수산화인화석이 피복된 두 가지 형태의 임플란트 안정성에 관한 연구

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A study on the stability of two types of HA coated implants

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Abstract

Purpose: The purpose of this study was to compare the stability of two types of HA coated implants.
Material and methods: The experimental group was divided into two groups according to HA coating method. Dentis Haptite HA coated implant(super high speed resorbable blast media coating) and Zimmer implant (microtextured surface created by grit-blasting the machined titanium implant surface with HA particles) were installed to each group at various site from anterior teeth to posterior teeth, then the stability of them was evaluated and compared. The stability was assessed using Ostell and Periotest immediately, and bone resorption was measured using periapical radiograph at 6 weeks and 12 weeks after installation. Each measurement was compared and analyzed using paired t-test and Independent samples t-test
Result: According to measurement using Osstell and Periotest, both HA coated implant showed increased measurement as time flows. Comparing two types of HA coated implant, significant difference was not observed. And at periapical radiograph, the amount of bone resorption didn't show significant difference between two types of implant.
Conclusion: Two types of HA coated implant which installed at various site with excellent initial stability showed successful osseointegration.

Key words : : dental implant, hydroxyapatite, stability

I. Introduction

Intrabone implants that are widely used in the dental field have been used successfully for the restoration of single tooth loss and in partial edentulous patients and complete edentulous patients. Therefore, clinical applications are increasing gradually.[1,2] Branemark et al.[3] defined osseointegration as the direct contact of an implant surface with living bones at the level of the light microscope. Afterward, Albrectssonet et al.[4] defined it as implants and bone tissues obtaining firm fixation without the inclusion of fibrous connective tissues and simultaneously as bone being maintained under functional occlusion.

The osseointegration of implants is affected by implant materials, design, surface, bone conditions, surgical techniques, and loading conditions. Recent studies on dental implants are focused on surface treatment methods, and diverse efforts to improve clinical success rates by rendering implant surfaces advantageous for osseointegration and stability have been made[1,2,3,5].

Surface treatment methods include titanium plasma spray (TPS) and hydroxyapatite plasma spray(HA coating), which are methods that increase the surface area by removing a portion of the implant surface through microparticle blasting and acid etching[6]. The surface treatment methods that have been frequently used in clinical practice recently are Sandblasted large grit acid etching (SLA), Resorbable blast media (RBM), and hydroxyapatite (HA) coating. The SLA surface treatment method forms a large crater in the implant surface and subsequently renders the implant surface rough by forming additional small craters, which accelerates osseointegration[7]. Using histomorphological studies, Cochran[8] et al. have reported that SLA implants showed high ratios of bone-to-metal contact. RBM methods not only render the implant surface rough using blasting processes but also remove contaminants on the surface, and therefore, the early stability is improved by increasing the activity level of the metal surface[9].

HA coating is a method that attaches hydroxyapatite particles to the implant surface. It provides a level of biocompatibility as high as that found in natural bone grafts and shows increases in roughness. Thus, osteoblasts are attached better than on machine-cut surfaces. As a result, regeneration of the alveolar bone is induced, and accordingly, HA coating is effective for the recovery of alveolar bone[10-12].

However, HA-coated implants are known to result in a poor prognosis in long-term evaluations due to the problems of being released from the interface by HA shedding and dissolution. Recently, to overcome such problems, HA coatings have been deposited by a variety of methods[13].

In this study, in patients with implants that are coated with HA by different methods, implant stabilities according to implant methods were compared by assessing the measured value of Osstell and Periotest with time and the rate of bone resorption of the implant that was visible in the radiographs.

II. Materials and methods

Subjects

A total of 48 implants were placed in 34 patients (16 males and 18 females) who visited the Chosun University Dental Hospital from March 2009 to March 2012. The study was conducted on subjects who were healthy adult patients with edentulous areas in the maxilla and the mandible. Smokers, patients with uncontrolled metabolic diseases, patients with a compromised immune system, patients with psychiatric disorders, patients who had undergone radiation therapy, patients taking bisphosphonate, and pregnant women were excluded.

Materials

HA-coated implants, Haptite (Dentis Co., Ltd., Daegu, Korea) and Tapered Screw-Vents (TSV; Zimmer Inc., Warsaw, IN, USA), were used. Haptite implant was prepared at room temperature with a vacuum level of 10^{-2} 10^{-3} torr, and highly pure HA was coated on the surface of resorbable blasting media (RBM) using high-velocity techniques. When the room-temperature coating techniques were applied, the coating thickness was shown to be less than 2 μm. The TSV implant is an HA-coated implant in which the surface of the machined-surface implants was treated with grit-blasting of HA particles to generate the microtextu red titanium surface with a roughness in the medium level, and the center area of the implants was coated with HA by a pressurized hydrothermal post-plasma-spray process. For each each HA-coated implant method, 24 implants were placed in 16 patients with edentulous areas in the maxilla and the mandible.

Stability measurement methods

Implant placement was performed by a one-step surgical method. Osstell Mentor (Integration Diagnostics, Gothenburg, Sweden) and Periotest®(Siemens AG, Bensheim, Germany)measurements were performed immediately after placement, 6 months after placement and 12 months after placement, and then, periapical radiographs were taken. In the Osstell™ and Periotest measurements, the average of the values measured on the buccal side and the lingual side was used. To minimize errors in the evaluation, only a single surgeon participated. On the radiographs, the bone resorption rate with time was measured by the application of the average of the height of the mesiodistal bone. The measured values were analyzed by an independent-sample t-test using SPSS version 22.0 (SPSS Inc., Chicago, IL, USA). Cases with $P<0.05$ were considered to be statistically significant.

III. Results

In a total 34 patients, 24 Haptite implants and 24 TSV implants were placed by 1-step surgical procedures, and Osstell and Periotest measurements were performed immediately after placement, 6 weeks after placement and 12 weeks after placement (Tables 1 and 2). In the Haptite cases, when the values obtained immediately after placement and 6 months after placement were compared, the implant stability quotients (ISQs) of the OsstellanPeriotest values (PTVs) were not significantly different. In TSV cases, the PTVs were slightly increased ($P<0.05$). Nevertheless, 12 weeks after placement, both Haptite and TSV showed patterns in which the implant stability quotients and PTVs were significantly increased ($P<0.05$). When Haptite was compared with TSV, the average values measured immediately after placement, 6 months after placement, and 12 months after placement were slightly different, but statically significant differences were not shown.

On radiographs, the bone resorption rates at 6 months after placement and 12 months after placement were assessed by comparing their values with the value obtained immediately after placement. Bone resorption with time was not observed, and significant differences between Haptite and TSV were not observed ($P<0.05$, Table 3).

Table 1. ISQ (implant stability quotients) depending upon timing tested

	At installation	6 weeks	12 weeks
Haptite	66.56±10.70	69.96±5.15	75.67±11.61*†
TSV	69.58±9.89	73.26±5.39	77.58±6.00*†

* Statistically significant difference relative to installation group
† Statistically significant difference relative to the 6-week group
$P<0.05$
ISQ : stability test with Osstell Mentor (Integration Diagnostics, Gothenburg, Sweden)
Haptite : HA coated implant, Dentis Co., Ltd., Daegu, Korea
TSV : Tapered Screw-Vents, HA coated implant, Zimmer Inc., Warsaw, IN, USA

Table 2. PTV (periotest value) depending upon timing tested

	At installation	6 weeks	12 weeks
Haptite	0.10±4.43	-1.79±2.69	-3.64±1.90*†
TSV	-0.58±2.91	0.10±4.44*	-4.83±2.31*†

* Statistically significant difference relative to installation group
† Statistically significant difference relative to the 6-week group
$P<0.05$
PTV : stability test with Periotest® (Siemens AG, Bensheim, Germany)
Haptite : HA coated implant, Dentis Co., Ltd., Daegu, Korea
TSV : Tapered Screw-Vents, HA coated implant, Zimmer Inc., Warsaw, IN, USA

Table 3. PTV Mean bone loss on radiographs depending upon timing tested

	6 weeks	12 weeks
Haptite	0.26 mm ± 0.97	0.32 mm ± 1.33
TSV	0.31 mm ± 0.86	0.39 mm ± 3.38

*$P<0.05$
Haptite : HA coated implant, Dentis Co., Ltd., Daegu, Korea
TSV : Tapered Screw-Vents, HA coated implant, Zimmer Inc., Warsaw, IN, USA

IV. Discussion

In the early period of the development of implants, studies have been conducted primarily on the resorption of the jaw bone and on the shape and volume of the bone. Recently, the interest of clinicians has been focused on the design and surface structure of implants.[14,15] Buser et al.[16] et al. placed 6 types of implants with different surface structure characteristics in minipigs and reported that the osseointegration of the implants with irregular surfaces was higher than that of the implants with smooth surfaces; the surface characteristic of the implant exerted effects on local tissue reactions.[4,17] Similarly, Wennerberg et al.[9] have reported that implants were compared according to their surface, and the bone contact ratio and removable torque of implants with rough surfaces were higher. It has been reported that smooth surfaces are not suitable for cell attachment, but excessively rough surfaces cause ionic leakage and thus impede bone reactions. Hence, it is important to properly control the surface roughness. Implants with a rough surface that are used presently include titanium plasma spray (TPS), HA coating, acid (AE), sandblasted with large grit and acid-etched (SLA), and resorbable blast media (RBM).

Among them, the hydroxyapatite of the HA coating is a major mineral component of bones in vivo, its affinity to the bone surface is excellent, and HA binds to the bone directly. Thus, the strength of the interface between HA and the bone is strong. Because the physical strength of HA is weak, its use in implants that continuously experience occlusion forces is limited. De Groot et al.[18] thus suggested a method for thinly coating the titanium surface[19,20]. HA-coated implants contain crystalline HA, tricalcium phosphate (TCP), and amorphous calcium phosphate in abundance. Because implants contain more crystalline HA, the dissolution resistance becomes stronger. The surface coated with HA induces rapid bone deposition on the implant surface and thus shortens the healing period. It may improve the distribution of loading to adjacent bones by inducing better early fixation and increasing the rate of osseointegration[16,21-23].

However, HA-coated implants using plasma spraying methods resolved the physiological, immunological, and chemical stability problems of machined surface implants to a certain degree. However, because of the problems involving the chemical inhomogeneity of the coating layer, recession or resorption in vivo, low dynamic characteristics, and the low affinity to metals, implants that apply ion microfilm techniques have been developed[11-13].

The implants of Haptite and TSV used in our study were HA-coated using a super-high-speed resorbable blast media coating method and a pressurized hydrothermal post-plasma-spray process, so the content of HA was increased, the durability of the coating was improved, and the phenomenon of HA dissociation was decreased. This study was conducted to evaluate the clinical stability of the implants.

Reversible clinical methods for measuring the stability of the implant and the level of osseointegration are the percussion reaction, radiological tests, Periotest, Osstell, dental fine tester, thread cutting force, and reverse torque test[24,25]. Irreversible methods include a histomorphometric analysis, measurement of the insertion torque and removal torque, and push-through and pull-through tests[26]. In our study, the stability was evaluated by Osstell and Periotest measurements and by measuring the volume of bone resorption observed in the periapical radiograph. Periotest is a method that quantitatively measures the demagnify tendency of the alveolar ligaments around the tooth and presents the mobility numerically. Because PTVs may vary depending on the angle of the hand piece and the site to which impacts are delivered, attention should be paid to these factors during measurements[27,28]. By the application of Osstell, which uses Resonance Frequency Analysis (RFA), the change of the stiffness and stability of the interface of implants and adjacent tissues were assessed[26].

Friberg et al.[29] interpreted the reduction of the early stability of the implant as the result of bone compression caused by implant placement, mechanical bone relaxation, biological changes that occurred during the early bone healing process, and marginal bone absorption. Park et al.[25] have reported that in patients with placement of HA-coated implants, the change of the stability with time was measured by the application of resonance frequency analysis and that the stability showed a tendency to decrease up to 4-6 weeks. After 1-3 additional weeks, the stability increased again. In this study, in patients with implant placement, PTVs and ISQs were measured after the placement, and good early stability was shown. However, from the time point 6 weeks after placement, the PTVs and ISQs of patients who had Haptite implants did not change. In patients who had TSV implant placements, PTVs were shown to be increased. For early osseointegration, Haptite is considered to be more advantageous than TSV. After 12 weeks, in both Haptite and TSV, the PTVs and ISQs of the Osstell measurement were increased, and significant differences between the two groups were not observed. Hence, the stability of the two implants is considered to be sufficient.

On periapical radiographs, in both Haptite and TSV implants, bone resorption with time could not be observed, and the non-osseointegration of implants or the inappropriate connection of subjects was not observed. Nevertheless, radiological test methods are not accurate for the diagnosis of implants with failed osseointegration, and thus, even if the radiograph is normal, a more accurate evaluation of implant stability should be conducted together with various clinical evaluations.

V. Conclusion

To compare the implants of Haptite and TSV that are HA-coated by different methods, 24 implants were placed in the edentulous maxilla and the edentulous mandible in 34 patients. At 6 weeks and 12 weeks, using dental radiographs, the Periotest value (PTV), the ISQs of the Osstell measurement, and the volume of bone resorption were evaluated. The results show that at the time 6 weeks after implant placement, the PTV of the TSV implant was decreased in comparison with the time immediately after placement, and a statistically significant difference was revealed. Twelve weeks after implant placement, the stabilities of the Haptite and TSV implants were not different. In the measurement of the volume of bone resorption on periapical radiographs, reduction was not shown. Summarizing the results, the early stability of Haptite is better than that of TSV, but after the bone formation period, no significant difference is observed.

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