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= Abstract =

Chemical, Structural & Osteoconductive Properties of Mineralized Porcine Cancellous Bone

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Purpose : The purpose of this study is to determine the efficacy of bioactive hydroxyapatite obtained from the porcine cancellous bone for the treatment of bone defect and nonunion.

Materials and Methods : Porcine cancellous bones were heat-treated at 1300 for 2 hours. The chemical compositions, calcium to phosphate ratio and microstructures of mineralized porcine bone were examined. For *in vivo* implantation, bone defects were made on the anteromedial aspects of proximal tibia in 7 beagle dogs and these artificial bones were inserted. Plain X-ray was taken at every 2 weeks interval for radiologic evaluation. At 12 weeks, specimens were evaluated histologically with hematoxylin and eosin stain.

Results : The composition and morphology of mineralized porcine cancellous bone were similar to those of heat-treated human cancellous bone. Radiographs showed union at the host bone-bone block interfaces. At 12 weeks, all uniform and substantial new bone formations were observed.

Conclusion : This mineralization technique has several advantages such as no disease transmission, no immune reaction, excellent biocompatibility, and cost-effectiveness. Consequently, mineralized porcine cancellous bone showed an effective osteoconductivity.

Key Words : Porcine cancellous bone, Mineralization, Chemical, Structural, Osteoconductivity

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Lake Bluff, IL, USA) 가 15mm,
 15mm, 10mm
 가 (fatty
 bone marrow)
 (autologus bone graft) 30% (H₂O₂) 2
^{3,7)} 가 , 가
 9% 95% 4
 , 21% , 12
⁴⁾
 (allograft) (arti- 가 (Siliconit muffle furnace,
 ficial bone graft)) , 10 /min
 가 , 가 , 1300 2
 , , 가 silicon-rubber
 , 가 (A)
 가 (B)
 (bioceramics) . 2 , 가
 가 .
 2.
 X (X-ray Diffrac-
 tometer, XRD) ,
 가 (Hydroxyapatite, HA) X (Energy
 HA Dispersive X-ray Spectrometer, EDX)
 ,
 (Scanning
⁹⁾ 가 Electron Microscope, SEM)
 .
 3.
 2가 가 (121 ,
 15lb/in²) . 7 beagle
 1cm³ ,
 5 . ,
 1. (Group 1) A (Group
 2), B (Group 3),
 , A (Group
 Diamond wheel blade cutter(ISOMET™ 4), B (Group
 1000 Precision Saw, Buehler Analyst Ltd., (Group 5) . 4 5

2cc 가 가 (osteoid) , (fibrotic
 가 tissue) (100x)
 (>70%;+++,
 30 . 30~70%;++, <30%;+) , (osteoblast)
 2 (400x)
 가 , 12 beagle (>150;+++, 50~150;+, <50;+) 3가
 가 .
 hematoxylin & eosin(H &E)
 3

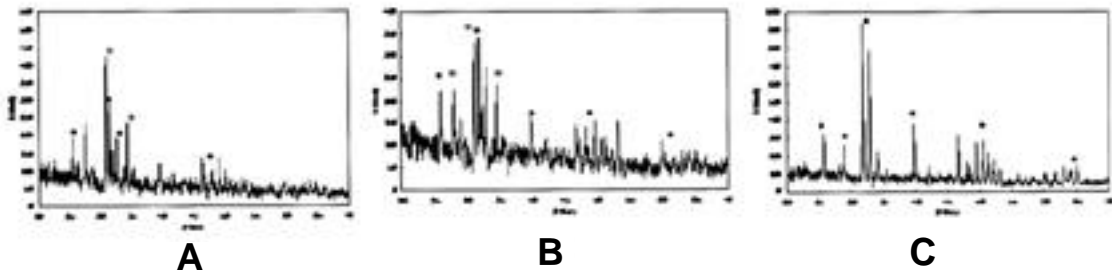


Fig. 1. The Results of X-Ray Diffractometer of human cancellous bone(close heating, A), porcine cancellous bone(close heating, B) and porcine cancellous bone(open heating, C). The porcine bones were composed of hydroxyapatite(HA.) and tricalcium-phosphate(β -TCP, *) in Bone A, but HA only in Bone B.

Table 1. Results of Energy Dispersive X-Ray Spectrometer

Heat treat condition	Human cancellous bone		Porcine cancellous bone	
	Close	Open	Close	Open
Ca/P	1.71	1.65	1.48	1.65
	1.68	1.66	1.50	1.66

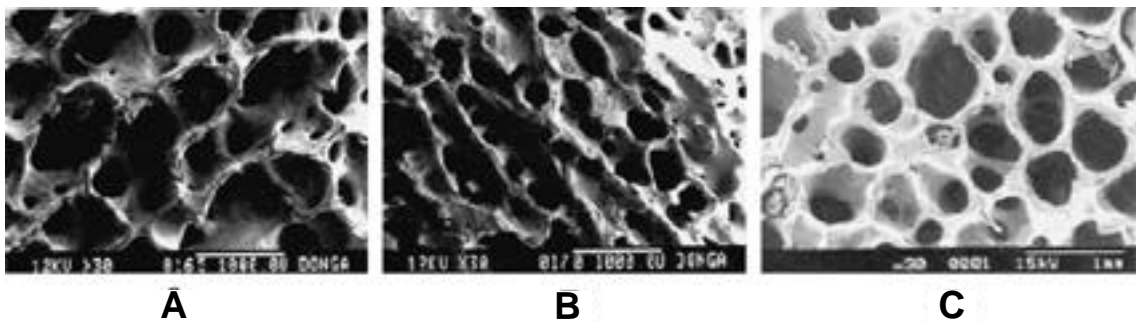


Fig. 2. Findings of Scanning Electron Microscopy ($\times 30$). **A.** human cancellous bone with close heating, **B.** porcine cancellous bone with close heating, **C.** porcine cancellous bone with open heating. The microstructures of both bone blocks were similar to human cancellous bone which showed various pore size(pore size : 300~600 μ m).

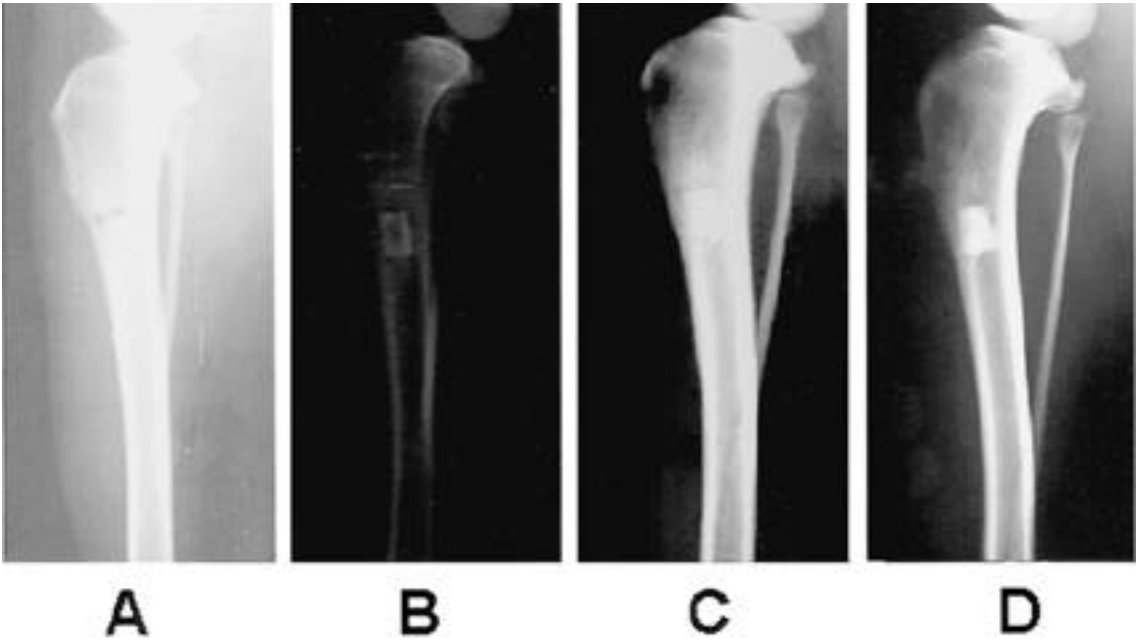


Fig. 3. Serial Radiologic Findings. The 1cm³ sized bone defect was made on medial side of proximal tibia in a beagle dog. The mineralized porcine cancellous bone was inserted into the bone defect. At 3 months after operation, the trabeculation was continued to the bone defect side compared to the immediate post-operative X-ray. **A.** immediate post-operation, **B.** 1 month after operation, **C.** 2 month after operation, **D.** 3 month after operation.

(Fig. 2).

2. 가

1. ,

(Fig. 3). ,

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A HA -TCP(-tricalci (peak)

(umphosphate)

(B) -TCP 12 (Fig. 4).

, HA (Fig. 4).

ure 1).

B Ca/P 가

4

1.7 1.66 ,

5), (fatty marrow cell)

A 1.49 (Table 1). SEM (Fig. 6,7).

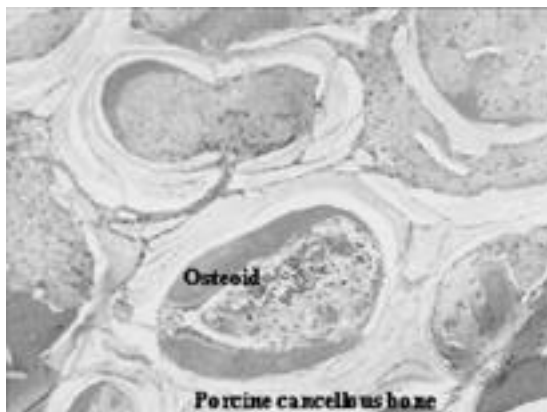


Fig. 4. Histologic findings of 3 months after operation (HE stain, $\times 100$). Osteoids formed between pores of porcine mineralized cancellous bone.

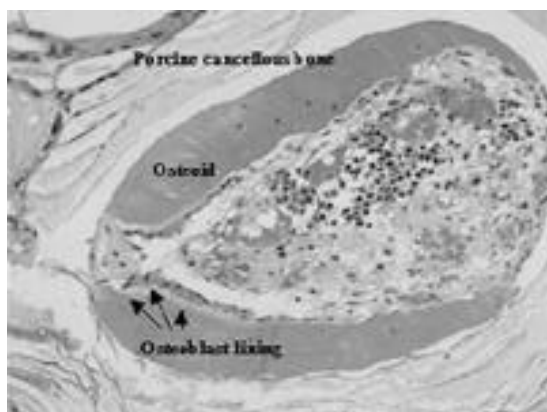


Fig. 5. Histologic findings of 3 months after operation (HE stain, $\times 400$). Osteoblastic linings were observed in the newly formed osteoid.

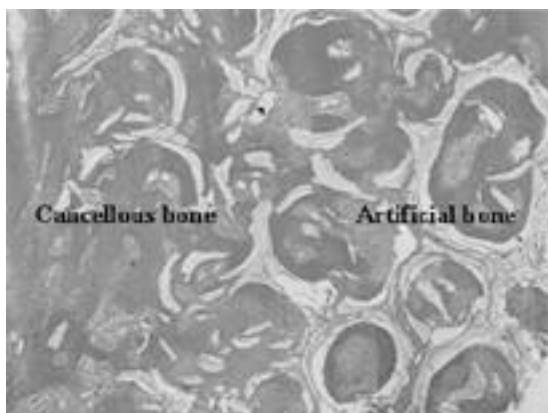


Fig. 6. Junction of artificial bone-cancellous bone(HE stain, $\times 100$). The trabeculation was continued from cancellous bone to the grafted site.

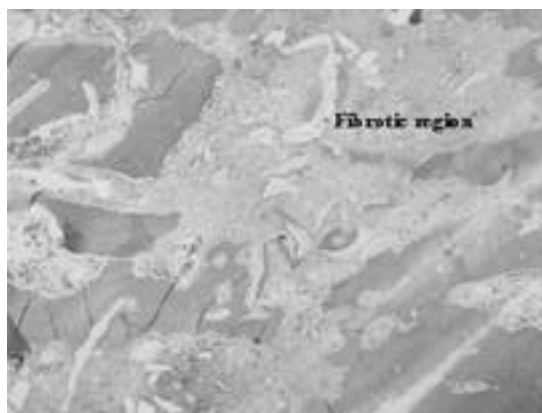


Fig. 7. Some fibrotic regions were observed in the grafted sites(HE stain, $\times 100$).

Table 2. Summary of Histologic Findings

Group	Animal No.	Radiology(+/-)		Histology(+/+/+/++)		
		Union	Resorption	Osteoblast lining	Osteoid	Fibrotic region
1	1	-	-	+	+	+++
2	2	+	-	+	++	+
	3	+	-	++	+	++
3	4	+	-	+++	++	+
	5	+	-	++	+	+
4	6	+	-	++	++	+
5	7	+	-	+++	++	++

가 가 (Table 2), 가 ²⁾ 가

12

XRD

-TCP HA

HA

가 , HA -TCP HA

HA -TCP

가

⁶⁾

(bone morphogenic protein, BMP)

demineralized bone

가

⁸⁾ 가

EDX , HA Ca/P

가 1.67 가 가 ⁹⁾

(human immunodeficiency virus, HIV)

60 ~ 80

Ca/P

⁶⁾

In vivo

가 ¹⁾ 가 3

, Lane ⁴⁾ Griz

zardi ⁵⁾

가

Aoki¹⁾

1200

30 ~ 50%

가

가 2가

가

가 ,
 가 (Mes-
 enchymal stem cell)가
 가 .
 ,
 가 ,
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 가
 ,
 가

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