

Application of interconnected porous hydroxyapatite ceramic block for onlay block bone grafting in implant treatment: A case report (Review)

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Abstract. Autogenous block bone grafting as treatment for alveolar ridge atrophy has various disadvantages, including a limited availability of sufficiently sized and shaped grafts, donor site morbidity and resorption of the grafted bone. As a result, interconnected porous hydroxyapatite ceramic (IP-CHA) materials with high porosity have been developed and used successfully in orthopedic cases. To the best of the author's knowledge, this is the first report of clinical application of an IP-CHA block for onlay grafting for implant treatment in a patient with horizontal alveolar atrophy. The present study performed onlay block grafting using an IP-CHA block to restore bone volume for implant placement in the alveolar ridge area without collecting autogenous bone. Dental X-ray findings revealed that the border of the IP-CHA block became increasingly vague over the 3-year period, whereas CT scanning revealed that the gap between the block and bone had a smooth transition, indicating that IP-CHA improved the process of integration with host bone. In follow-up examinations over a period of 5 years, the implants and superstructures had no problems. An IP-CHA block may be useful as a substitute for onlay block bone grafting in implant treatment.

Introduction

Alveolar ridge atrophy developing after tooth extraction may result in insufficient bone volume, thus rendering incorrect implant placement from both functional and esthetic viewpoints (1). Autogenous onlay block bone grafts are widely used

for external augmentation in cases of horizontal and vertical alveolar ridge atrophy, as placement on the surface of the host bone can restore bone volume (2,3). Furthermore, several reports have noted that implant treatment with an autogenous onlay block bone graft for horizontal or vertical alveolar ridge atrophy results in bone gain and high rates of implant success (3-6). However, autogenous block bone grafting also has some disadvantages, such as limited availability of grafts with sufficient size and shape, and risk of donor site morbidity, including long-lasting pain, fracture, and nerve damage (7-9). In addition, other problems associated with resorption of the grafted bone during the healing process remain.

Interconnected porous hydroxyapatite ceramic (IP-CHA) materials with high porosity have been developed and used successfully in the field of orthopedics medicine (10). An IP-CHA block, which consists of a porous sintered body composed of hydroxyapatite ceramics with a unique pore structure, is able to undergo extensive incorporation into host bone more rapidly than conventional porous calcium hydroxyapatite ceramic (10,11). We speculated that problems associated with autogenous block bone grafting could be avoided if an IP-CHA block of the same size as an autogenous block bone were to be used for onlay grafting. In our previous study, we used titanium implants in IP-CHA blocks placed on cortical bone surfaces in a rabbit model, which resulted in direct contact between the implant surface and new bone incorporated into the block (12). Those results indicated that use of an IP-CHA block promotes osseointegration of the dental implant from the surface of the host bone. Here, we present the first report of clinical application of an IP-CHA block for onlay grafting in implant treatment in a patient with horizontal alveolar atrophy.

Case report

The patient was 51-year-old woman, whose left incisor had been extracted at a primary care dental clinic because of caries. Six months later, she was referred to our hospital for consideration of implant treatment for the missing tooth (Fig. 1). Orthopantomograph and computed tomography (CT) images showed horizontal alveolar bone atrophy in the

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anterior region (Fig. 2). Data obtained from the examinations were then transferred to 3D planning software (SimPlant; Materialise Dental NV, Leuven, Belgium) for ideal implant placement (Fig. 3), and those findings showed that the implant thread would be exposed because of the insufficient bone volume in the alveolar ridge. Therefore, we planned to use of an onlay graft with an IP-CHA block to restore bone volume for implant placement in the alveolar ridge area without collecting autogenous block. The virtual planning data were then utilized to create a 3D model by a rapid prototyping machine (Eden 260; Objet Geometries Inc., Rehovot, Israel). An IP-CHA block was fabricated (6x7x3 mm in size) by MMT. Co., Ltd., Osaka, Japan, to fit the alveolar ridge of the patient (Fig. 4).

The patient underwent informed consent according to a protocol approved by the Ethical Committee of Hiroshima University Hospital, and onlay grafts and implant placement were performed under general anesthesia in October 2011. A crestal incision and 2 vertical releasing incisions were made, after which the soft tissue flap was raised, and the cortical bone surface was polished using a small round bur to support blood vessel outgrowth. An implant (Replace Tapered groovy NP 3.5x10 mm; Nobel Biocare, Gottenborg, Sweden) was installed into alveolar bone according to the manufacturer's instructions, and the thread remained exposed, as expected (Fig. 5A). Next, 2 small holes for the suture were opened through labial and palate cortical bone on both sides of the thread using a small round bur, with CT imaging employed to avoid injury to the incisive canal, then an absorbable suture was passed through in the labial and palate alveolar ridge via these holes. The IP-CHA block was placed over the exposed thread and fixed to the alveolar ridge with an absorbable suture (Ethicon, Inc., Somerville, NJ, USA) (Fig. 5B). Another incision was made through the periosteum at the base of the flap, thus allowing the tissue to cover the graft without tension, and the flap was sutured. Six months after the procedure, we performed a second operation for abutment connection. Using the same incision as before, subperiosteal dissection of the alveolar bone was performed under local anesthesia. At that time, we observed that the IP-CHA block had become stabilized on the host bone, and no abnormal resorption was found. The ISQ value for the implant obtained at the second operation was found to be increased to 64.6 ± 0.58 as compared to that at the first operation (58.6 ± 0.58). Finally, a healing abutment was exposed above the gingival tissue, and the flap was then sutured. No complications, including infection, abnormal pain and hypoesthesia, were observed following surgery.

At 16 months after implant placement with the onlay graft, CT scanning showed that the IP-CHA block had stabilized without abnormal resorption and no problems with the implant were revealed (Fig. 6), thus the final superstructure was placed (Fig. 7). Dental X-ray findings showed that the border of the IP-CHA block had become increasingly vague over the 3-years period (Fig. 8A-C). CT scan images obtained at 3 years 5 months after onlay grafting showed the IP-CHA block on the alveolar bone, with a smooth transition in the gap between the block and bone, indicating that use of IP-CHA improved the process of integration with host bone (Fig. 8D and E). In the follow-up examinations conducted over 5 years, the implants and superstructures have had no problems.



Figure 1. Initial intraoral findings.

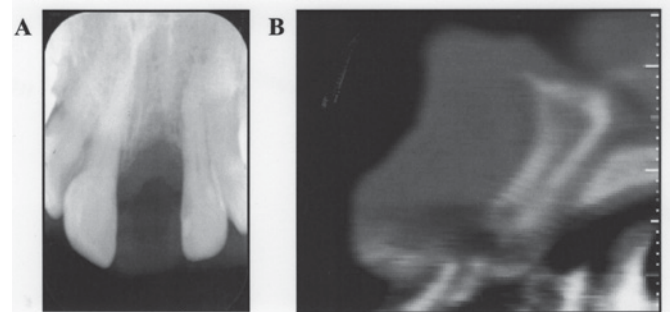


Figure 2. Initial radiographic findings. (A) Dental radiograph (B) Reconstructed sagittal CT scan image.

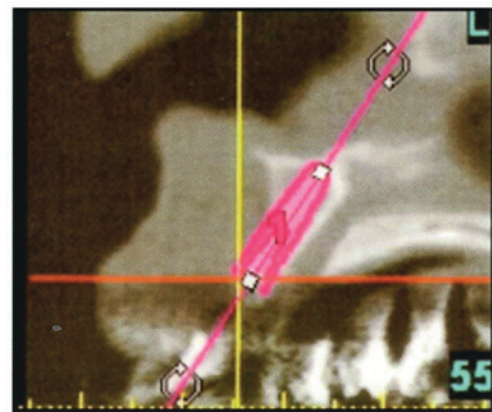


Figure 3. 3D planning analysis for determining ideal implant placement.

Discussion

Onlay block bone grafts are used for external augmentation of horizontal or vertical alveolar ridge atrophy, with autogenous bone harvested from the mandibular ramus or symphysis used for the graft, as those locations offer the greatest bone volume (13). However, intraoral grafts have been reported to have various drawbacks, such as need for an additional surgical procedure to procure the bone graft material, increased operative time, graft bone limitations, post-operative pain, altered sensation in mandibular teeth, neurosensory disturbances, nerve paresthesia, and mandibular fracture (8,14). In addition, an autogenous bone block usually undergoes extensive resorption during healing (15),

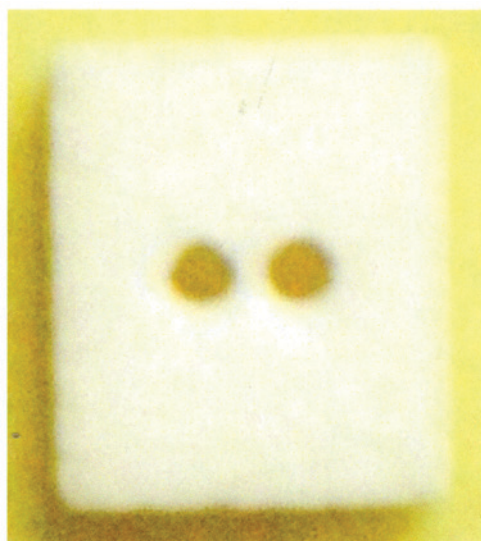


Figure 4. Fabricated IP-CHA block.

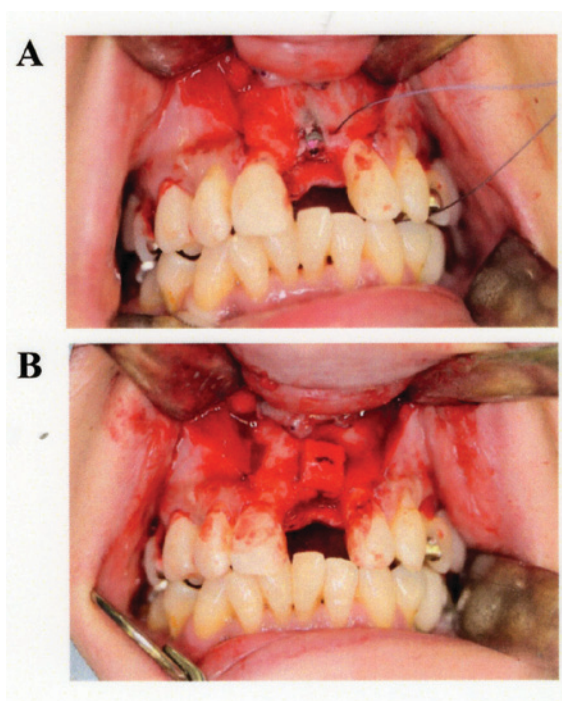


Figure 5. Onlay grafting using an IP-CHA block. (A) The implant was inserted into the alveolar bone, though the thread remained exposed. (B) The IP-CHA block was placed over the exposed thread, and fixed onto the alveolar bone.

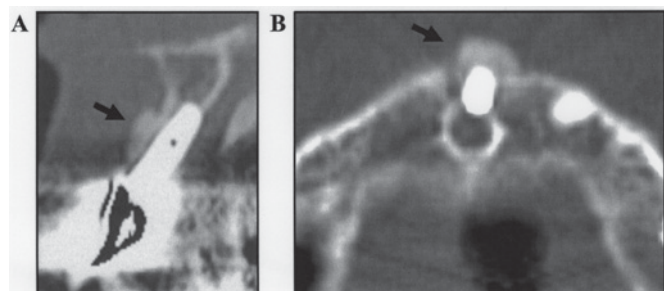


Figure 6. CT scan images at 16 months after onlay block grafting. Reconstructed (A) sagittal and (B) axial CT scan images. An IP-CHA block was shown by arrows.



Figure 7. Intraoral view at 16 months after onlay block grafting.

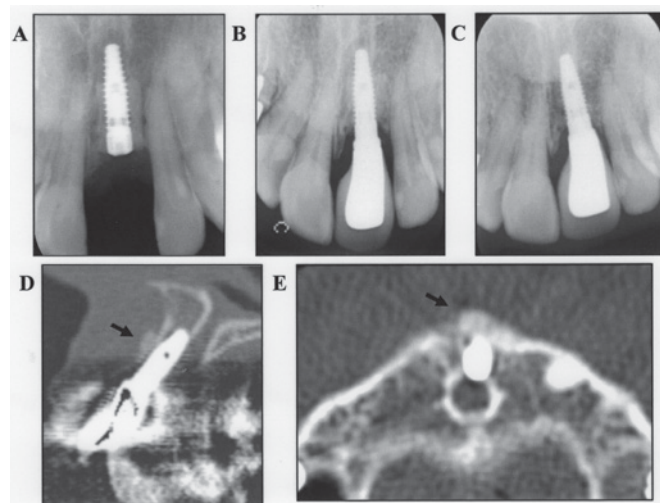


Figure 8. Dental radiograph and CT scan images after onlay block grafting. Dental radiograph obtained (A) immediately, (B) 10 months, and (C) 3 years 5 month after initial surgery. Reconstructed (D) sagittal and (E) axial CT scan images. An IP-CHA block was shown by arrows.

which may result in implant failure from osseointegration loss leading to reduced bone-to-implant contact and an unfavorable outcome.

Hydroxyapatite ceramics (HA) materials have been used as a substitute for bone grafting because the crystalline phase of natural bone is similar to that of HA (16,17), while porous calcium hydroxyapatite ceramics (CHA) materials have been utilized in orthopedic and craniofacial surgery procedures since the 1980s (18). However, few studies have reported cases in which conventional CHA became fully filled by newly formed bone, which may be due to its structure and limited connectivity between pores (19). IP-CHA consists of a porous sintered body made of hydroxyapatite ceramics with a unique pore structure, in which the pores are fully interconnected, likely allowing ingrowth of osteoblasts (20,21). Tamai *et al* (20) implanted cylindrical blocks made of IP-CHA into femoral condyles of rabbits, and observed mature bone ingrowth in most of the pores within 6 months. IP-CHA has adequate compression strength (10-12 MPa), similar to that of cancellous bone, and was shown to have IP-CHA increased compression strength up to 9 weeks after implantation, reaching approximately 30 MPa (20). It has also been reported that IP-CHA did not show active resorption in clinical applications (10). Since an

Table I. Reported applications of IP-CHA in oral and maxillofacial surgery cases.

A,

Case	Age (yrs)	Gender	Site	Region	Grafting method	Autogenous block bone graft
1	59	Female	Maxilla	Premolar and molar	Sinus floor augmentation	Cortical bone block (10x8 mm) from maxillary tuberosity
2	51	Male	Maxilla	Incisor	Onlay block bone grafting	Cortical bone block (10x15 mm) from mandibular ramus
3	51	Female	Maxilla	Incisor	Onlay block bone grafting	None

B,

Type of IP-CHA	Implant treatment (diameter x length mm)	(Refs.)
Granular type (1-2 mm)	3 implants placed (4.3x10, 4.3x13, 5.0x13)	(24)
Granular type (1-2 mm)	None	(25)
Block type (6x7x3 mm)	1 implant placed (4.3x10)	Present case

IP-CHA, interconnected porous hydroxyapatite ceramic.

IP-CHA block can be prefabricated into a specific size and shape to match the alveolar ridge of the patient, application as a substitute autogenous block bone graft for onlay grafting is possible. In the present study, we used an IP-CHA block to overcome disadvantages normally associated with an autogenous bone graft and obtained good results.

Recently, Doi *et al* (22) reported successful use of IP-CHA as a grafting material for implant treatment *in vivo*. They examined the effects on bone regeneration of an implant/IP-CHA complex placed directly into femur sockets of dogs as well as implant stability, and found no significant differences in regard to bone implant contact and ISQ values between the complex and control groups at 3-6 months after surgery. In our previous *in vivo* study, to examine whether an IP-CHA block could be applied as an onlay graft substitute, titanium implants were inserted into IP-CHA blocks placed on the cortical bone surface of the mandibular in rabbits. We observed high levels of new bone formation from the host bone in the pores of the IP-CHA as well as significantly increased ISQ values at 12 weeks after surgery (12). In the present case, the IP-CHA block became stabilized on the host bone, and no abnormal resorption was observed during a second operation performed 6 months after the initial operation. In addition, the ISQ value was increased as compared with that at the first operation. Together, these results show that an IP-CHA block can promote osseointegration from the surface of the host bone and periosteum, leading to osseointegration of the implant in host bone tissue.

Clinically, IP-CHA is widely used in the field of orthopedic surgery (10). Yoshikawa *et al* (10) and Shi *et al* (23) applied IP-CHA granules or blocks as bone substitute for treatment of 59 patients with benign bone tumors and 12 with cystic lesions

associated with rheumatoid arthritis, and reported that none of those patients showed any signs of inflammatory reaction, rejection, or infection, nor abnormal results in blood tests. More recently, IP-CHA has been used as an autogenous bone graft substitute in oral and maxillofacial surgery cases (24). We previously reported implant treatment and maxillary sinus floor augmentation performed with a granular type of IP-CHA in a female patient, and those results showed a sufficient amount of osseointegration in the implant fixture, while histological analysis indicated that IP-CHA granules have strong potential to induce bone growth (24). In that case, we collected an autogenous bone block (10x8 mm) from the maxillary tuberosity to prepare a graft comprised of a mixture of IP-CHA and cortical bone (Table I). We have also previously reported a clinical case of horizontal alveolar ridge atrophy following resection of a maxillary bone cyst, in which autogenous onlay bone grafting with IP-CHA granules was successfully used for prosthetic treatment (25). In that case, an autogenous block bone (10x15 mm) was collected from the mandibular ramus, and a granular type of IP-CHA was applied to fill gaps between an autogenous bone block and host bone in order to restore bone volume (Table I). When a granular type of IP-CHA is applied as a substitute for bone augmentation, a residual bone wall or additional materials, such as titanium mesh, are needed to ensure space maintenance of the granules. For the present case, we used an IP-CHA block for onlay grafting in implant treatment without autogenous block bone grafting (Table I). At a follow-up examination performed 3 years 5 month after initial placement, the IP-CHA block could be observed on the alveolar bone, and the gap between it and the host bone showed a smooth transition, suggesting that

IP-CHA improves integration with newly-formed bone tissue. At more than 5 years after the initial surgery, the implant and superstructure continued to show no problems. Application of an IP-CHA block can overcome disadvantages associated with autogenous bone block grafting, thus we consider it to be useful as a substitute for block bone grafting in patients undergoing implant treatment.

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