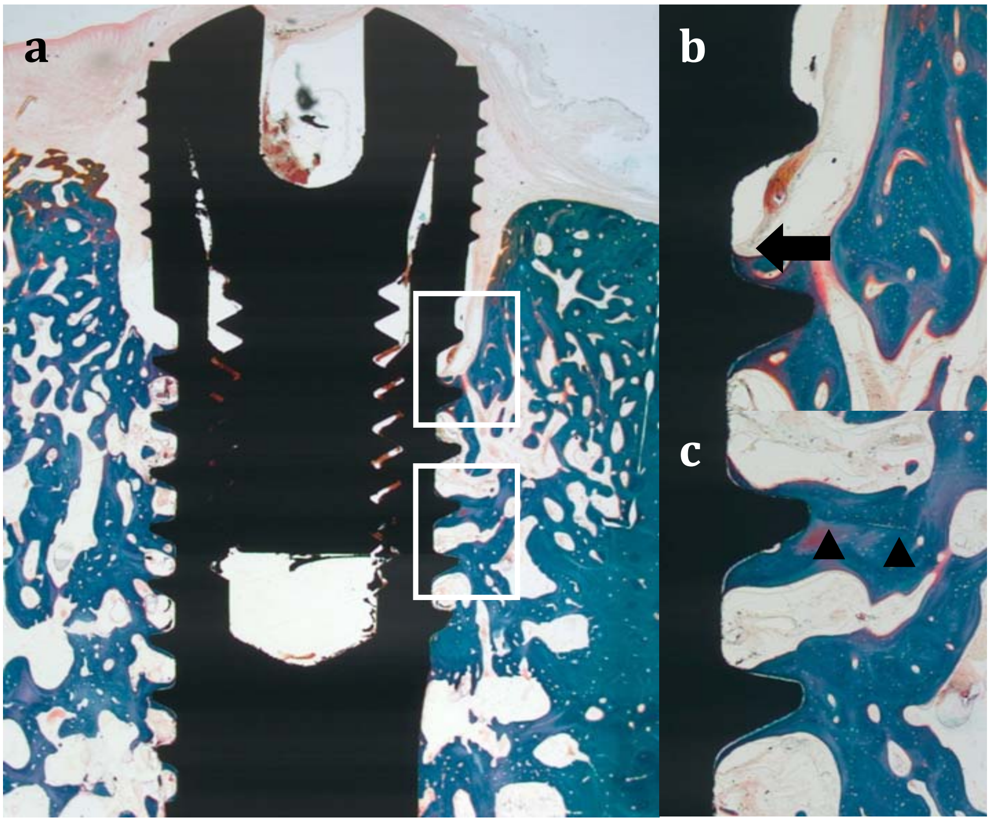

Figure 5. Histologic view of the negative control group at 8 weeks. (a) overall view. Bone regeneration is filled in the defect. (x12.5, Goldner trichrome staining) (b) Osseointegration can be observed. Arrow; most coronal part of bone to implant contact site. (x40, Goldner trichrome staining) (c) Drilled margin of defect site can be seen. Arrow head; reversal line demarcating the defect margin. (x40, Goldner trichrome staining)

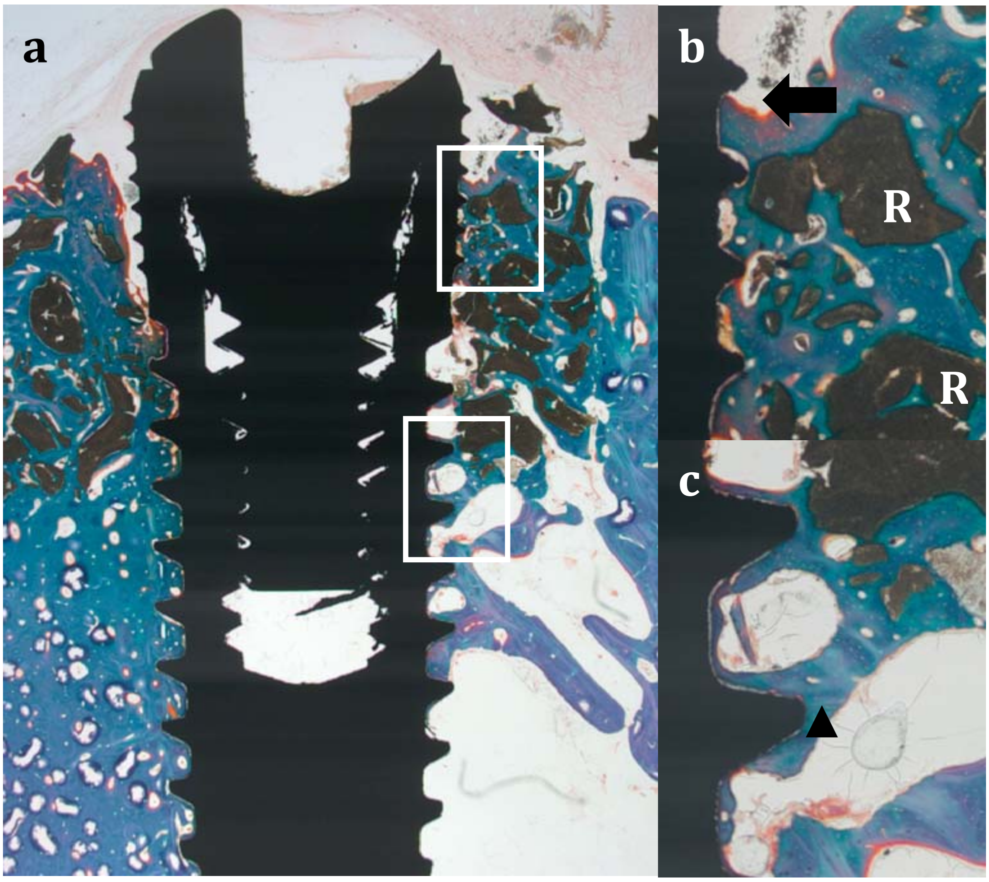

Figure 6. Histologic view of the BCP group at 8 weeks. (a) overall view. The defect site is filled with new bone and calcium phosphate particles. (x12.5, Goldner trichrome staining) (b) Osseointegration can be seen. arrow; most coronal part of bone to implant contact, R; calcium phosphate particles. (x40, Goldner trichrome staining) (c) Drilled margin of defect site can be seen. Arrow head; reversal line demarcating the defect margin. (x40, Goldner trichrome staining)

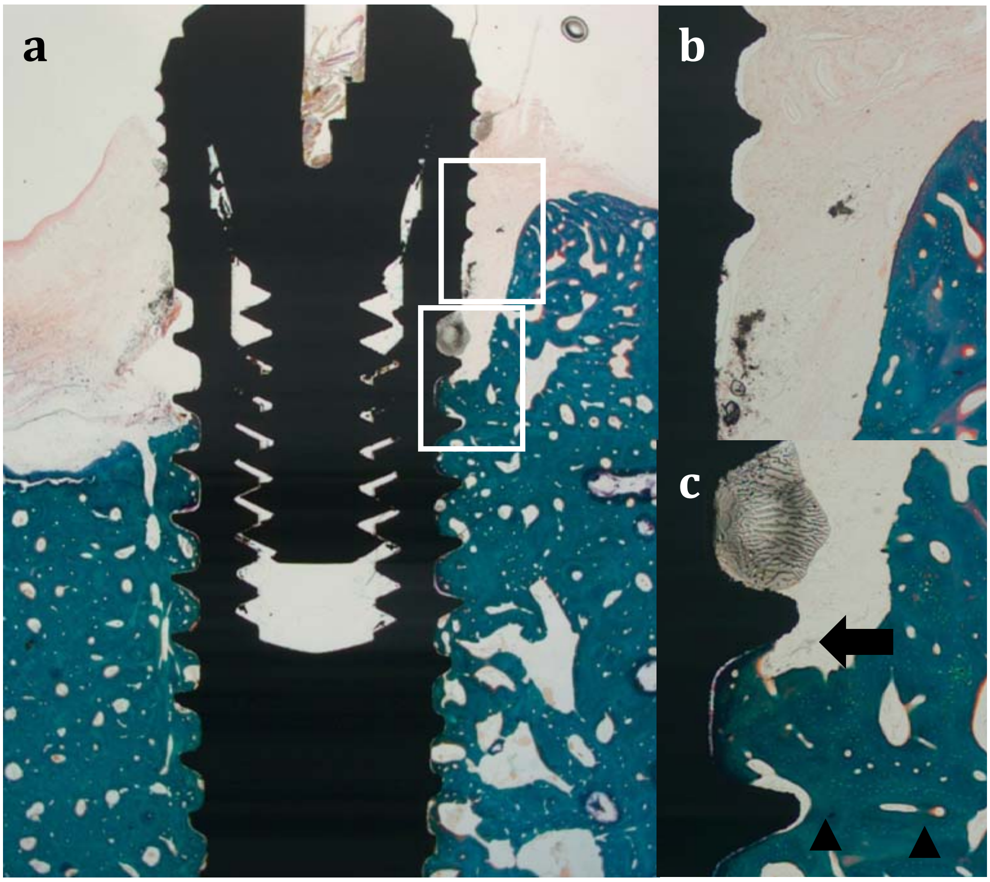

Figure 7. Histologic view of the CCP group at 8 weeks. (a) overall view. Bone regeneration is filled in the defect. (x12.5, Goldner trichrome staining) (b) Osseointegration cannot be observed. (x40, Goldner trichrome staining) (c) Drilled margin of defect site can be seen. Arrow; most coronal part of bone to implant contact site. Arrow head; reversal line demarcating the defect margin. (x40, Goldner trichrome staining)

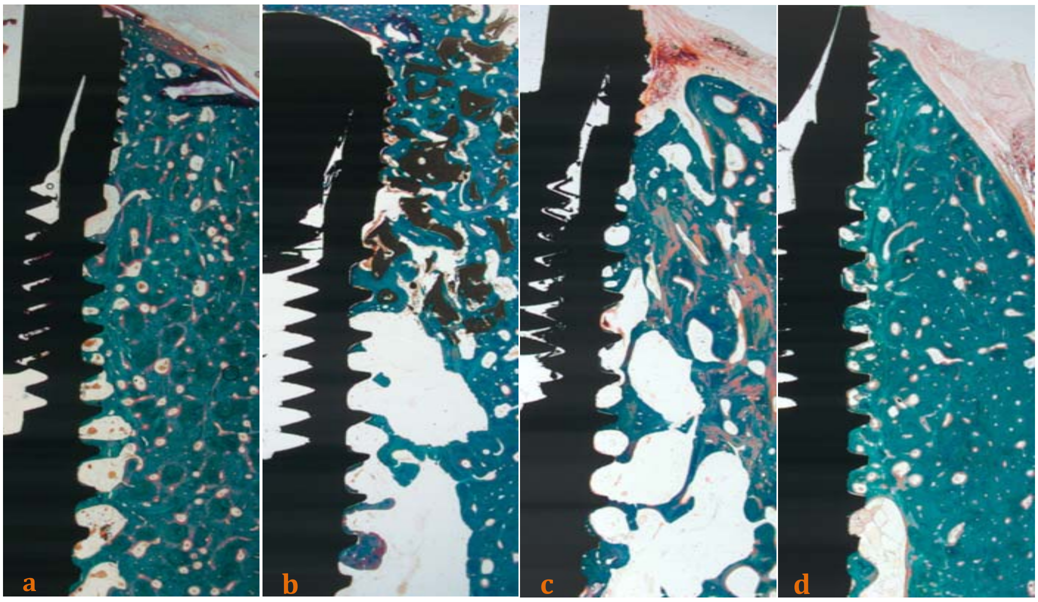

Figure 8. Histologic view of the 16 weeks healing groups. (a) Negative control group ; Complete healing can be seen in the negative control group. (x12.5, Goldner trichrome staining) (b) BCP group ; Excessive bone healing can be seen with calcium phosphate particles in the BCP group. (x12.5, Goldner trichrome staining) (c) CCP group ; Healing with slight gingival inflammation can be seen in the CCP group. (x12.5, Goldner trichrome staining) (d) Positive control group ; Complete bone healing can be in the positive control group. (x12.5, Golner trichrome staining)

TABLES

Table 1. Bone regeneration height (mm; mean ± standard deviation)

	Negative Control	BCP	CCP
8 weeks	0.86±1.24	1.00±1.05	0.47±0.41
16 weeks	3.55±.86*	3.63±1.63*	1.14±1.41†

*: statistically significant differences between 8 weeks and 16 weeks group (p<0.05)

†: statistically significant differences compared to other three groups (p<0.05)

Table 2. Bone to Implant Contact (BIC) in the defect site (%; mean ± standard deviation)

	Negative Control	BCP	CCP
8 weeks	7.90±6.28	14.78±11.30	8.44±6.83
16 weeks	32.93±16.55*	45.49±25.35*	14.19±11.29†

*: statistically significant differences between 8 weeks and 16 weeks group (p<0.05)

†: statistically significant differences compared to other two groups (p<0.05)

Table 3. Bone volume regenerated in the defect site (mm^2; mean ± standard deviation)

	Negative Control	BCP	CCP
8 weeks	11.97±3.50	13.99±3.08	7.92±3.00
16 weeks	19.52±1.43*	18.11±2.93*	12.34±2.52†

*: statistically significant differences between 8 weeks and 16 weeks group (p<0.05)

‡: statistically significant differences between BCP and CCP group (p<0.05)

국문요약

Biphasic Calcium Phosphate 와 cyanoacrylate-calcium phosphate 골대체 복합재료가 성견의 환상형 임플란트 결손부 치유에 미치는 영향

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김 영 택

발치 후 발치와의 치유는 항상 이상적으로 이루어질 수 없으며, 치주질환이나 치수질환 등으로 인해 골이 많이 흡수되어, 임플란트 시술시 다양한 골결손부의 형태로 나타나게 된다. 또한, 즉시 식립 임플란트의 경우 환상형 결손부가 나타나게 된다. 이러한 환상형의 결손부를 수복하기 위해 골이식재가 사용되어지거나, 골유도재생술이 행해졌다. 골이식재로는 다양한 재료가 사용되고 있으며, 합성골 중에서는 calcium phosphate 를 이용한 다양한 합성 골이식재들이 연구되고 개발되고 있다.

이 연구의 목적은 성견에서 외과적으로 형성된 임플란트의 환상형 결손부를 여러 골대체 복합재료로 수복하였을 때 8 주와 16 주 간의 치유기간을 비교하여 그 치유 양상을 조직학적, 조직계측학적으로 평가하고자 함이다.

환 상형의 결손부를 성견에서 외과적으로 형성하여 실제 임상에서 일어날 수 있는 모형을 재현하였다. 임플란트 주위에 폭 2.0mm, 깊이 5.0mm 의 결손부를 형성하여 cyanoacrylate-calcium phosphate 골대체 복합재료 (CCP)와 biphasic calcium phosphate (BCP)를 결손부에 이식하여 두 군을 설정하고, 골이식을 하지 않은 음성 대조군과 결손부를 가지지 않는 양성 대조군을 설정하였다. 8 주와 16 주간의 치유기 후의 조직학적 소견 및 조직계측학적 결과를 분석하였다.

8 주의 치유기간을 가진 군에서 CCP 군과 BCP 군의 형성된 골 높이및 골 임플란트 접촉율은 16 주 군에 비하여 통계적으로 유의성있게 낮은 수치를 보였다. 결손부 내의 골형성 양은 CCP 군만 다른 군들에 비하여 통계적으로 낮은 수치를 보였다.

16 주의 치유기간을 가진 군에서 CCP 군만을 제외한 나머지 군은 모두 임플란트 주위에 완전한 골형성을 보였다. BCP 군은 8 주, 16 주에서 다른 군에 비하여 모두 높은 골형성을 보였다.

BCP 는 골결손부 수복에 적합한 골대체제로 추천되나, CCP 는 임플란트 주위 골결손부 수복에 효과적이지 않아, 추가적인 연구가 필요할 것으로 보인다.

2mm 이상의 임플란트 주위 환상형 골결손부 골재생을 위해서는 추가적인 골재생 술식이 필요하거나 충분한 골형성 시간이 필요한 것으로 보인다.

핵심되는 말 : 성견 모형, 임플란트, 환상형 골결손부, cyanoacrylate, biphasic calcium phosphate, 치유기간