Evaluation of surface treated implant with nanotitania

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Evaluation of surface treated implant with nanotitania

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This certifies that the dissertation of
Bolortsog Oyunbat is approved.

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Did not forget you've done to reciprocate the love and grace will make an effort to make of Oral and Maxillofacial Surgeon.

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Bolortsog Oyunbat

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ABSTRACT

Evaluation of surface treated implant with nanotitania

Dental implants are valuable devices for restoring lost teeth. Implants are available in various shapes, sizes and length using a variety of materials with different surface properties. At this moment, nanotechnology has emerged with several techniques to modify implant surfaces. In addition, some evaluation techniques at the nano level are contributing important information regarding tissue and cell interactions with the implanted material. Increased knowledge of the early healing events at the nano level may help to understand the sequence of events at bone-implant interfaces and provide guidelines for the further development of osseointegrated implant surfaces.

The purpose of this study was to analyze and compare the bone responses to 3 different types of 4.1-mm-diameter, 10mm-long implant surfaces on a dog femur model: 1) Sand blasted with alumina and Acid etched (SA), 2) Resorbable blast media (RBM), functioning as

control groups, and 3) Anode oxidation nano-titana (Anodized TiO_2) surface implants as experimental group.

Implants were placed in the femurs of 3 adult male dogs. Eight weeks after the surgical placement of the implants, the animals were sacrificed.

After this period, the animals were sacrificed, and the femurs were extracted and histologically processed to obtain decalcified sections. Computed tomography images of each sample were obtained and two-dimensional bone density was analyzed using Dataviewer program. Two longitudinal ground sections were made for each implant and analyzed under light microscopy coupled to a computerized system for histomorphometry. Removal torque was only evaluated in the 4 and 8-week experimental groups.

A histological evaluation of the specimens in this study showed that osseointegration was achieved for all control and experimental group after a healing period of 4 and 8 weeks. The following means were obtained for bone-implant contact (BIC) percentage for 4 and 8-week groups, respectively: SA: 85.16%, 38.88%; RBM: 41.62%, 58.87%; and Anodized TiO_2: 43.85%, 61.3%. The following means were obtained for bone volume (BV) percentage for 4 and 8-week groups, respectively: SA: 34.48%, 51.55%; RBM: 58.56%, 81.56%; and Anodized

TiO_2: 47.22%, 63.53%.

In this study, 8-week consolidated Anodized TO_2 surface implants showed increased removal torque value (RTV) compared to that of the 4-week group. The obtained RTV means were 86.0 and 99.7Ncm, respectively, for 4 and 8-week Anodized TiO2 implants.

The present study showed that osseointegration occurred in all investigated types of surface-treated implants. However, the control groups showed slight increase in the BIC and BIV values compared to those of the experimental groups.

Key words: implant surface, torque, histology, osseointegration, beagle, femur.

Evaluation of surface treated implant with nanotitania

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I. INTRODUCTION

Osseointegration implies a direct structural and functional connection between living bone and the surface of an implant (Bra°nemark, 1985). Formation and maintenance of this direct contact between an implant and its surrounding bone is a determining parameter for clinical success.

Regarding the knowledge that above mentioned implant features significantly influence the formation of bone at implant surfaces, several methods were introduced to alter the surface topography4: coating by plasma spraying, abrasion, blasting, blasting and etching, anodizing, cold working, sintering, magnetron sputtering, electropolishing and laser preparation (Cooper et al., 2000). Many studies have attempted to enhance the osseointegration of implants by various surface modifications (Hayashi et al.,1994; Piatelli et al., 1995; Wong et al., 1995; Chehroudi et al., 1997; Wennerberg et al., 1998; Lazzara et al., 1999; Martinez et al., 2001).

Many researchers have found that the response of cell and tissue to the surface of the implant is affected not only by the chemical properties, but also the surface topography or roughness. Shalabi et al. (2006) described the possibility of an existent positive correlation between surface roughness and bone-to-implant contact. Therefore, there were many efforts to modify titanium implant surface to achieve better tissue responses.

When the surface topography of an implant is altered, its surface chemistry is also altered. Cell behavior is not dependent on topography alone; surface topography and chemistry are inseparable.

In the investigation of bone tissue reactions to various surface oxide properties, previous studies have shown that bone-forming cells is critically influenced by nanoscale TiO_2 surface topography with a specific response to nanotubes with diameters between 15 and 100nm (Bauer and Park, 2006; 2007). Oh et al. (2005) cited that TiO_2 nanotube arrays and associated nanostructures were able to be useful as the well-adhered bioactive surface layers on Ti implant metals and alloys for orthopedic and dental applications. Karlsson et al. (2003) suggested that the anodized nano-porous alumina membranes seem to provide better surface for osteoblastic cell growth, increasing cells spreading, flattening and firm adherence to the surfaces of the materials.

The purpose of this study was to compare and analyze BIC (Bone-to-implant contact) and BV (Bone volume) and the histological characteristics of nano-treated (Nano Titania) and micro-treated implants placed on femurs of dogs.

It was hypothesized that the nano titania implant provides a sufficient primary stability and that the limited initial bone-to-implant contact at the marginal implant part could allow a faster osseointegration compared to implants with modified surfaces.

II. MATERAL AND METHODS

1. Experimental animals and material

For this study, implants were placed in 3 beagle dogs (age, 18 months; weight, 11-14 kg). Their purchase, selection, management, and experimental procedure were carried out according to established conditions by the Department of Laboratory Animal Medicine, Medical Research Center, Medical College of Yonsei University.

Nineteen turned screw-shaped implants with 3 different surfaces (4.1mm in diameter, 10mm in length) were made from commercially pure titanium (grade IV). Thirteen implants were placed in each beagle dogs no. 1 and 2 and six implants were placed in the remaining beagle dog. Implants placed in beagle dogs no. 1 and 2 underwent histology analysis, X-ray and CT taking, and analysis of relative bone mineral density with Dataviewer program. While removal torque was measured in the implants placed in beagle no. 3 after a healing period of 4 and 8 weeks.

2. Surface characteristics of the fixture

2.1 Control group

A) Three implants with sand blasted with alumina and acid etched (TS III SA) surface (Osstem, Busan, Korea) (TS3S4010S) (Ra: 2.5-3.0μm).

B) Three implants with resorbable blast media (RBM) surface (PrimaConnex® , Keystone Dental, Inc., Middlesex Turnpike Burlington, USA) (15617K).

2.2 Experimental group

C) Thirteen implants with Anode oxidation nano-titana (TiO_2) surface (P25 coating fixture, Korea) (Ra: 0.8-2.5μm) (Figure 1 and 2).

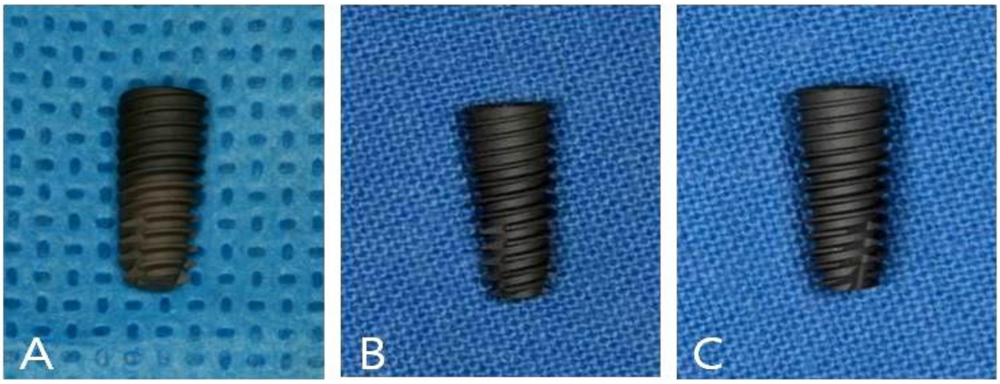

Figure 1. Implant design. Three fixtures with different treated implant surfaces

- **A.** **Osstem TS III SA** (Sand blasted with alumina and Acid etched surface) (SA)
- **B.** **PrimaConnex®** (Resorbable blast media surface) (RBM)
- **C.** **P25 coating fixture** (Anode oxidation nano-titana surface) (Anodized TiO_2)

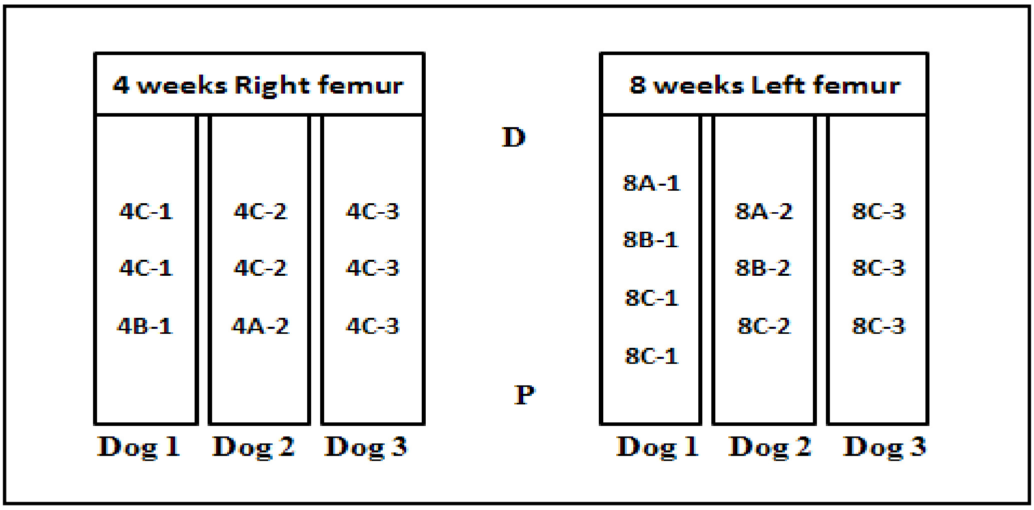

Figure 2. Study design according to consolidation period (4-week and 8-week), implant type (A, B, C), beagle dog number (1, 2, 3), (D –Distal, P – Proximal).

3. Methods

A. Surgical procedures and implant placement

Surgical interventions were conducted under general anesthesia by intramuscular injection of an anesthetic cocktail composed of Zalazepam (Zoletil® , Virbac, Carros, France , 5mg/kg) and Xylazine (Rompun® 2%, Bayer, Kiel, Germany, 0.2mg/kg). The anesthesia was maintained with 2% enflurance, and each animal's was with an electrocardiogram and monitored. Before placing the implant the local area was infiltrated with 2% hydrochloric acid lidocaine containing 1:100,000 epinephrine. Hind legs were prepared in the standard sterile fashion.

The flat surface on the lateral aspect of the proximal femur was selected for the implant placement. The skin incision was performed to expose the lateral aspect of femur, muscles were dissected to allow elevation of the periosteum and then implant sites were prepared.

For implant insertion the INTRAsurg300® (KaVo, Kaltenbach & Voigt GmbH & Co. KG, Biberach) motor was used. The surgical site was closed in layers with resorbable suture materials (3-0 POLYSORBTM, Tyco Healthcare USA) (Figure3).

B. Animals sacrifice

Eight weeks after the surgical placement of the implants, the animals were sacrificed. From each femur a 8x10cm bone segment with the inserted implants were collected and fixed in a 10% buffered formalin (pH 7.4) for 48 hours.

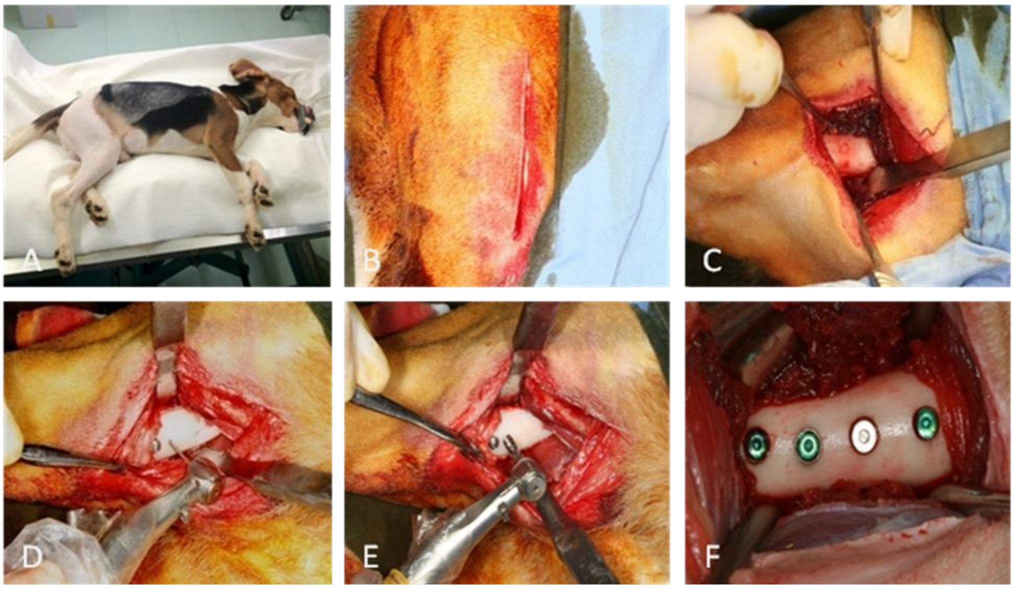

Figure 3. Surgical preparation and implant placement.

C. Plain radiography and Micro-CT imaging.

Standard plain radiography (60kV, 70mA and exposure time of 0.08s) was obtained from all specimens. In addition, micro computer tomography (Micro-CT, SkyScan 1076, Belgium) with a resolution of 18μm, 100kV, 100μA, 0.05mm aluminum filter, exposure time of 1475 ms and 0,500/360 rotation step. Bone density was analyzed with Dataviewer Program (1.4.4 32-bit, SkyScan, Kontich, Belgium) after two-dimensional analysis of all images. Obtained results from all specimens were analyzed and compared.

D. Preparation of specimens and the histological analyses

The retrieved specimens were processed to obtain thin ground sections according to the cutting-grinding technique described by Donath et al. (1982) with slight modifications. Specimens were infiltrated with resin from a starting solution of 50% ethanol/resin and subsequently 100% resin, with each step lasting 24 hours. Final photopolymerization of the resin was achieved during a 48-hour exposure to blue-light. After polymerization, the blocks were ground to remove the excess resin and to expose the implant-bone areas. The specimen blocks were attached to plastic slides using a methacrylate-based adhesive.

The samples were serial sectioned with a flat diamond saw (Maruto, Japan) by a cutting hard tissue grinding system (Maruto, Japan) to 100-110 μm. Then the sections were hand-ground with diamond disks to the final thickness of approximately 25-50 μm for subsequent analyses. In this manner, 3 to 4 sections were obtained per femur resulting in a total of 13 sectioned slides, which were stained with hematoxylin and eosin for histological analysis with an optical microscope and measurement of bone volume (BV) and bone to implant contact (BIC) using an automated image analysis program (IMT iSolution Lite Version 8.1, Walter Gage Rd., Vancouver, BC, CANADA).

E. Removal torque values measurement

Removal torque was measured and compared to installing torque in the implants placed in beagle no. 3 after a healing period of 4 and 8 weeks. Removal torque values were measured with a torque measurement device (MGT12, ELECTROMATIC Equipment, NY, USA) (Figure 4).

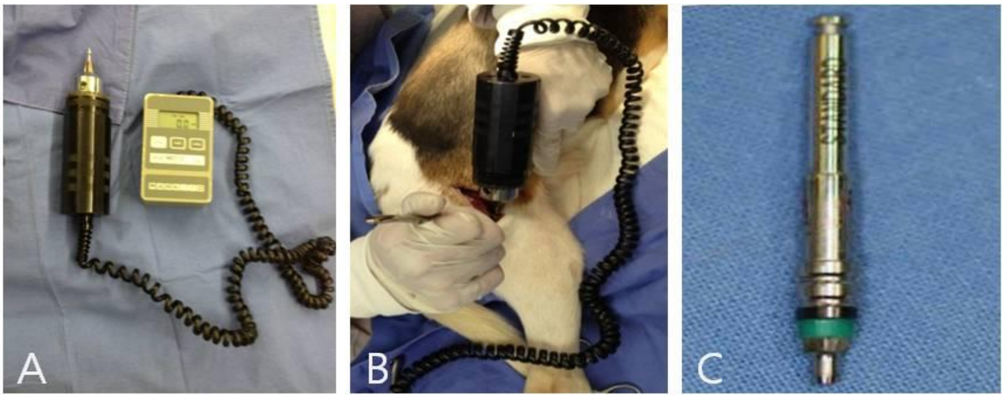

Figure 4. A. Removal torque measurement device (MGT12, ELECTROMATIC Equipment, USA). **B.** Mount holder of the removal torque measurement device connected to the inserted implant during evaluation of removal torque force. **C.** Image of the mount holder unattached to the measurement appliance.

III.RESULTS

1. Gross findings

(1) 4 weeks

Healing was uneventful following device installation in all 3 dogs and for all 19 implant insertion sites. No infection arose during the observation interval as well. During the extraction of all specimens the periosteum was strongly attached to the femur bone and any implant loosening was not observed. (Figure 5)

(2) 8 weeks

During the extraction of all specimens the periosteum was strongly attached to the femur bone and any implant loosening was not observed. (Figure 6)

(3) 4 and 8 weeks

Anodized TO_2 surface group, removal torque value was increased at 8 weeks compared to at 4 weeks. No infection arose during the observation interval in 4 and 8 weeks. (Figure 7)

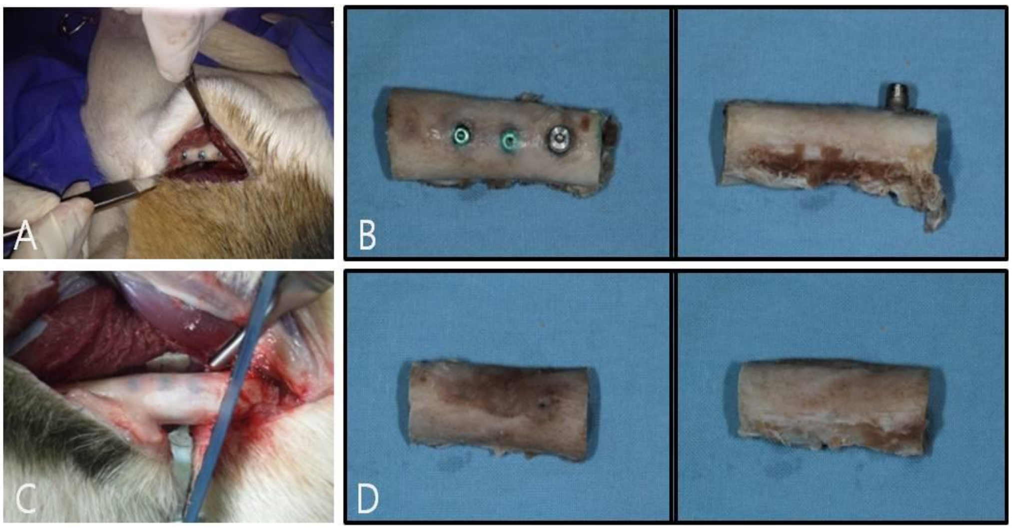

Figure 5. Gross findings of right beagle femur (Beagle No. 1 and No. 2) after a 4-week consolidated period. Refer to Fig.2 for labeling details.

- **A.** Beagle No. 1. Operated site (right femur) after 4-weeks of implant insertion.
- **B.** Beagle No. 1. Specimen (right femur) after 4-weeks of implant insertion.
- **C.** Beagle No. 2. Operated site (right femur) after 4-weeks of implant insertion.
- **D.** Beagle No. 2. Specimen (right femur) after 4-weeks of implant insertion.

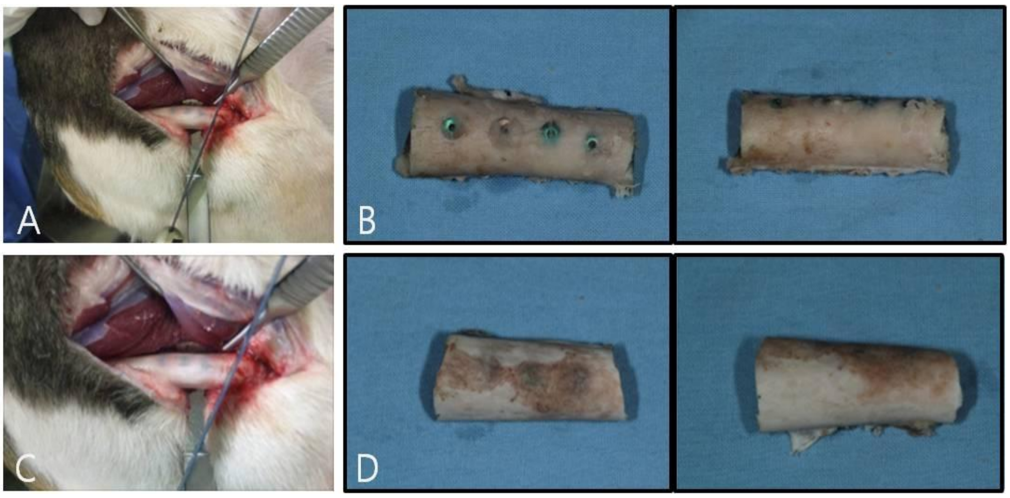

Figure 6. Gross findings of left beagle femur (Beagle No. 1 and No. 2) after a 8-week consolidated period. Refer to Fig.2 for labeling details.

- **A.** Beagle No. 1. Operated site (left femur) after 8-weeks of implant insertion.
- **B.** Beagle No. 1. Specimen (left femur) after 8-weeks of implant insertion.
- **C.** Beagle No. 2. Operated site (left femur) after 8-weeks of implant insertion.
- **D.** Beagle No. 2. Specimen (left femur) after 8-weeks of implant insertion.

Figure 7. Gross findings of Beagle No. 3 at the end of consolidation period. Refer to Fig.2 for labeling details.

- **A.** Operated site (right femur) after 4-weeks of implant insertion. Images of right femur before and after evaluation of removal torque force.
- **B.** Operated site (left femur) after 8-weeks of implant insertion. Images of left femur before and after evaluation of removal torque force.

2. Radiographic findings

2.1 Plain radiography

(1) 4 weeks

On plain radiography all implants were stable in position. No bone loss around the implants was observed. (Figure 8)

(2) 8 weeks

As well as the 4-week groups all implants were stable in position. (Figure 8)

2.2 Micro-Computed tomography image

(1) 4 weeks

As with the plain radiography findings of both control and experimental groups, a good union between bone and implant treated was noticed. No bone loss around the implants was observed. (Figure 9)

(2) 8 weeks

As with the plain radiography findings of the control and experimental groups, similar findings were noticed as the 4-week groups. However, compared to the 4-week group, an increased bone mineral density among the implant treated was characteristic. (Figure 9)

3.1 Bone density

CT images of each sample were obtained and two-dimensional bone density was analyzed using Dataviewer program. The program in the analysis between four weeks and eight weeks not show significant differences in bone mineral density in all implants (Figure 10, 11, 12, 13, 14).

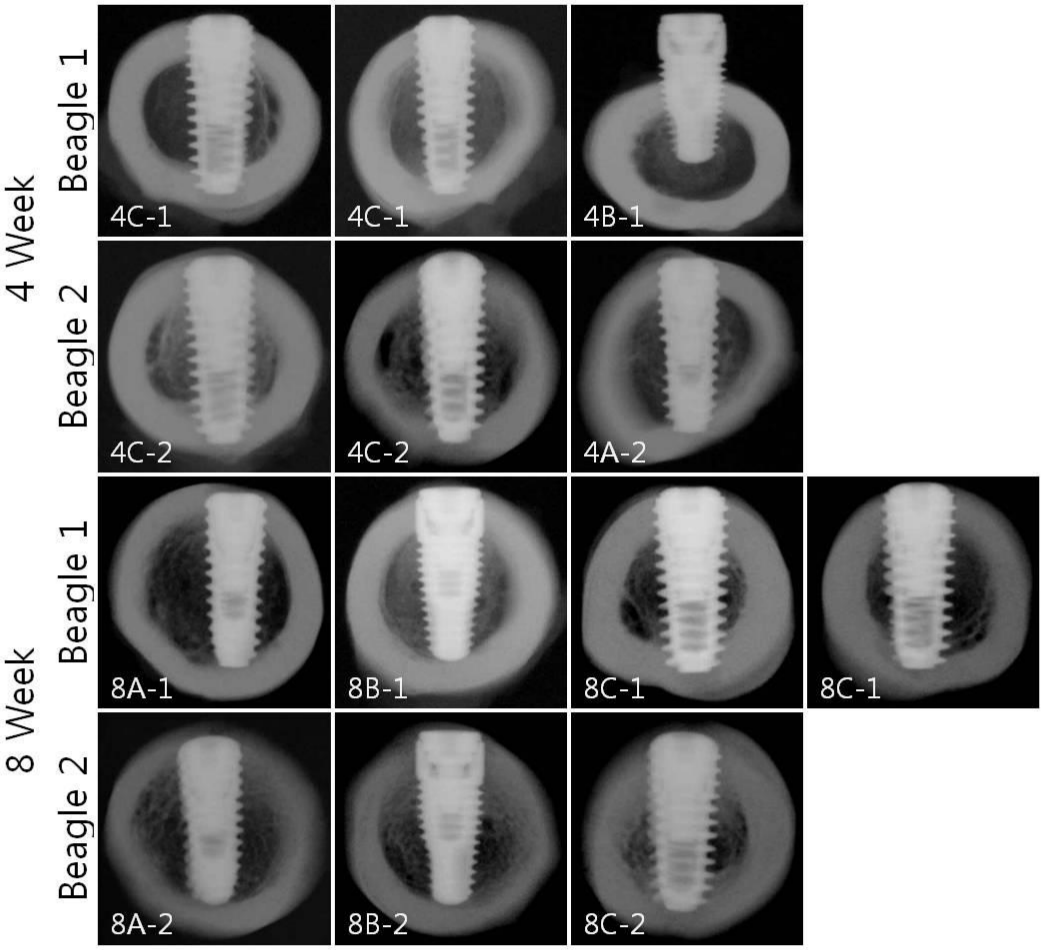

Figure 8. Radiographic (plain X -ray) findings

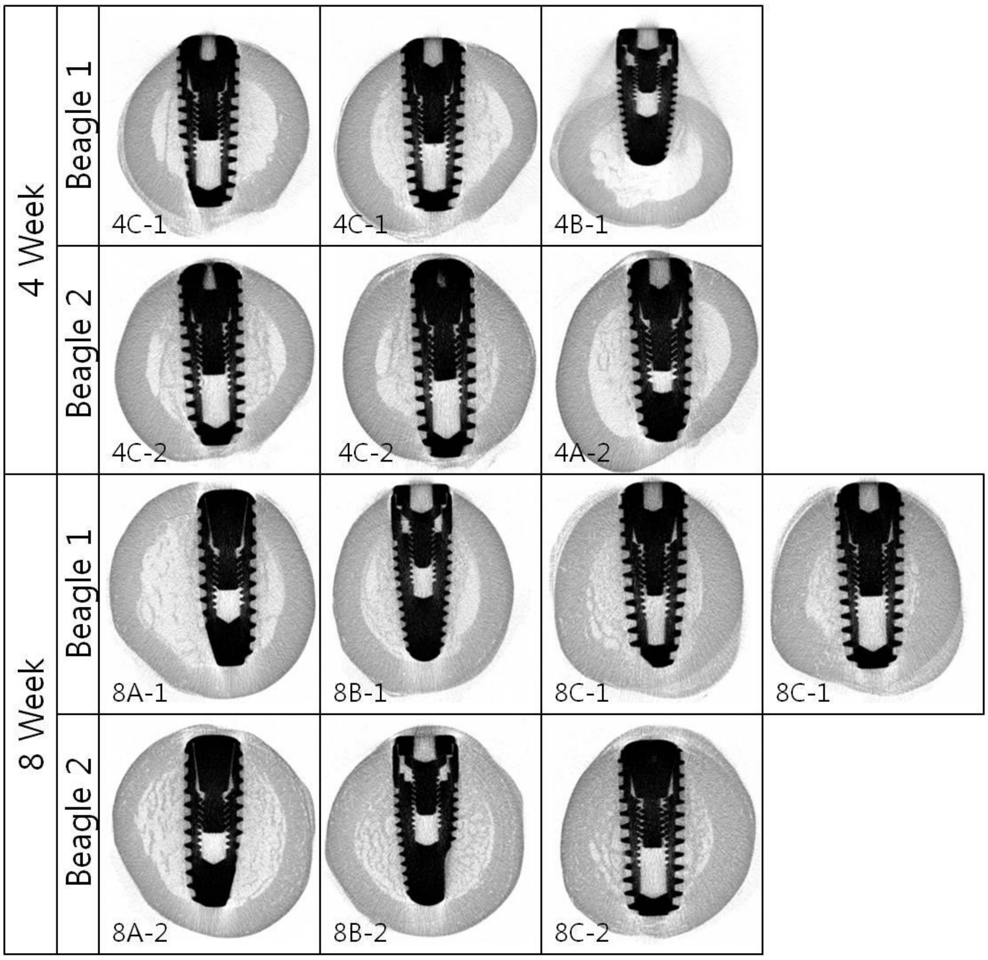

Figure 9. Radiographic (Micro –CT image) findings

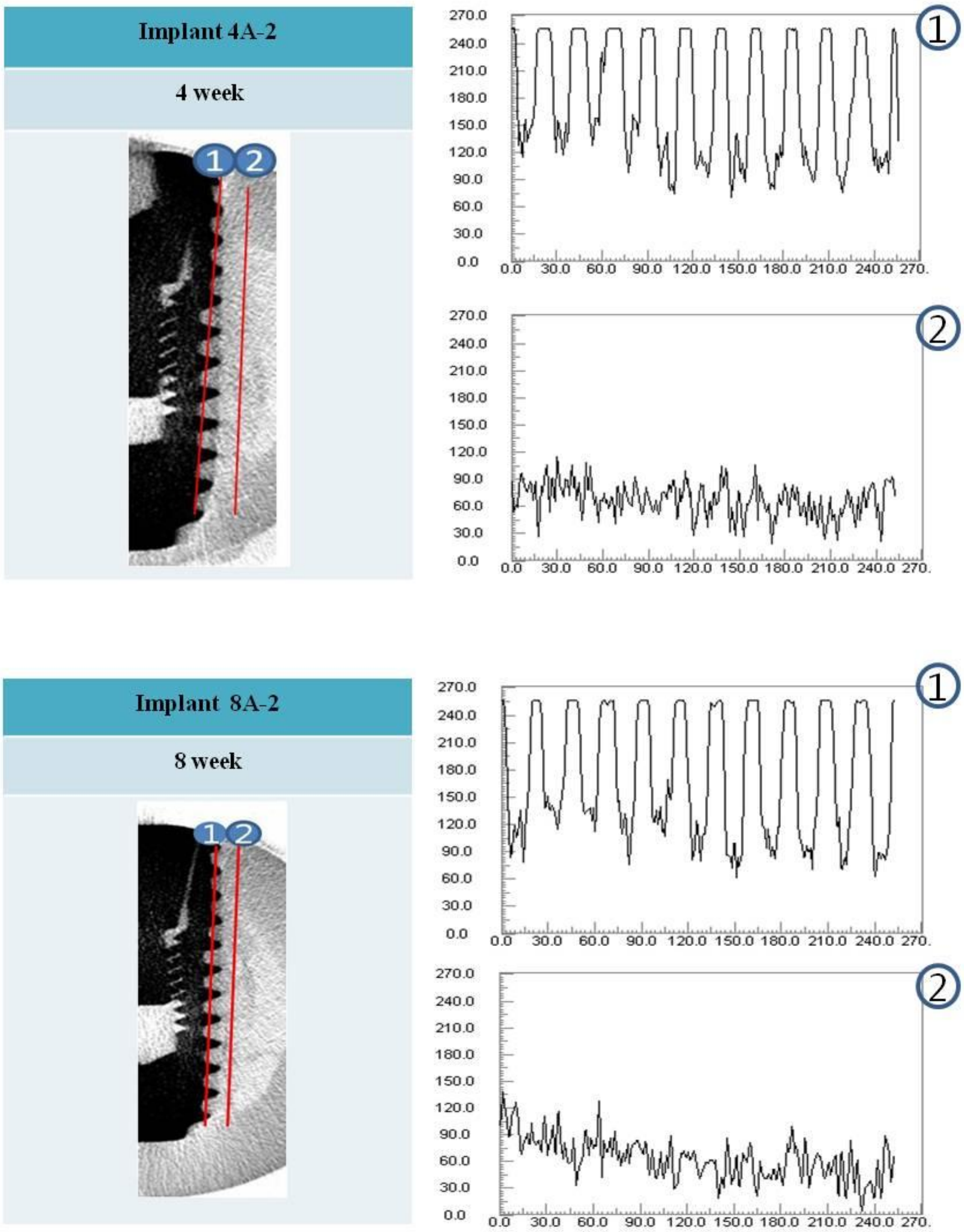

Figure 10. Comparison of bone density (implant 4A-2; 8A-2)

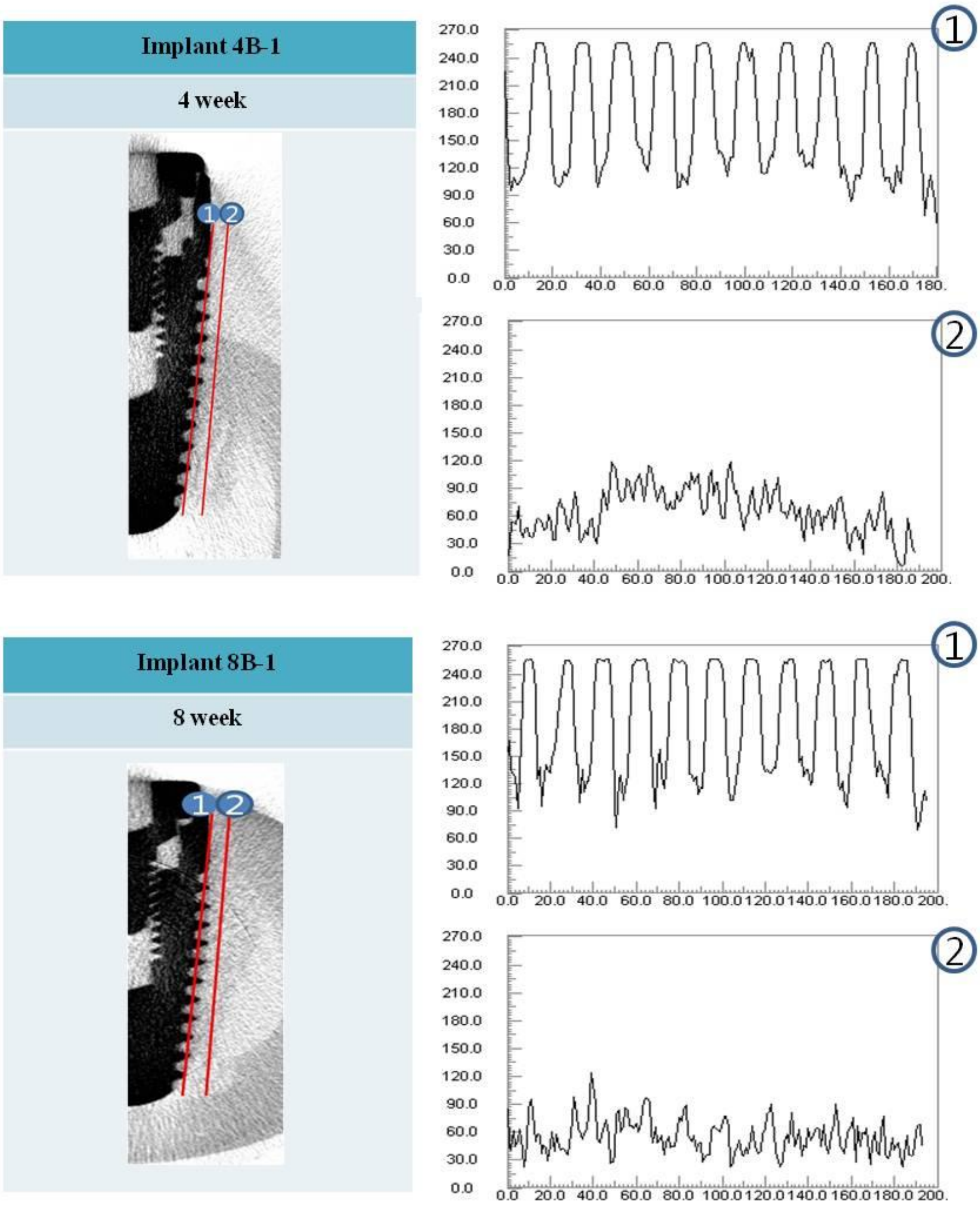

Figure 11. Comparison of bone density (implant 4B-1; 8B-1)

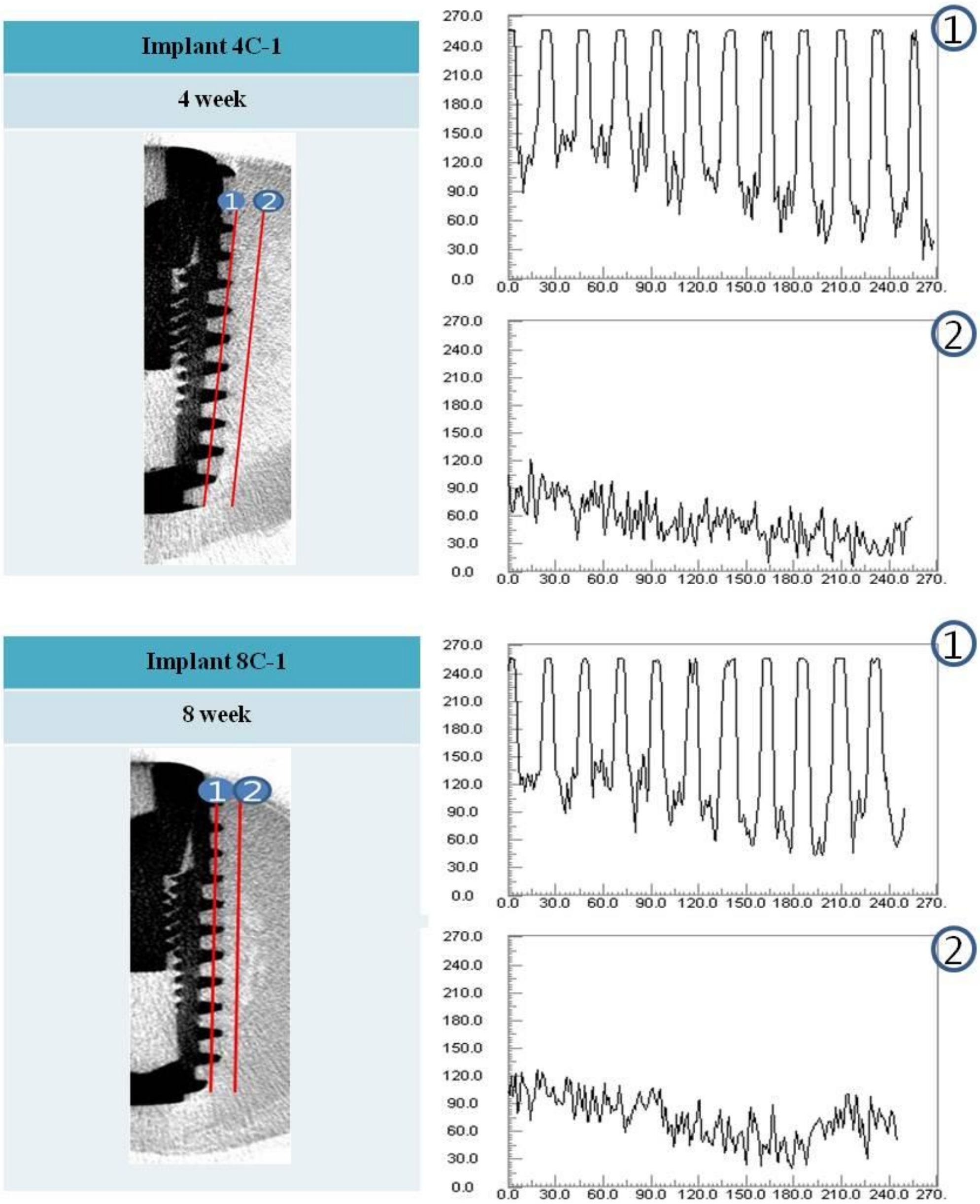

Figure 12. Comparison of bone density (implant 4C-1; 8C-1)

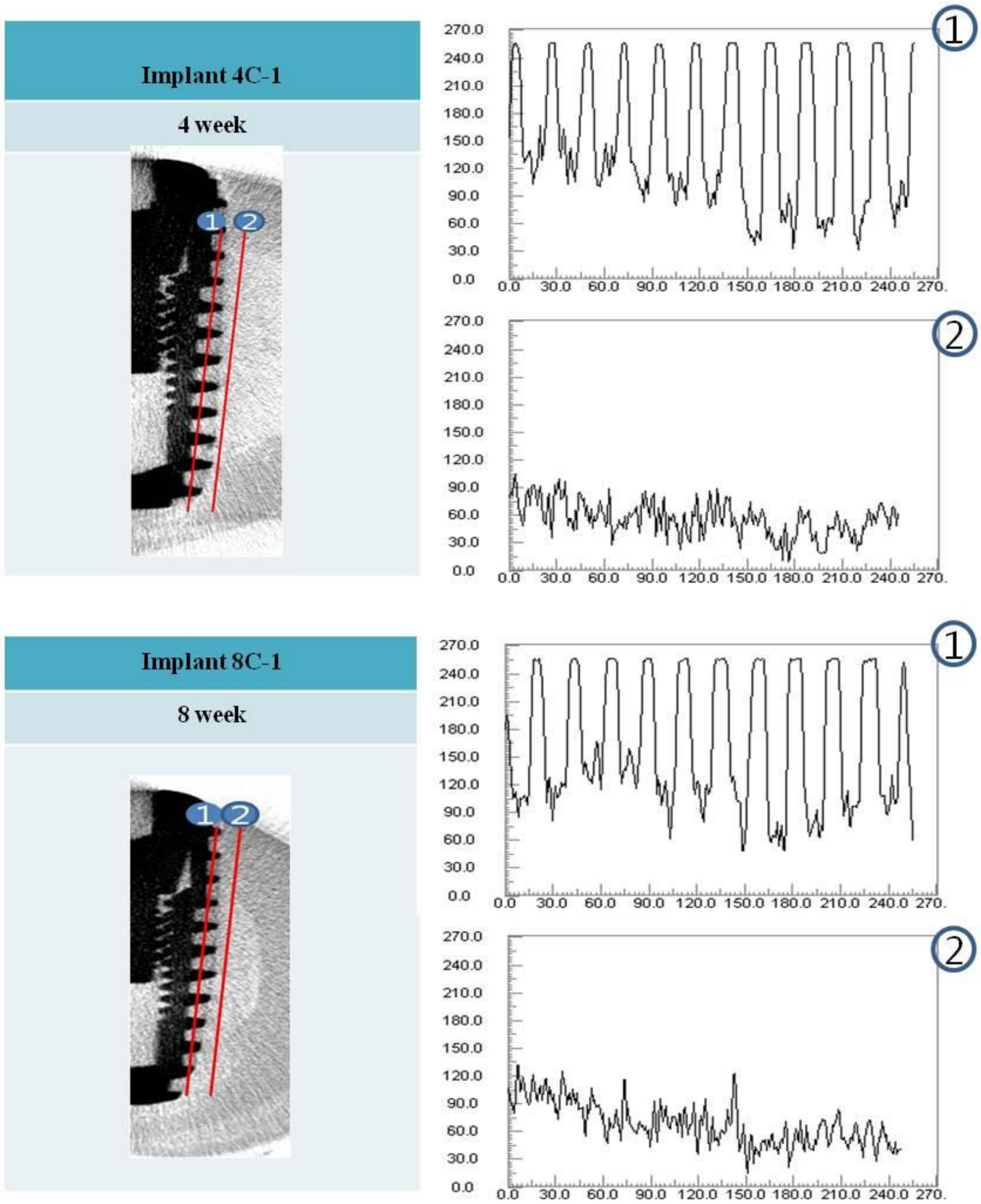

Figure 13. Comparison of bone density (implant 4C-1; 8C-1)

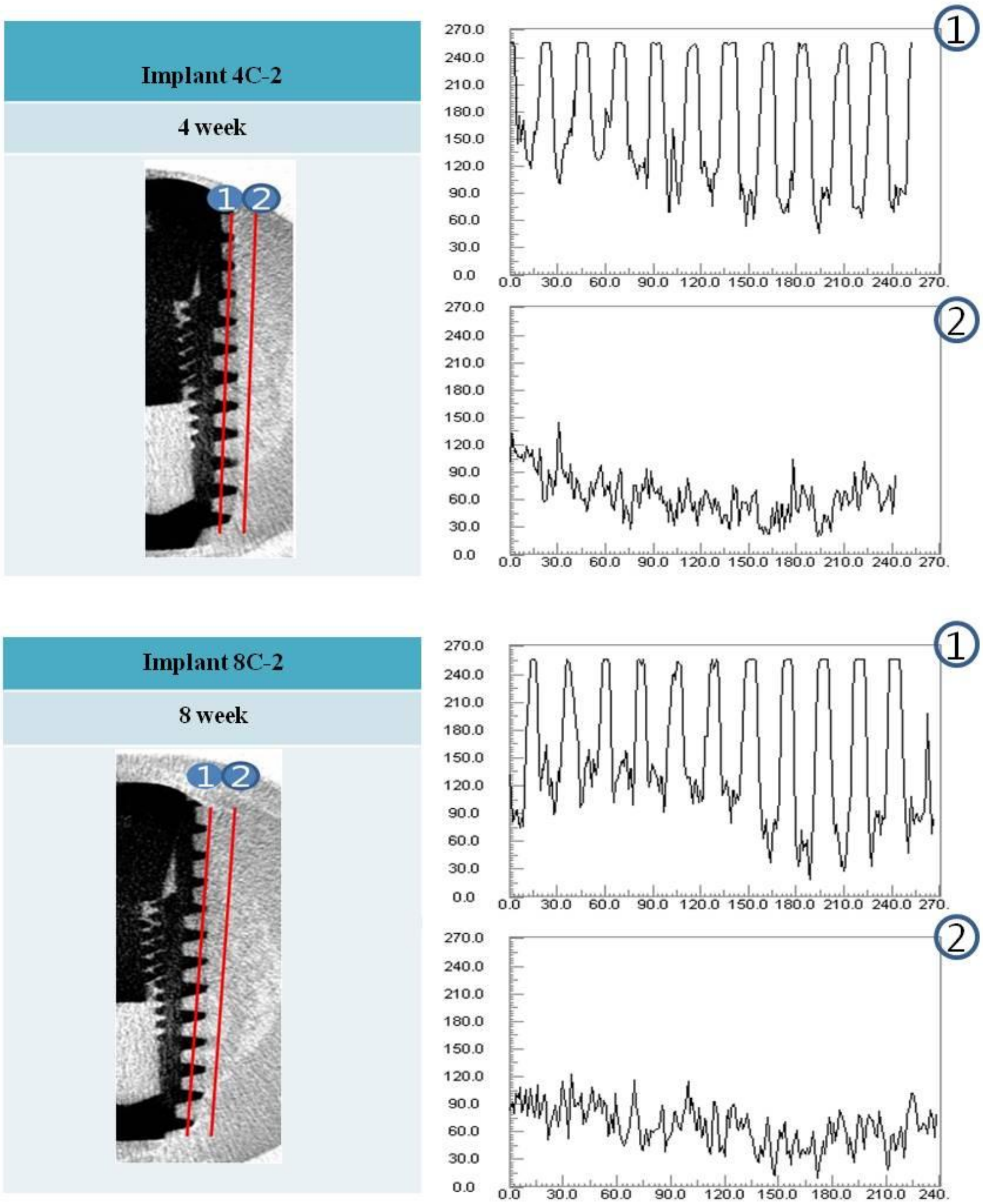

Figure 14. Comparison of bone density (implant 4C-2; 8C-2)

3. Histological analyses

Every implant was osseointegrated well except of one implant that was placed short. There was much of bone formation at 8-weeks groups, and all implants showed good healing. Bone tissue was distinctively observed and showed the intimate contact with implants in the cortex area. The bone-to-implant contact (BIC) and the bone volume (BV) were assessed by light microscope after 4 (Figure 15, 17, 19, 21, 23) and 8 (Figure 16, 18, 20, 22, 24) weeks of healing.

Thirteen sectioned slides, measurement of bone volume (BV) and bone to implant contact (BIC) using an automated image analysis program (I Solution Lite) (Figure 25, 26).

As for the BIC percentage of the specimens at 4 weeks, SA surface implants showed a percentage of 85.16% while RBM surface implants showed a percentage of 41.62%and Anodized TiO2 surface implants 43.85%. At 8 weeks, SA surface implants showed a BIC percentage of 38.88% while RBM surface implants showed a percentage of 58.87% and Anodized TiO2 surface implants 61.3% (Table I, Figure 27).

As a result of the BV analysis, at 4 weeks SA surface implants showed a BV percentage of 34.48% while RBM surface implants showed a percentage 58.56% and Anodized TiO2 surface implants 47.22%. At 8 weeks, SA surface implants showed a BV percentage of 51.55% while RBM surface implants showed a percentage of 81.56% and Anodized TiO_2 surface implants 63.53% (Table II , Figure 28).

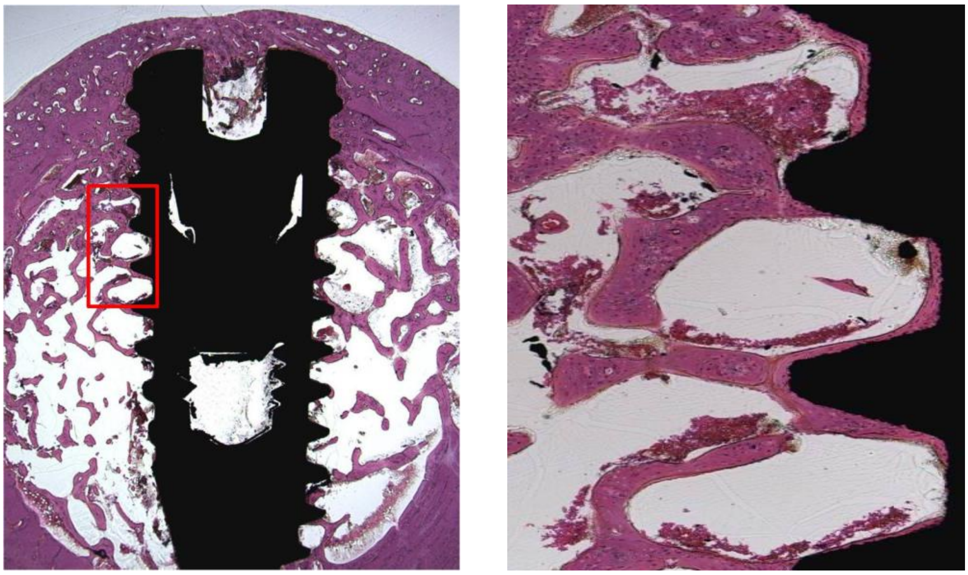

Figure 15. Histologic feature at 4 weeks after Implant 4A-2 installation

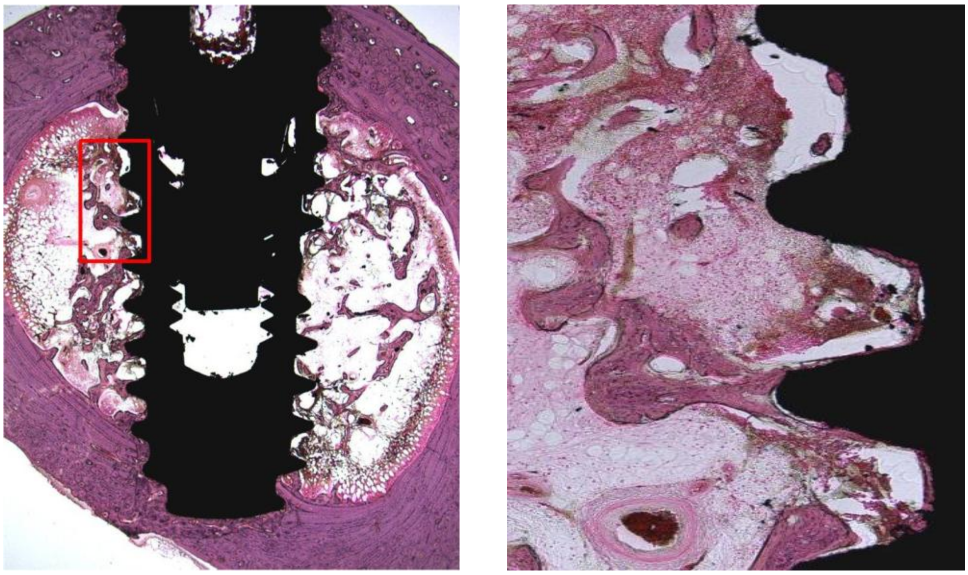

Figure 16. Histologic feature at 8 weeks after Implant 8A-2 installation

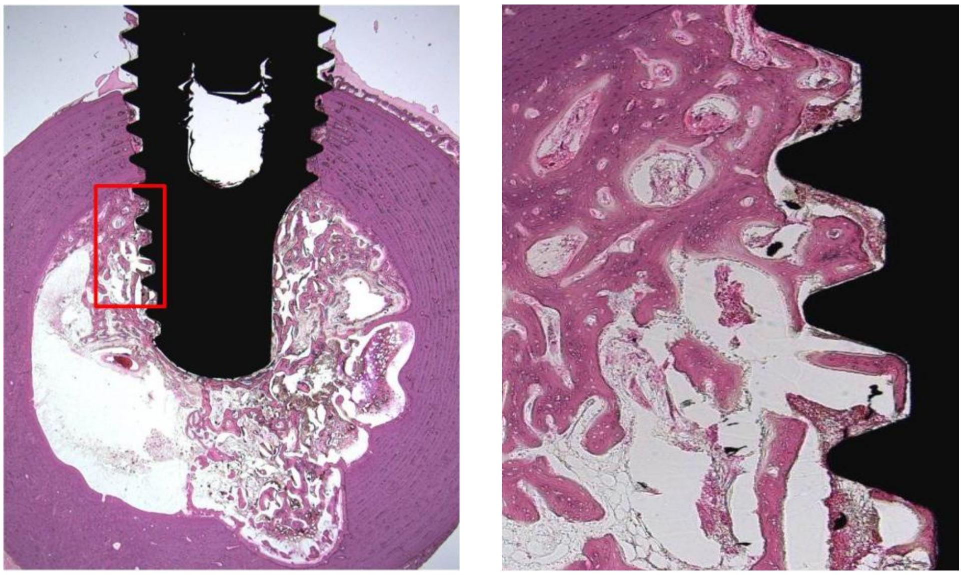

Figure 17. Histologic feature at 4 weeks after Implant 4B-1 installation

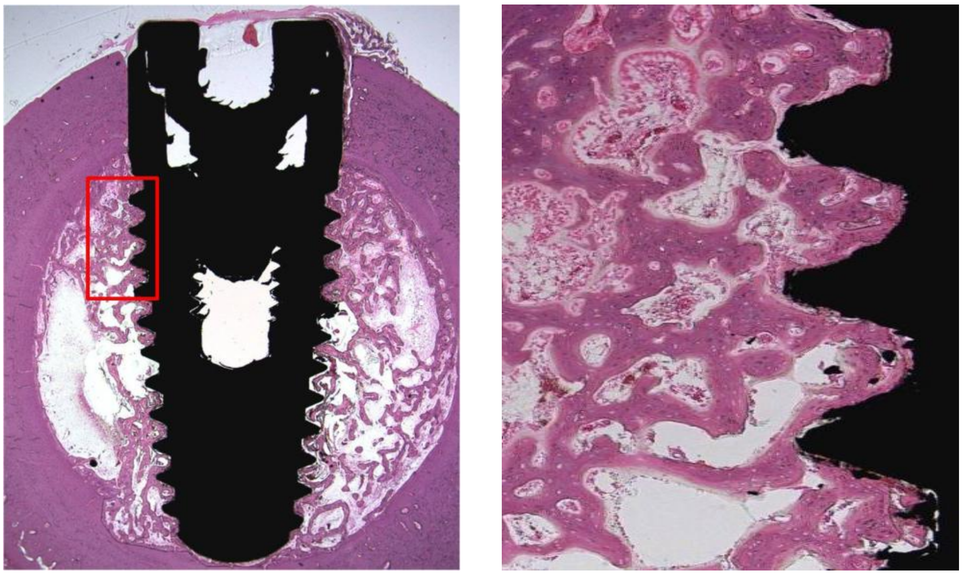

Figure 18. Histologic feature at 8 weeks after Implant 8B-1 installation

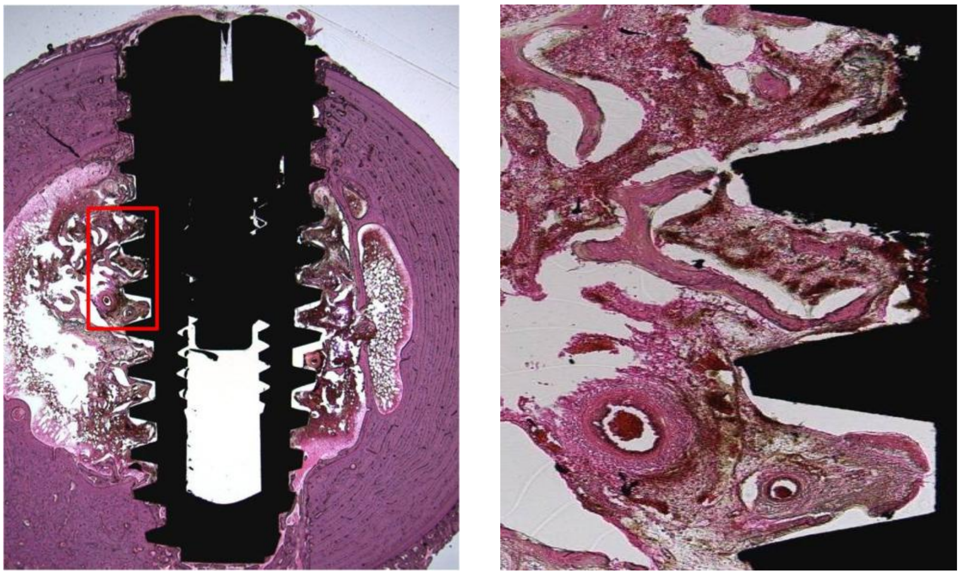

Figure 19. Histologic feature at 4 weeks after Implant 4C-1 installation

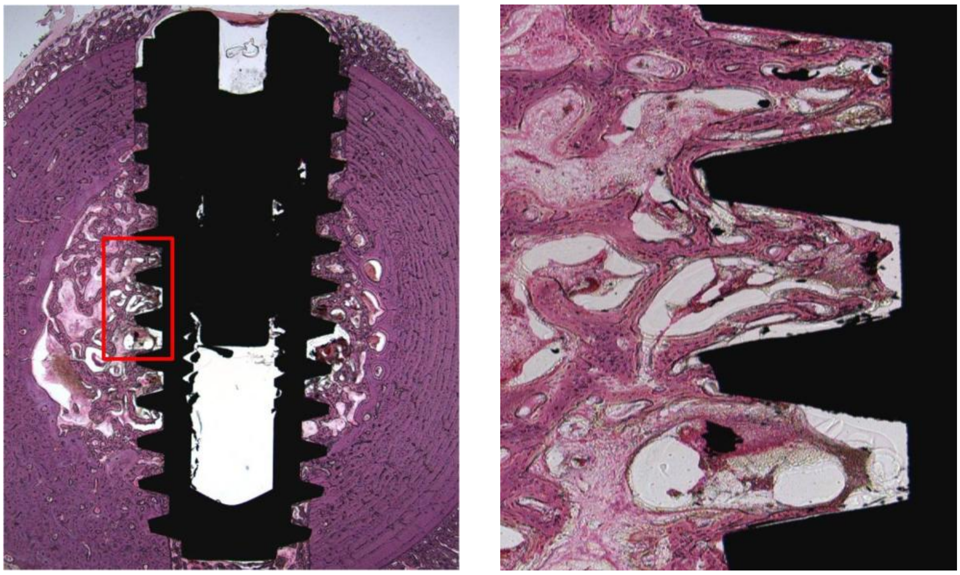

Figure 20. Histologic feature at 8 weeks after Implant 8C-1 installation

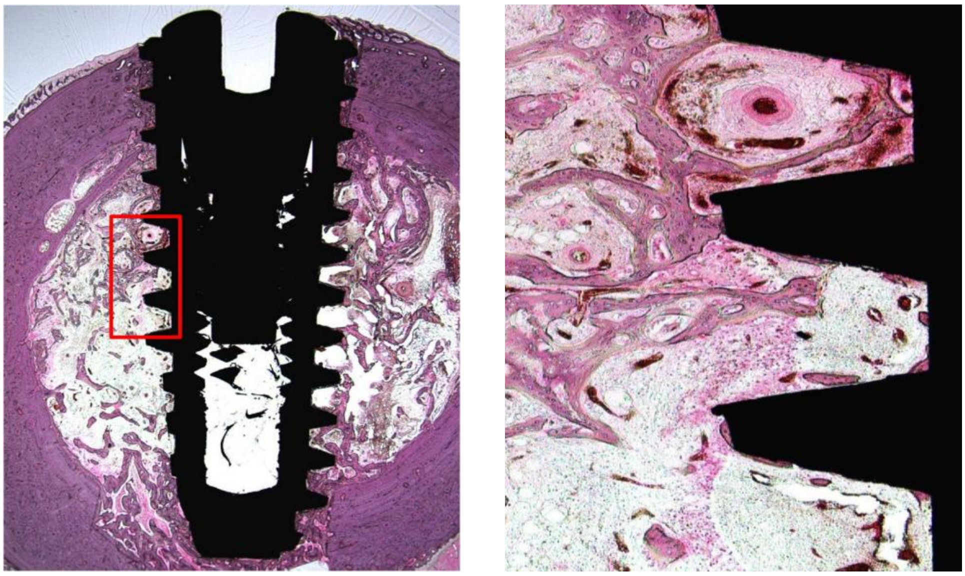

Figure 21. Histologic feature at 4 weeks after Implant 4C-1 installation

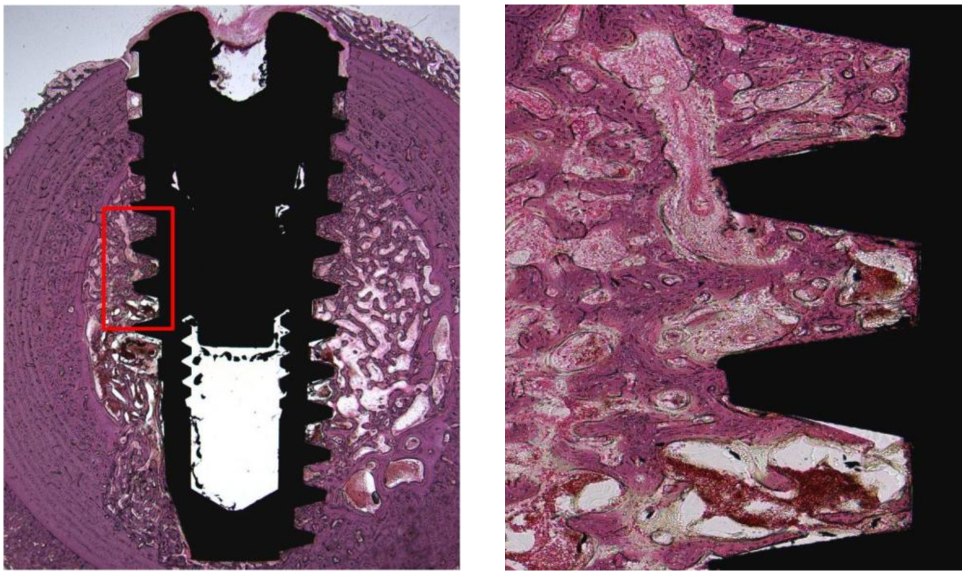

Figure 22. Histologic feature at 8 weeks after Implant 8C-1 installation

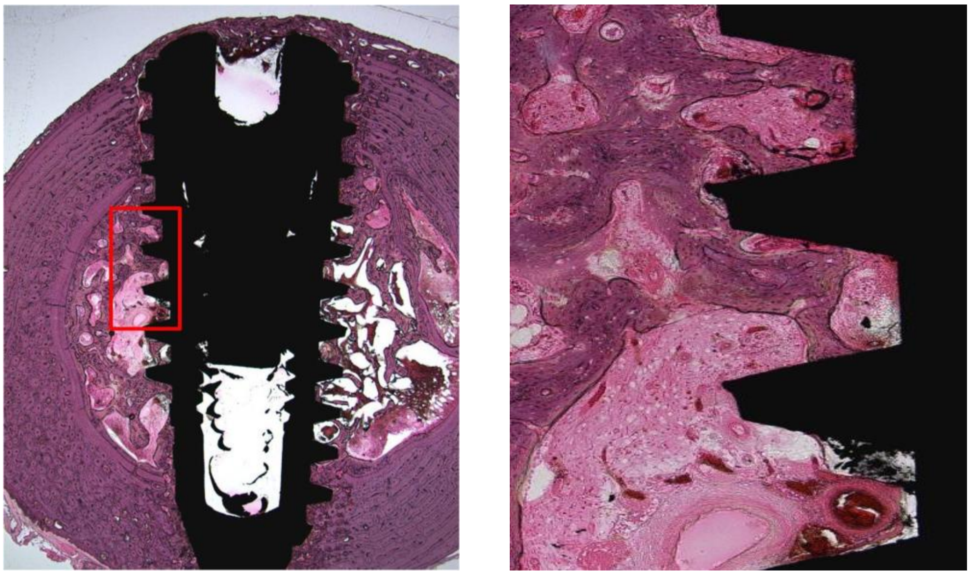

Figure 23. Histologic feature at 4 weeks after Implant 4C-2 installation

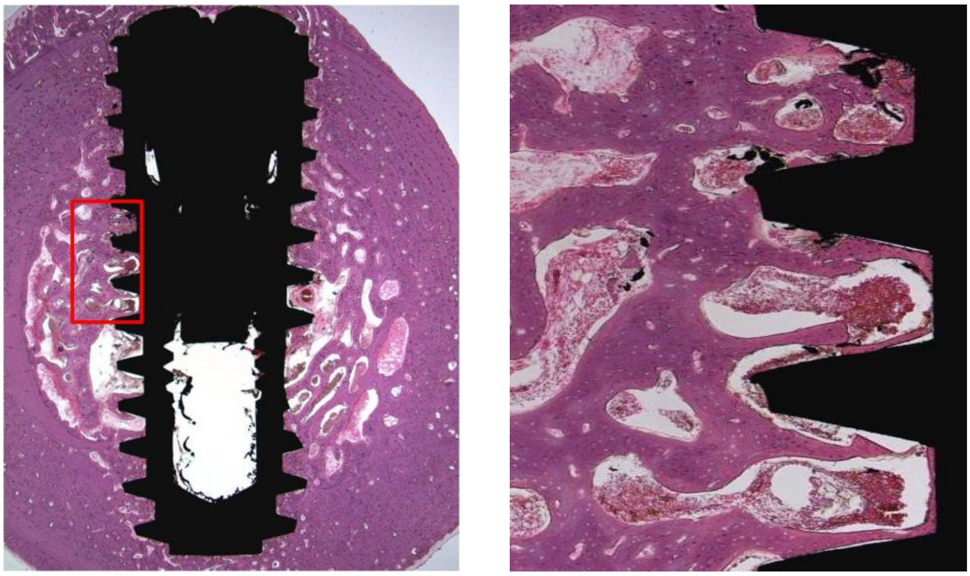

Figure 24. Histologic feature at 8 weeks after Implant 8C-2 installation

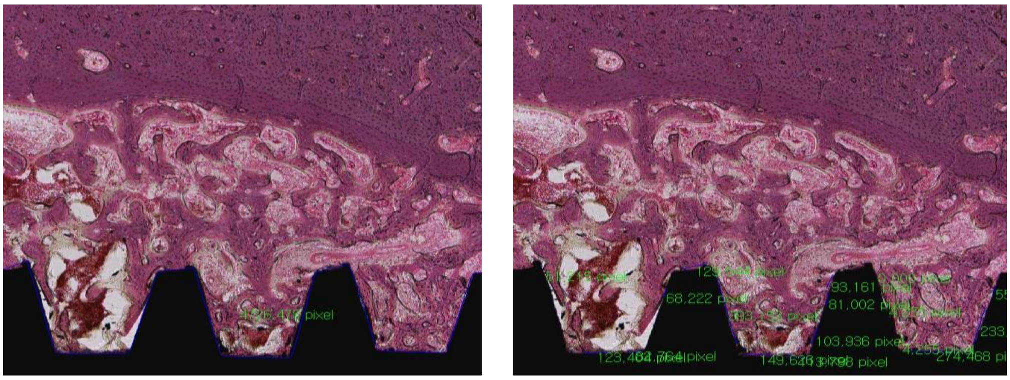

Figure 25. Calculation of bone-to-implant contact

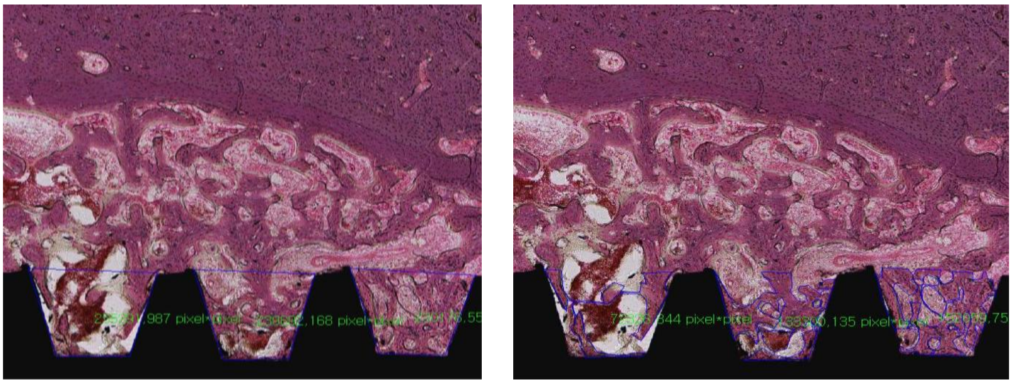

Figure 26. Measurement of bone volume

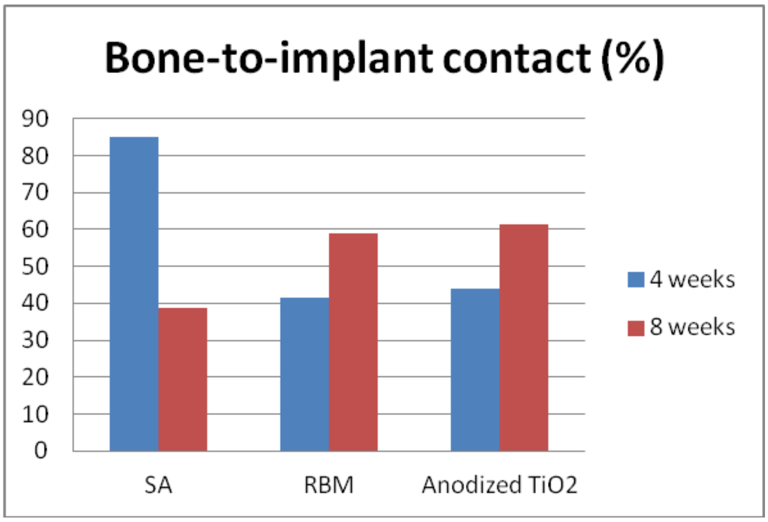

Figure 27. The means of the bone-to-implant contact ratio

Table I. The means of the bone-to-implant contact percentages

	SA	**RBM**	**Anodized TiO_2**
4 weeks	85.16	41.62	43.85
8 weeks	38.88	58.87	61.3

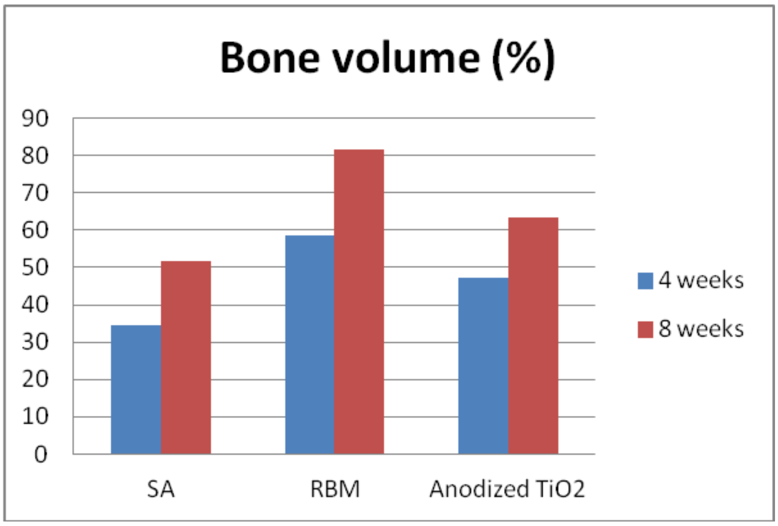

Figure 28. The means of the bone volume ratios

Table II. The means of the bone volume density percentages

	SA	RBM	Anodized TiO_2
4 weeks	34.48	58.56	47.22
8 weeks	51.55	81.56	63.53

4. Removal torque values

The removal torque values, measured after a 4-week and 8- week healing period, were summarized in Table III. The mean values of the removal torque and diagram were found (Figure 29).

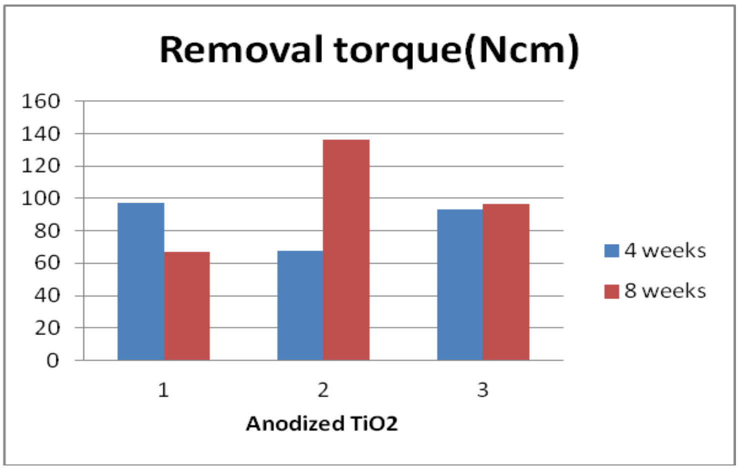

Figure 29. A diagram showed the values of removal torque value between 4 weeks and 8 weeks.

Table III. Removal torque values (Ncm) data after installing torque moment and 4- and 8- weeks of healing time (3rd Beagle)

Removal torque	Installing torque	4 weeks (Right)	8 weeks (Left)
	0C-3 = 45	4C-3 = 97.3	8C-3 = 66.9
	0C-3 = 50	4C-3 = 67.7	8C-3 = 136.1
	0C-3 = 50	4C-3 = 93.2	8C-3 = 96.3
Mean	48.3	86.0	99.7

IV. DISCUSSION

In the current study, bone response to implants with different surface properties were evaluated through clinical, radiograph, computed tomography, removal torque force and histological analysis in a dog femur.

A major consideration in designing implants has been to produce surfaces that promote desirable responses in the cells and tissues. To achieve these requirements, the titanium implant surface has been modified in various ways. However, the degree of surface roughness may not be the only aspect of surface topography that effects osseointegration.

The intimacy of bone contact with the implant surface may be important as well as the surface ionic charge, energy and tension and other still undefined properties of the surface. (Ellingsen et al., 2000) Recently, the implant systems having new surface were developed on the basis of anodic oxidation methods. This implant system has more than 2 ㎛ thick oxides prepared by anodic oxidation. Anodic oxidation processes have been extensively investigated by several authors due to the potential of controlling the oxide properties. Aalam et al., (2005) reported that the anodized titanium implant can be successfully applied for restoring the edentulous patient jaw although the observation period is relatively short (within 2 years after loading). The anodic oxidation process used in this study was one of the several techniques available to produce adequate anodized surfaces (Yeo et al., 2008).

Morphological changes on a nanometer level may introduce additional effects to the tissue response which, in turn, can further improve the bone healing. According to Webster et al., (2000) an introduction of nanostructure significantly improves osteoblast adhesion. Adhesion of osteoblasts is a crucial prerequisite to subsequent cell functions such as synthesis of extracellular matrix proteins, and formation of mineral deposits.

Bone density was analyzed with Dataviewer program after two-dimensional capture of CT images. To analysis the bone density, 2 parallel lines were drawn; the first line was drawn between threads and the second line was drawn parallel with the first line off to the implant. According to the analysis using this program, in the control and experiment groups the bone density between the threads (first line) was higher compared to the area off to the side of the implant (second line). Although, bone mineral density was relatively increased, there were no difference between group A, B, C implants neither at week 4 and 8.

Bone response from deduction of BIC in loading conditions can be increased if the implant has a topographically changed surfaces. However, there were few studies on relations between BIC and surface chemistry in loading conditions. It is generally believed that the degree of BIC varies depending on implant macro/micro structures, surface characteristics, different healing period, and the presence or absence of loading (Cochran and Buser., 2000).

Berglundh et al., (2003) reported, in a study *in vivo*, at 8 and 12 weeks, there were the marked signs of remodeling within the wound chamber. It means that the implants have no mechanical and functional problems on the loading after 4 weeks. In this study, it was suggested that there was no mechanical and functional problems, if the implants had been loaded after 4 weeks. In the histologic findings of this study, showed that osseointegration occurred in all investigated types of surface-treated implants. However, the control groups showed slight increase in the BIC and BIV values compared to the experimental groups.

The process of osseointegration is affected by many factors, including surgical techniques and the conditions of the implant bed (Schatzker et al., 1975). Clinical observations have also indicated that the final healing time is affected by individual differences and operation conditions (Albrektsson et al., 1989). In this study, same investigator installed implants and the implants were planted always the same place with the same sequences. All implants except of one that installed at the short site of femur healed well.

A greater removal force can be generally interpreted as an increase in bone healing around the implants and improvement in osseointegration. Gotfredsen et al., (1992) reported significantly higher removal torque values for the blasted implants. These observations are in agreement with findings by Johansson (1991) and Carlsson et al. (1994), who obtained higher removal torques with rough rather than with smooth implants. In this study, Anodized TO_2 surface group, removal torque value was increased at 8 weeks compared to at 4 weeks. This means that osseointegration is influenced more by the bone maturity than the bone strength.

Several limitations were associated with this study. We didn't select a comparison group, such as other roughened surface or other ion-incorporated surface. Small sample size and relatively large standard deviations were thought to be the reasons.

The tissue responses may not depend on only one specific surface property but rather on a number of different alterations. However, it is not fully understood whether these properties influence the bone tissue response separately or synergistically. In this study the experimental condition may not always be extrapolated the clinical situations. This may be due to differences in bone anatomical, physiological, and unloaded conditions.

From this experiment, we can suggest that the newly investigated nano-treated surface needs to be studied in combination with micro-treated surfaces for better clinical results rather than it is studied by itself. However, further studies with increased specimen number are needed for more significant results.

V. CONCLUSIONS

From this study, following results were obtained:

1. No infection arose during the observation interval as well. During the extraction of all specimens the periosteum was strongly attached to the femur bone and any implant loosening was not observed.

2. As with the plain radiography findings of both control and experimental groups, a good union between bone and implant treated was noticed. No bone loss around the implants was observed. Bone density was analyzed with Dataviewer program after two-dimensional capture of CT images. In the control and experiment groups the bone density between the threads (first line) was higher compared to the area off to the side of the implant (second line). Although, bone mineral density was relatively increased, there were no difference between group A, B, C implants neither at week 4 and 8.

3. In the histologic findings of this study, showed that osseointegration occurred in all investigated types of surface-treated implants. However, the control groups showed slight increase in the BIC and BIV values compared to the experimental groups.

4. In this study, Anodized TO2 surface group, removal torque value was increased at 8 weeks compared to at 4 weeks.

From this experiment, we can suggest that the newly investigated nano-treated surface needs to be studied in combination with micro-treated surfaces for better clinical results rather than it is studied by itself.

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국 문 요 약

웅성 성견 모델에 시립한 Nano-titania 임플란트의 방사선학적, 조직학적 평가

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치과용 임플란트는 상실된 치아를 회복하기 위한 효과적인 치료방법 중 하나로서 각기 다른 표면의 특성과 재료를 이용하여 여러 가지 모양, 크기 그리고 길이로 적용할 수 있다.

현재, 나노 기술을 이용하여 임플란트 표면을 처리하는 몇 가지 기법이 부상하고 있는데 이러한 나노 레벨에서의 평가 방법은 이식 재료와 조직 그리고 세포 상호 작용에 관한 중요한 정보를 제공한다. 또한 임플란트 시술 후 초기 치유 과정에서 일어나는 일들에 대한 나노레벨에서의 지식은 곧 골-임플란트 결합 접촉면에 대한 보다 나은 이해와 골유착 임플란트 표면 개발의 발전에 가이드라인을 제

시할 수 있을 것이다.

본 연구의 목적은 세 종류의 각각 다른 임플란트의 표면처리 방법을 지름 4.1mm, 길이 10mm의 임플란트에 적용하여 골 반응을 비교 및 분석하는 것으로서 1) 알루미나 분사처리 후 산 부식(SA) 임플란트와 2) RBM(Resorbable Blast Media) 표면처리 임플란트를 대조군으로, 3) 양극산화법을 이용한 티타니아 나노튜브 표면처리 임플란트를 실험군으로 사용하였다.

본 실험에 사용된 임플란트는 3마리의 수컷 성견 대퇴골에 식립되었고, 식립 후 8주의 치유기간을 거친 뒤 각 동물은 희생되었다. 채취된 샘플은 조직 탈회를 거친 뒤 Micro CT로 촬영되었고 Dataviewer program을 이용하여 2차원 골 밀도 분석을 실시하였다. 조직형태학적 분석을 위해 광학현미경을 이용하였고 4주, 8주 실험군에 한해서 뒤틀림 제거력(Removal torque)은 측정하였다.

조직학적 관찰 시 4주와 8주의 치유기간을 거친 모든 군에서 양호한 골 유착 소견을 보였으며, 4주와 8주군에 대한 Bone-Implant Contact, BIC(%)의 평균값은 각각 다음과 같았다. SA: 85.16%, 38.88%; RBM: 41.62%, 58.87%; and Anodized TiO2: 43.85%, 61.3%. 또한 4주와 8주군에 대한 Bone Volume, BV(%)의 평균값은 각각 다음과 같았다. SA: 34.48%, 51.55%; RBM: 58.56%, 81.56%; and Anodized TiO2: 47.22%,

63.53%. 티타니아 나노튜브로 표면 처리한 8주군에서는 4주군보다 뒤틀림 제거력이 증가하였으며 그 평균값은 다음과 같았다. 4주군: 86.0Ncm, 8주군: 99.7Ncm.

본 연구를 통해 모든 표면처리 임플란트 군에서 양호한 골 유착 소견을 보였으나 대조군에서는 실험군과 비교시 BIC와 BV값이 증가하였다.

핵심 용어: 임플란트 표면, 제거토크, 조직학, 골유착, 비글.