Histomorphometric Analysis of Two Types of Coated Implants : a Preliminary Study Using the Rabbit Tibia Model

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• Abstract

Purpose : The purpose of this pilot experiment was to evaluate early bone response in two types of coated implants using the rabbit tibia model.

Materials and Methods : Screw type titanium implants manufactured with a calcium metaphosphate (CMP) coating and hydroxyapatite (HA) coating were placed in the tibiae of 3 New Zealand White rabbits. The bone responses at 2 weeks after insertion were evaluated and compared by histomorphometry.

Results : There was no significant difference in bone-to-implant contact between the groups (P>.05). However, some qualitative differences on histologic views were found.

Conclusions : CMP-coating is suggested to be the preferred candidate for fast osseointegration over HA-coating.

• Keywords : calcium metaphosphate, hydroxyapatite, implant surface, surface coating, surface treatment

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Introduction

The surfaces of dental implants have been modified for better bone response and implant success. Plasma-sprayed hydroxyapatite (HA) coating has some advantages, including more rapid and stronger osseointegration[1]. However, coating delamination, cohesive and adhesive failures, and disintegration with the formation of particulate debris can be caused by porosity, a thick coating layer, weak interfacial bonding, and the resistance of HA particles to biodegradation[1]. Calcium metaphosphate (CMP) ceramic has been suggested as a new bone substitute because of good osteoconductivity and adequate biodegradable properties[2, 3]. Nonetheless, there have been few in vivo studies to compare CMP coating with HA coating.

The purpose of this preliminary study was to evaluate the early bone responses of CMP-coated and HA-coated implants with respect to bone-to-implant contact (BIC), using the rabbit tibia model. The hypothesis was that there would be no significant difference in BIC between both types of implants.

Materials and Methods

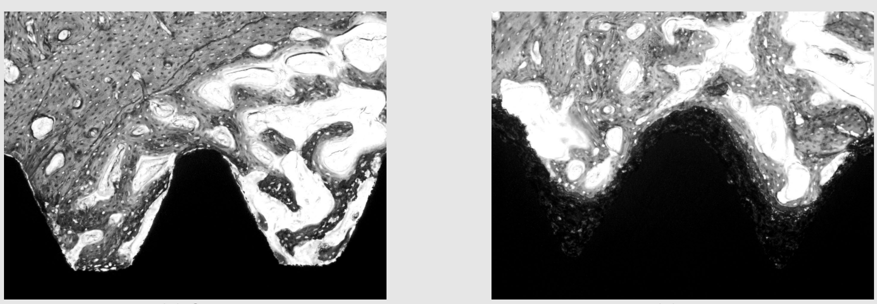
Six threaded titanium dental implants, 8 mm in length and 3.75 mm in diameter, were divided into two groups : three CMP-coated implants by dip-spin method whose technique was described by You et al[2] (Osstem Co., Pusan, Korea) and three plasma-sprayed HA-coated implants (Sustain®, Lifecore, Chaska, MN). Three mature New Zealand White rabbits, weighing 2.5 to 3.5 kg, were used. Prior to surgery, the shaved skin in the proximal tibial area was washed with Betadine and preoperative antibiotics, 0.12 g kanamycin IM, was administered prophylactically. Rabbits were anesthetized with a combination of ketamine (28.8 mg/kg) and xylazine (11.7 mg/kg) intramuscularly. Local anesthesia with 1.8 ml of 2% lidocaine was administered in the regions planned for surgery. The proximal aspect of each tibia was surgically exposed via skin incision and the muscles were dissected to allow elevation of the periosteum. The flat surface on the medial aspect of the proximal tibia was selected for implant placement. The implantation holes were drilled with a low rotational speed, profuse saline irrigation and with successively increasing diameters, no countersink preparation, and finally tapped with a 3.3 mm tap. Two implants were installed in the tibiae of each rabbit : a CMP-coated implant in one tibia, and an HA-coated implant in the other. The implants penetrated the first cortical layer only, with three threads visible above the cortex. The periosteum and fascia were sutured with chromic gut and the skin was sutured with silk. Each rabbit recovered without complications and received 0.06 g kanamycin IM per day for three days postoperatively.

For histomorphometry, the rabbits were sacrificed after two weeks of healing. Each set of implants was surgically removed en bloc with an adjacent bone collar and immediately fixed in 4% neutral formaldehyde. The specimens were processed to be embedded in light-curing resin (Technovit 7200 VLC, Kultzer, Wehrheim, Germany). Un-decalcified, cut and ground sections were prepared using the Exakt® system (Exakt Apparatebau, Norderstedt, Germany) based on a method described by Donath[4]. The specimens were stained with hematoxylin and eosin. BIC ratios were calculated (Kappa PS30C Imagebase, Kappa Opto-electronics GmbH, Gleichen, Germany) on the light microscopic images (Olympus BX microscope, Olympus, Tokyo, Japan) at 100× magnification.

The statistical significance of the difference in BIC ratio between the groups was assessed by Mann-Whitney U test. Values of P less than .05 were considered statistically significant.

Results

Much cancellous bone was observed to be in contact with the dental implant at the marrow area in both groups at 2



(a) CMP (b) HA

Fig 1 Light microscopic views at 100× magnification after two weeks of healing.

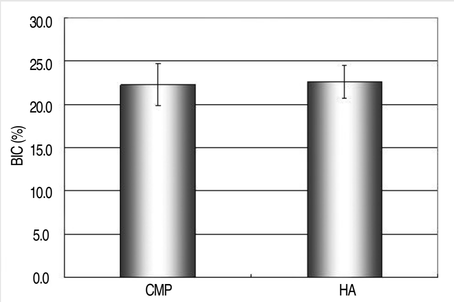


Fig 2 The means and standard deviations of each group in BIC during the two-week healing period

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weeks after implant insertion (Fig 1). The outer cortical bone, on the other hand, did not grow enough to reach the implant surface. There were no observed inflammatory responses on the slides of either group. The means and SDs of the BIC ratios after two weeks were 22.2±2.4 % for the CMP, 22.6±1.9 % for the HA (Fig 2). No significant differences between the groups were found (P=.83). Microscopically, the discrete coating layer was difficult to find on the slides of the CMP-coated implants because the CMP coating by dip-spin method onto the cp-Ti surface resulted in a thin layer of about 1 μm^2. For the HA-coated implants, however, an HA coating layer of 50~100 ㎛ with multiple porosities and irregularities was found (Fig 1).

Discussion

This experiment reported that the CMP-coated implants were not significantly different in BIC from the HA-coated implants. However, the dip-spin technique produced a thin CMP coating of about 1 μm^2, while plasma-spraying caused the HA coating layer to be thicker and porous. Thick and porous HA coatings could lead to coating delamination and the release of coating segments[1]. Such cohesive failure could leave isolated HA particles that would cause osteolysis and implant failure if the particles were not properly resorbed. A thin coating layer could overcome those disadvantages.

In conclusion, CMP applied by the dip-spin method was suggested to be a good substitute for plasma-sprayed HA to coat the implant surface, although both coated surfaces showed similar early bone responses in this study.

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