

COMPARISON BETWEEN TIUNITE™ AND ANOTHER OXIDIZED IMPLANT USING THE RABBIT TIBIA MODEL

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Statement of problem. Various anodic oxidation techniques can be applied to dental implant surfaces. But the condition for optimal anodized surfaces has not been described yet.

Purpose. The purpose of this investigation was to compare an implant that was oxidized by another method with TiUnite™ through resonance frequency analysis and histomorphometry.

Material and methods. Turned (control), TiUnite™ and another oxidized fixtures, which used Ca²⁺ solution for anodic oxidation, were placed in the tibiae of 5 New Zealand White rabbits. The bone responses were evaluated and compared by consecutive resonance frequency analysis once a week for 6 weeks and histomorphometry after a healing period of 6 weeks.

Results. At the first week, both oxidized implants showed significantly higher implant stability quotient (ISQ) values than the control. No significant differences in resonance frequency analysis were found between the two oxidized groups for 6 weeks. The means and standard deviations of bone-to-implant contact (BIC) ratios were 71.0 ± 4.2 for TiUnite™, 67.5 ± 10.3 for the Ca²⁺-based oxidation fixture, 22.8 ± 6.5 for the control. Both oxidized implants were significantly superior in osseointegration to the turned one. There was, however, no statistically significant difference between the two oxidized implants.

Conclusion. TiUnite™ and the Ca²⁺-based oxidation fixture showed superior early bone response than the control with respect to resonance frequency analysis and histomorphometry. No significant differences between the oxidized groups, however, were found in this investigation using the rabbit tibia model.

Key Words

Anodic oxidation, Surface modification, Dental implant, Resonance frequency analysis, Histomorphometry

Dental implants have been an excellent and popular treatment option in restoring singly, partially and fully edentulous areas. However, the dental implant material, commercially pure titanium itself requires much time for osseointegration. In order to achieve better and more rapid bone response to implant surfaces, various surface modifications have been introduced¹⁻³. Anodic oxidation is one of them.

Machined titanium implants with anodized poly-crystalline, thick oxide and a microporous roughness and structures on the submicro- and micrometer level (TiUnite™, NobelBiocare, Gthenburg, Sweden) have shown good experimental results⁴⁻⁶. But the optimum surface chemistry about anodic oxidation has not been confirmed and is still under study⁷⁻⁸. In another oxidized implant, which used Ca²⁺ solution for anodic oxidation (Osstem Co., Pusan, Korea), the chemical composition of the solution and other conditions for oxidation are known to be slightly different from those of TiUnite™ although the exact formulation including voltage and current is not known. The surface properties of the oxide such as thickness, microstructure, and composition depend on different process parameters including electrolyte composition, anodic potential, electric current, temperature, and electrode geometry⁹. The purpose of this investigation is to test and compare biocompatibilities between two differently oxidized dental implants using the rabbit tibia model.

MATERIAL AND METHODS

Thirty threaded and turned titanium (grade IV) dental implants with a length of 7 mm and a diameter of 3.75 mm were used in this study. The implants were divided into 3 groups: TiUnite™, the Ca²⁺-based oxidation, and turned (control)

implants.

This investigation using animals was approved by the Animal Research Committee of Seoul National University (approved number: SNU-061003-1) and all experimentation was done in accordance with the Institute of Laboratory Animal Resources (ILAR) guidelines of Seoul National University (SNU). Five New Zealand White rabbits, weighing 3.0 to 3.5 kg, were used in this investigation. 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. Three types of implant were installed at each tibia. The implants penetrated the first cortical layer only, with two 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.

Huang et al¹⁰ concluded that resonance frequency analysis (RFA) was a reliable and accurate method for early assessment of the osseointegration process with respect to implant stability. For RFA, the rabbits were anesthetized with the same method above once a week for six weeks. The

suture silk was removed and only the skin was dissected. Then, implant stability quotient (ISQ) values were measured by Osstell™ (Integration Diagnostics Ltd., Gteborgsvgen, Sweden). The skin was resutured with silk after measurement.

At the sixth week, all the rabbits were anesthetized, the ISQ values were measured and then the rabbits were sacrificed in a carbon dioxide chamber. The fixtures were 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 Donath¹¹. The specimens were ground to an approximate thickness of 30 μm and stained with hematoxylin and eosin (HE-staining). An IBM personal computer connected to an Olympus BX microscope (Olympus, Tokyo, Japan) and image analysis software (Image Analysis, Bildanalysis, Stockholm, Sweden) was used for calculating the percentage of bone-to-implant contact (BIC). All light microscopic calculations were made with a 10 objective and 10 eyepieces. The highest percentage of BIC in the two consecutive threads was calculated.

The statistical significance of the differences in RFA and BIC ratio among the groups was assessed by one-way ANOVA and Scheffe's

post hoc analysis. Values of P < .05 were considered to be statistically significant.

RESULTS

All rabbits recovered from anesthesia. Slight inflammation at skin was found during the measurement for RFA but neither inflammation nor infection of the bone was noted.

Fig. 1 shows the means of ISQ values for each implant group. The ISQ values for TiUnite™ kept increasing for 6 weeks while those for the control group decreased at the first week of healing (Fig. 1 and Table I). Both the anodized implants showed significantly higher ISQ values than the control at the healing period of the first week (P < .05). There was almost no significant differ-

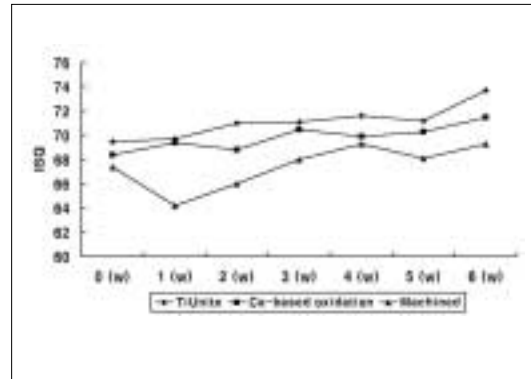


Fig. 1. The means of ISQ values for each implant group.

Table I. The means and standard deviations of ISQ values for each group

Week(s)	TiUnite™	Ca ²⁺ -based oxidation	Turned
0	69.5 ± 1.3	68.4 ± 2.6	67.4 ± 3.0
1	69.7 ± 1.4	69.4 ± 1.1	64.2 ± 6.3
2	71.0 ± 1.8	68.8 ± 2.3	66.0 ± 5.7
3	71.1 ± 2.7	70.5 ± 1.8	68.0 ± 3.2
4	71.6 ± 3.2	69.9 ± 1.9	69.3 ± 2.2
5	71.2 ± 3.0	70.3 ± 2.7	68.1 ± 2.9
6	73.7 ± 3.7	71.5 ± 2.2	69.3 ± 2.6

Table II. The means and standard deviations of BIC ratios for each group

	TiUnite™	Ca ²⁺ -based oxidation	Turned
BIC ratio (%)	71.0 ± 4.2	67.5 ± 10.3	22.8 ± 6.5

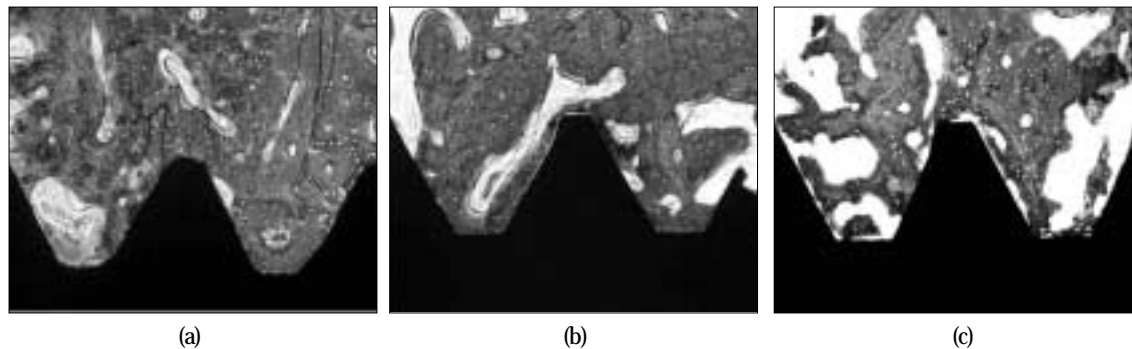


Fig. 2. Histologic views at 100 magnification for each implant group: (a) TiUnite™ (b) Ca²⁺-based oxidation (c) Turned.

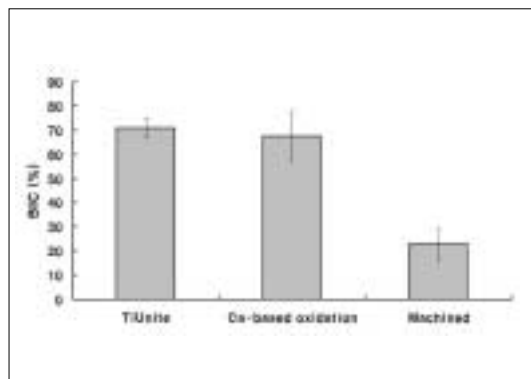


Fig. 3. The means and standard deviations of bone-to-implant contact ratio for each implant group.

ence between TiUnite™ and the Ca²⁺-based oxidation fixtures. However, because TiUnite™ showed significantly higher ISQ values than the control ($P < .05$) at the second and sixth weeks, while the Ca²⁺-based oxidation and the control implants showed no significant difference, TiUnite™ was considered to be slightly superior in RFA to the Ca²⁺-based oxidation fixture although nei-

ther of the anodized groups was found to be significantly different in resonance frequency measurements from each other.

The means and standard deviations of bone-to-implant contact (BIC) ratios were 71.0 ± 4.2 for TiUnite™, 67.5 ± 10.3 for the Ca²⁺-based oxidation group, and 22.8 ± 6.5 for the control (Fig. 2 and Table II). TiUnite™ and the Ca²⁺-based oxidation fixtures showed better osseointegration ($P < .05$) than the turned implant (Fig. 3). There was no significant difference in BIC between the two anodized groups.

DISCUSSION

The resonance frequency analysis told that TiUnite™ was superior in early implant stability and maintenance of it. The Ca²⁺-based oxidation implant showed similar but more various results than TiUnite™ although both the anodized implants reported better resonance frequency values than the control group. Slightly fluctuat-

ed ISQ values were reported in the Ca²⁺-based oxidation fixture, which indicated such an implant system can have a problem in early bone response and achieving proper stability. More investigations about biocompatibility, implant designs and surface characteristics seem to be required.

Although the means and standard deviations of BIC ratios were slightly different maybe because of the differences in experimental conditions and healing periods, this investigation reported the results that were similar to those of others⁵⁻⁶. Both the anodized implants showed similar bone-to-implant contact ratios that were significantly superior to the control after six weeks of healing. For RFA, however, TiUnite™ was thought to be better than the Ca²⁺-based oxidation group, considering ISQ value-comparisons with the control in spite that there was no significant difference between the two oxidized implants, as mentioned above. Implant stability is an important factor for implant success. Some authors^{10,12-13} reported that osseointegration was related to implant stability. But this experiment indicated that other factors than surface modification can be important to keep the fixture stable. Sul, et al⁸ discussed various conditions for anodic oxidation and tried to find the optimum surface properties of oxidized implant because surface characteristics of dental implants directly influenced osseointegration. Therefore, more studies about factors to contribute to implant stability, optimal surface properties of anodic oxidation and the relation between surface characteristics and clinical meanings are needed.

CONCLUSION

This *in vivo* investigation concluded the following:

1. For RFA, the ISQ values for TiUnite™ kept increasing for 6 weeks while those for the

control group decreased one week after installation. At the first week of healing, both the oxidized implants showed significantly higher ISQ values than the machined one, which meant superior early stability. However, at the sixth week, TiUnite™ was considered better than the Ca²⁺-based oxidation fixture, considering ISQ value-comparisons with the control although there was no significant difference between the two oxidized implants.

2. For histomorphometry, the means and standard deviations of BIC ratios were 71.0 ± 4.2 for TiUnite™, 67.5 ± 10.3 for the Ca²⁺-based oxidation group, and 22.8 ± 6.5 for the control. TiUnite™ and the Ca²⁺-based oxidation implants showed significantly higher BIC ratios than the turned implant. No significant difference was found between the two oxidized groups.

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