Investigation on Inducement of Tissue Around the Porous Hydroxyapatite Ceramics in Different Environmental Factors: Bone, Cartilage, Muscle

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Abstract. Porous hydroxyapatite ceramics(HA) are known to have an osteoinductive ability. HA now only is used in the area of plastic surgery but also in orthopedic surgery and dentistry, and other fields as a replacement of autogenous free bone grafts. The authors investigated inducement of tissue around the HA in different environment. HA (Apaceram, porosity: 40%, 2x2x5mm) was implanted into ribs, costal cartilages and intercostal muscles of dogs. Histopathological examination four to thirteen weeks after implantation of HA was performed. Active bone formation was observed as HA was implanted to rib and muscle. Cartilage formation was observed as HA was implanted to costal cartilage. Hematopoietic tissue was found inside a pore of the HA, when HA was implanted to bone.

Key words: cartilage inducement, costal cartilage, hydroxyapatite, hemopoiesis

Introduction

The authors have investigated inducement of tissue around the hydroxyapatites(HA) in different environments. HA (Apaceram, porosity: 40%, 2x2x5mm) was implanted into ribs, costal cartilages and intercostal muscles of dogs. Histological examination revcaled different induced reaction between cartilages, bone, and muscles.

Materials and Methods

Apaseram (Made by Pentax, porosity of 40%, size 2x2x5mm, semicylinder type) was implanted as a hydroxyapatites.
Ribs were exposed under general anesthesia. Periosteum or perichondrium was striped before drilling a 2 mm hole to a rib. HA was inserted into the hole. HA was implanted into the muscle simultaneously (Fig. 1). Each dog under went operation four times for implantation. 36 pieces of HA were implanted to one dog, and three dogs under went the examination. The implants amount to 108 in all. Histologial examination under went 4 to 13 weeks after implantation. All the materials were decalcifyed.
Hematoxylin-Eosin stain, Masson-Tricrome stein, and truisine-blue stein were used for histological investigation.

Results

1) HA implantation into the cartilage

Eight weeks after implantation, fibrous tissues are decreased around HA and a gap between HA and cartilage is filled by new cartilage formation. Thirteen weeks after implantation, chondroblast and new formed cartilage makes a perichondrium like pattern on the surface of HA (Fig. 2). Inside a pore of HA, cartilage formation was observed six weeks after implantation. Blood capillaries appear eight weeks after implantation. Thirteen weeks after implantation, osteoclasts appeared on the surface of a pore and blood capillaries were increased. This looks like bone marrow (Fig. 3). However, hematopoietic cells were not observed there.

Some pores presented increase of blood capillaries, other pores showed increase of cartilage formation instead of capillary.

2) HA implantation to the bone

Nine weeks after implantation, bone formation was observed around HA and inside pores of HA (Fig. 4). Thirteen weeks after implantation, bone formation was observed and polychromatophil erythroblasts were observed in the blood capillaries inside a pore of HA (Fig. 6). This resembles bone marrow.

3) HA implantation into muscles

Thirteen weeks after implantation, periosteum like tissue, including osteoblast and osteocytes was observed around HA (Fig. 7).

Inside a pore, bone formation and blood capillary were observed. Hematopoietic cells were not recognized.

Discussion

Cartilage

Many authors have reported bone inducement of HA. However, there are few reports concerning cartilage inducement of HA. There are two ways of cartilage development. One is interstitial growth. The other is appositional growth. In our study, cartilage formation was observed inside the pore where attachment to the perichondrium can not be obtained. Thus, the origin of cartilage formation inside the pore could be interstitial growth. It seems that mesenchymal tissue differentiated chondroblast cells.

Some pores presented increase of blood capillaries with poor cartilage formation, other pores showed increase of cartilage formation with poor capillary formation. Donski reported blood flow does not have an influence of cartilage formation.[1] Ohlsen reported grafted perichondrium is feed by synovia only, in a study of grafting a perichondrium to an articular cartilage.[2] A relationship between cartilage formation and capillary formation seemed reciprocal.

Muscle and bone

Bone formation was observed in the cases HA was implanted into the muscle and the bone. It seems that mesenchymal blast cells differentiated to osteoblast cells. Inside a pore, bone formation and capillary formation was observed. In our study, hematopoietic cells were not recognized. Nishihara has reported that one year after implantation of HA into muscles, hematopoietic field was induced. It seems that long term follow up should be necessary for formation of hematopoietic field.

Conclusions

We investigated inducement of tissue around HA in different environment, cartilage, bone and muscle. When HA was implanted into the costal cartilage, cartilage formation was observed. Other cases, HA was implanted into the bone or muscle, bone formation was observed. Inducement of HA was influenced by envuromental factors.

References

1) Donski, P. and O'Brien, B. M.: Perichondrial microvascular free transfer: An experimental study in rabbits. *Br.J. Plast. Surg.*, 33: 46-53, 1980

2) Ohlsen, L. and Widenfalk, B.: The early development of articular cartilage after perichondrial grafting. *Scand. J. Plast. Reconstr. Surg.*, 17: 163-177. 1983

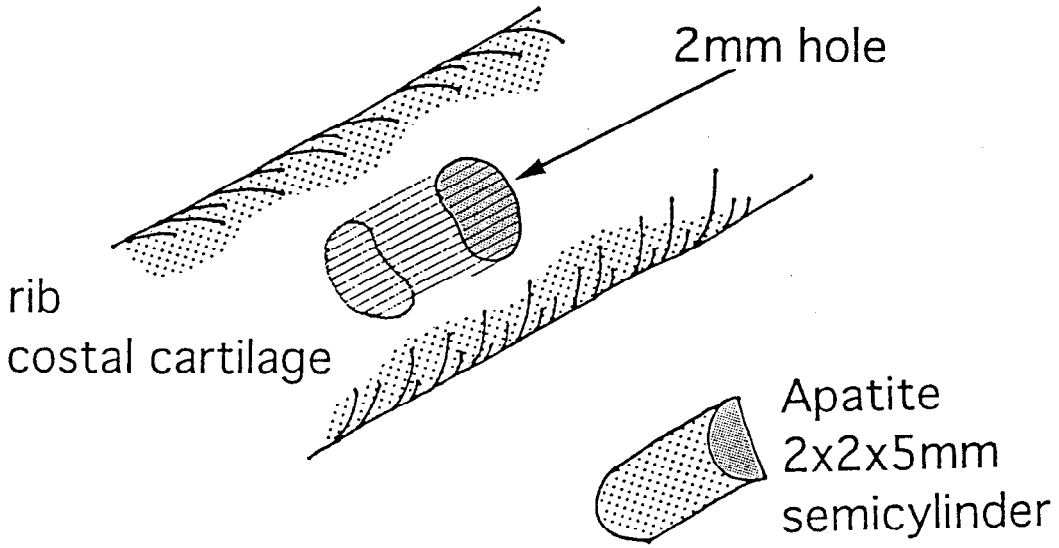

Fig. 1 Hydroxyapatites were implanted into the hole made on the rib.

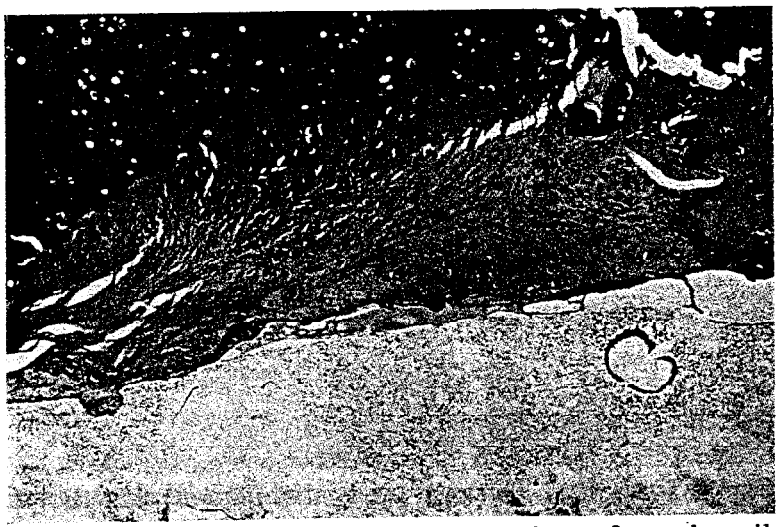

Fig. 2 Thirteen weeks after implantation, chondroblast and new formed cartilage makes a perichondrium like pattern on the surface of hydroxyapatites.

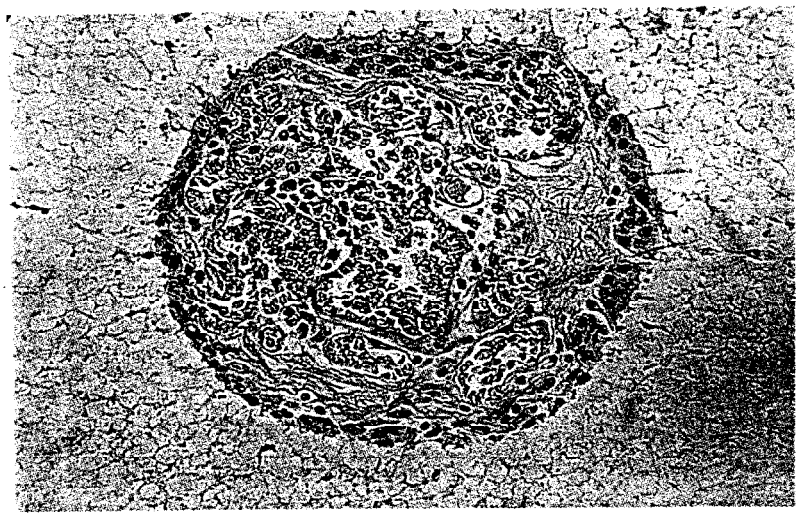

Fig. 3 Inside a pore of hydroxyapatites. Thirteen weeks after implantation. Osteoclasts appeared on the surface of a pore and blood capillaries were increased. This looks like bone marrow. However, hematopoietic cells were not observed.

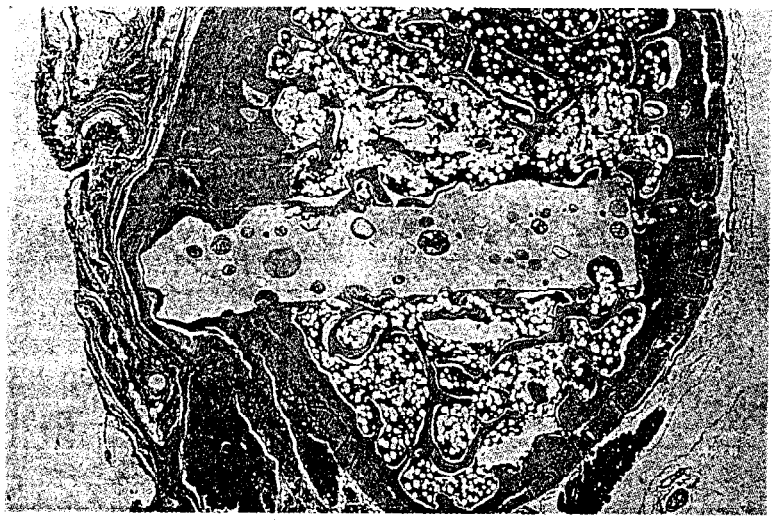

Fig. 4 Bone formation was observed around apatite and inside a pore of apatite, nine weeks after implantation.

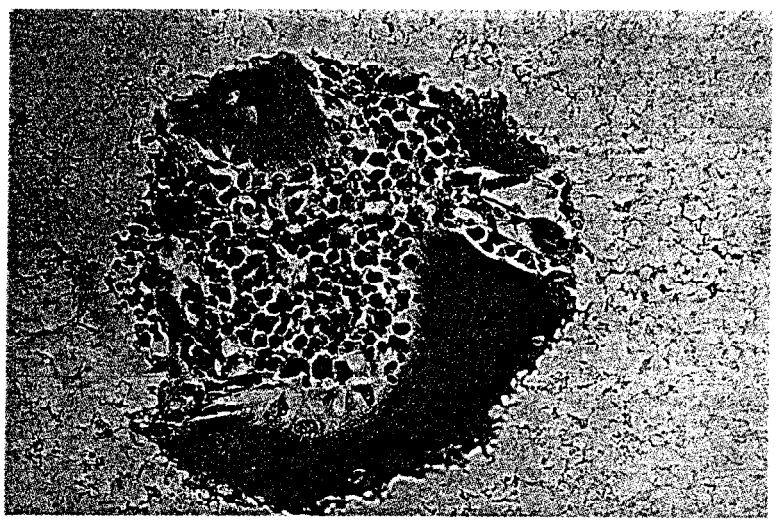

Fig. 5 Inside a pore of hydroxyapatites. Thirteen weeks after implantation. Polychromatophil erythroblasts were observed in the blood capillaries, this resembles bone marrow.

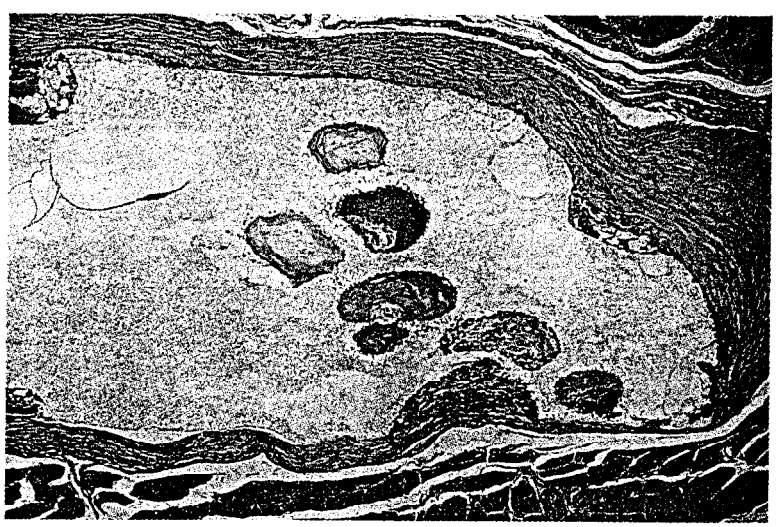

Fig. 6 Thirteen weeks after implantation. Periosteum like tissue, including osteoblast and osteocytes was observed around hydroxyapatites. Inside a pore, bone formation and blood capillary were observed. Hematopoietic cells were not recognized.