Bone–implant contact at calcium phosphate-coated and porous titanium oxide (TiUnite™)-modified oral implants

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Abstract
Background: Calcium phosphate (CP)-coated implants are usually referred to as having osteoconductive properties, whereas titanium implants with a native oxide layer are considered less osteoconductive. Often smooth titanium oxides (TOs) are compared to relatively rough CP structures. The objective of this study was to evaluate osteoconduction by comparing bone–implant contact at a relatively smooth, highly crystalline CP coating with a structured, porous TO (TiUnite™)-modified surface.

Material and methods: Ten adult Hound Labrador mongrel dogs were used. Four titanium implants (Nobel Biocare) with CP-coated (2) or TO-modified (2) surfaces were installed 12 weeks following mandibular premolar and molar teeth extraction. The implants were alternated within and between jaw quadrants in consecutive animals. Mucosal flaps were advanced and sutured leaving the implants in a submerged position. The animals were injected with fluorescent bone labels at 3 and 4 weeks postsurgery, and pre-euthanasia to monitor progress of bone formation. The animals were euthanized at 8 weeks postsurgery and block biopsies were prepared for histologic and histometric analysis.

Results: There were no remarkable differences in bone formation and apparent bone–implant contact comparing the TO-modified and CP-coated surfaces. However, the measured average bone–implant contact was 71% and 57% (P = 0.027) for TO-modified and CP-coated implants, respectively.

Conclusions: We conclude that the TO surface exhibits osteoconductive properties exceeding that of the CP surface. One or several of the chemical and physical properties of the TO surface may result in the remarkable bone formation along its surface. This study indicated that crystallinity and/or chemistry may be important.

Long-term clinical studies have shown that titanium oral implants representing various surface properties can be successfully utilized for the rehabilitation of completely and partially edentulous subjects [Adell et al. 1990; Zarb & Schmitt 1993a, 1993b; Buser et al. 1997]. Nevertheless, preclinical studies are necessary to discern factors relevant to the eventual clinical success of implant surfaces in development. Such preclinical studies have focus on biocompatibility of biomaterials, osseointegration including bone–implant contact, crestal resorption and immediate peri-implant bone density, and the biomechanical resilience and stability of the bone–implant interface.

Osseointegration has been defined as ‘direct structural and functional connection between ordered living bone and the sur-
face of a load-carrying implant’ [Brånemark 1985]. From an experimental perspective, osseointegration is evaluated as the direct mineralized bone–implant contact in histologic sections or using surrogate parameters including biomechanical torque removal and recently resonance frequency analysis. It is commonly thought that a high level of direct bone–implant contact is advantageous for clinical success. The surface microstructure has been suggested to influence the rate of bone adaptation to the implant surface [Buser 1999]. Thus new implant surfaces have been developed to increase bone adaptation and to simplify and increase the predictability of the clinical protocol, in support of the long-term success of the implant-supported prosthesis.

Calcium phosphate (CP)-coated implants are usually referred to as having osteoconductive properties, whereas titanium implants with a native oxide layer are considered less osteoconductive. Often smooth titanium oxides (TOS) are compared to relatively rough CP structures. The objective of this study was to evaluate osteoconduction by comparing bone–implant contact at a relatively smooth, highly crystalline CP coating to that at a structured, porous TO surface.

**Material and methods**

**Implants**

CP-coated and porous TO (TiUnite™) surface modified threaded titanium oral implants (Brånemark, Ø3.75 × 8.5 mm; Nobel Biocare AB, Göteborg, Sweden) were used [Fig. 1].

The CP coating was produced by radio frequency magnetron sputtering in a mixture of argon and reactive gases, followed by heat-treatment at 627°C for 12 h in a flow of saturated water vapor in synthetic air (O2: 20 ± 1 vol% + N2 impurities <5.5 ppm). The coat thickness was 0.1 ± 0.01 μm as measured using a profilometer over a step separating coated and uncoated section of a disk. The surface topography and roughness were investigated with SEM and found similar to the underlying machined surface at the micrometer scale. The coating was homogeneously covering the underlying substrate with no visible defects. Additional characteristics of the CP coating have been presented in a separate publication [Mohammadi et al. 2003].

The TO-modified surface was produced by anodic oxidation. The characteristic properties of the TO-modified surface have been published [Hall & Lausmaa 2000] and are summarized as follows: (1) The TO-modified surface consisted of an essentially pure partly crystalline TiO2 oxide. The oxide thickness increased continuously from 1–2 μm at the upper part to 7–10 μm at the apical aspect of the implant; (2) The surface roughness and area increased continuously from the flange to the apical part of the implant, where surface roughness was 1.2 μm and the area increase compared with an ideally flat surface was 95%; (3) The surface showed a rough surface topography without sharp features; and (4) The surface (apical portion) contained numerous open pores, with orifices predominantly in the range 1–2 μm.

All CP-coated and TO-modified implants were sterilized by dry heat at 200°C for 1.5 h.

**Animals**

Ten male, 18-month-old Hound Labrador mongrel dogs, approximate weight 25 kg, were used. Animal selection and management, and surgical protocol followed routines approved by the Institutional Animal Care and Use Committee, Temple University, Philadelphia, PA, USA. The animals had access to a canned soft dog-food-diet and water.

**Surgery procedures**

Food was withheld the night preceding surgery. The animals were pre-anesthetized with atropine (0.02–0.04 mg/kg)/buprenorphine HCl (0.01–0.03 mg/kg)/acepromazine (0.1 mg/kg) s.q., induced with xylazine (1 mg/kg, i.v.), and maintained on gas anesthesia [1–2% isoflurane/O2 to effect]. A sterile catheter was placed and animals received a slow constant rate infusion of lactated Ringer’s solution (10–20 ml/kg/h i.v.) to maintain hydration while anesthetized. Prophylactic antibiotics (enrofloxacin, 2.5 mg/kg i.m.) was administered before surgery.

All mandibular premolar and first molar teeth were surgically extracted. Care was taken to preserve the buccal, lingual, and lateral walls of the alveolar sockets. Following tooth extraction, the mucogingival flaps were advanced and sutured ensuring primary wound closure. Periosteal releasing incisions were used to allow tension-free flap apposition. The extraction sites were allowed to heal for 12 weeks. The maxillary first, second, and third premolar teeth were surgically extracted, and the fourth premolar teeth were reduced in height to the level of gingival margin and the exposed pulpal tissues sealed. Maxillary extractions were performed to alleviate...
potential trauma from the maxillary teeth to the experimental mandibular sites.

**Implant installation**

Animals were pre-medicated and anesthetized following the protocol described above. A mid-crestal incision from the first premolar tooth region to the second molar was made reflecting buccal and lingual mucoperiosteal flaps. Two CP-coated and 2 TO-modified implants were installed into the edentulated mandibular ridge in each animal using routine protocols (Fig. 2). The positions of the implants were alternated within and between jaw quadrants in consecutive animals. Each implant received a cover screw and the mucoperiosteal flaps were advanced and sutured using mattress sutures (GORE-TEX® Suture CV5, W.L. Gore & Associates Inc., Flagstaff, AZ, USA) to ensure complete wound closure.

**Postsurgery care**

A long-acting opioid (buprenorphine HCl, 0.015 mg/kg i.m., b.i.d. for 48 h) was administered for immediate postextraction/postimplant installation pain control. The broad-spectrum antibiotic (enrofloxacin, 2.5 mg/kg, i.m., b.i.d.) was used for continued infection control for 7 days following extractions and implant installation. The animal’s temperature was monitored and recorded for 10 days.

Plaque control was maintained by daily flushing of the oral cavity with chlorhexidine (Chlorhexidine Gluconate, Xtrarium Laboratories, Inc., Chicago, IL, USA; 20–30 ml of a 2% solution) until suture removal and daily thereafter (Monday through Friday) until completion of study. The animals were fed a canned soft dog food diet throughout the healing sequence. Sutures were removed under sedation (propofol, 4 mg/kg i.v. bolus; 0.2–0.6 mg/kg/min IV) at approximately 10 days post-surgery.

**Fluorescent bone labeling**

Oxytetracycline hydrochloride (Maxim-200, Phoenix Pharmaceuticals, St Joseph, MO, USA; 20 mg/kg, s.q.) was administered at 3 weeks postimplantation. Xylenol orange (200 mg/ml, Wyeth Research, Cambridge, MA, USA; 90 mg/kg, s.q., twice one day apart) was administered at 4 weeks postimplantation, and calcein green (25 mg/ml, Wyeth Research; 5 mg/kg, s.q.) at 10 and 3 days pre-euthanasia (Jee 1990).

**Clinical recordings**

Test material traceability was recorded in the animal’s chart. The presurgery condition of the oral tissues was noted. Intrasurgery photographs were taken prior to and immediately after placement of the implants, and following wound closure. Observations of experimental sites with regard to mucosal health, maintenance of suture line closure, edema, and evidence of tissue necrosis or infection were made daily until suture removal, and at least twice weekly thereafter. Radiographs were obtained immediately postsurgery, at suture removal (approximately 10 days postsurgery), and at 4 and 8 weeks postsurgery.

**Euthanasia**

The animals were euthanized at 8 weeks postsurgery. Following sedation with atropine (0.02–0.04 mg/kg), buprenorphine (0.01–0.03 mg/kg), acepromazine (0.1 mg/kg) s.q., the animals were euthanized with an overdose of pentobarbital (100 mg/kg i.v.). Block sections including titanium implants, alveolar bone, and surrounding mucosa were collected and radiographed. The specimens were rinsed in sterile saline, and the tissue blocks transferred to 10% neutral buffered formalin at a volume 10 times that of the block section.

**Histological processing**

After fixation, the tissue blocks were dehydrated in alcohol and embedded in methylmethacrylate resin (Technovit 7200 VLC, Heraeus Kulzer, Verheim, Germany). The embedded specimen blocks were mounted in an ultramicrotome and oriented to allow mid-axial sections in a mesial-distal plane. Sections were cut to a thickness of 200 μm using the cutting-grinding technique, and subsequently ground and polished to a final thickness of approximately 40 μm (Donath & Breuner 1982). The sections were stained utilizing Sanderson’s rapid bone stain (Surgipath, Richmond, IL, USA) and counterstained in fast green (Wyeth Research). Slides were blot-dried; no coverslip was required for the analysis.

**Analysis**

Radiographs were evaluated for crestal and immediate peri-implant bone formation/resorption. Fluorochrome bone histodynamic markers were analyzed under ultraviolet light by two experienced masked examiners. The entire peri-implant area in one to two sections per implant was evaluated for new bone formation rate and
location as delineated by the fluorescent markers, residual resident bone, fibrovascular tissue, and marrow.

A scanning electron microscope [SEM] equipped with an energy-dispersive X-ray spectrometer was used to evaluate of the in vivo stability of the CP coating. A specimen from the histology analyses was coated with a thin layer (100 Å) of gold, and SEM images were recorded. The chemical composition along a line over the implant–tissue interface in the direction from implant to tissue was recorded [line scan].

One experienced masked examiner performed the histometric analysis using light microscopy and a PC-based image analysis system [Image-Pro Plus™, Media Cybernetic, Silver Springs, MD, USA]. One section per implant was used for the analysis. The following measurements were recorded for mesial and distal surfaces for each implant:

- **Coronal bone contact**: distance from the implant platform to the most coronal bone–implant contact.
- **Bone–implant contact**: percent bone–implant contact along the 5 most coronal threads of the implant surface below the alveolar crest.
- **Bone density within threads**: ratio mineralized bone to fibrovascular tissue and marrow within the 5 most coronal threads of the implant surface below the alveolar crest.
- **Bone density outside threads**: ratio mineralized bone to fibrovascular tissue and marrow within an area extending 600 μm immediately outside the 5 most coronal threads of the implant surface below the alveolar crest.

Group means and standard deviations were calculated for each parameter. Differences between experimental conditions were analyzed using Student’s paired t-test. A P-value <0.05 was required for statistical significance.

**Results**

**Clinical and radiographic observations**

Healing of the implant sites appeared uneventful with no appreciable differences between the two implant surface types. The sites were covered by normal keratinized alveolar mucosa until euthanasia. Surgical re-entry at euthanasia typically revealed that the cover screws remained exposed without substantial bone coverage.

**Histological evaluation**

The concept of light microscopy evaluation revealed no remarkable differences in bone formation and apparent bone–implant contact comparing CP-coated implants with TO-modified implants [Figs 3 and 4]. New bone formation within and immediately adjacent to the threaded implant surface was the predominant observation comparing the two surfaces. One CP-coated implant exhibited an inflammatory lesion apparently resorbing the resident bone in the immediate area precluding bone–implant contact.

The SEM analysis of the in vivo stability of the CP coating showed a thin layer with a structure different from bone at the implant surface. The layer was observed in sections where bone was not in contact with the implant surface. A sharp increase of the calcium and phosphorous signals were observed for line scans over the layer. It was not possible to quantify the layer thickness due to spatial resolution limitations of the experimental setup. However, the combined observations from the SEM images and the line scans indicate that the CP coating was present after 8 weeks in vivo.

The fluorescence microscopy evaluation suggested minimal, if any, apparent differences in bone formation and bone–implant contact among CP-coated and TO-modified implants [Figs 3 and 4]. Although considerable inter-animal variability in bone healing ranging from limited to relatively extensive resorption and new bone formation of the immediate peri-implant bone was observed, there was limited intra-animal variability between the implant surfaces. Unsupported native resident bone, undergoing active resorption, was observed within and immediately outside the thread area. Fluorescent markers indicated slow new bone formation as appreciated by narrow oxytetracycline yellow (week 3), xylene orange (week 4), and calcein green labels (week 8), and limited bone formation between the labels.

**Histometric evaluation**

The result from the histometric evaluation is presented in Table 1. There were no significant differences in coronal bone contact and bone density within and immediately outside the thread area between CP-coated and TO-modified implants. Bone...
Both implant surface modifications including extensive peri-implant bone resorption and new bone formation.

Table 1. Results of the histometric analysis for the calcium phosphate (CP) and porous titanium oxide (TO) implant surfaces (group means $\pm$ SD in mm and %, $N=10$)

<table>
<thead>
<tr>
<th>Surface</th>
<th>Coronal bone contact (%)</th>
<th>Bone-implant contact (%)</th>
<th>Bone density within threads (%)</th>
<th>Bone density outside threads (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP</td>
<td>0.6 $\pm$ 0.5</td>
<td>56.6 $\pm$ 18.5</td>
<td>48.5 $\pm$ 15.9</td>
<td>58.6 $\pm$ 12.0</td>
</tr>
<tr>
<td>TO</td>
<td>0.5 $\pm$ 0.4</td>
<td>70.7 $\pm$ 9.0</td>
<td>53.2 $\pm$ 14.0</td>
<td>60 $\pm$ 13.4</td>
</tr>
<tr>
<td>P-value, CP vs. TO</td>
<td>0.2473</td>
<td>0.0269</td>
<td>0.2958</td>
<td>0.8064</td>
</tr>
</tbody>
</table>

Discussion

CP-coated implants are referred to as having osteoconductive properties, whereas titanium implants with a native oxide layer are considered less osteoconductive. Often, smooth TO surfaces have been compared with relatively rough CP structures. The objective of this study was to evaluate osteoconduction by comparing bone-implant contact at a relatively smooth highly crystalline CP coating with that of a structured porous TO surface. CP-coated or TO-modified implants were installed into the edentulated posterior mandible in 10 dogs. The animals received fluorescent bone labels to monitor bone formation. Block biopsies for histologic analysis following an 8-week healing interval showed that the porous TO surface exhibited osteoconductive properties exceeding that of the relatively smooth CP surface.

There were no remarkable differences in bone density following implantation between the implant surfaces. Bone density within the thread area approximated 50%, whereas bone density immediately outside the thread area approximated 60%. All implants exhibited a high level of osseointegration (bone-implant contact). Nevertheless, TO-modified implants exhibited a statistically significant higher level of osseointegration compared with CP-coated implants.

Intra-animal variability among the implant surfaces. These data indicate that most of the implants placed in the posterior mandible of the dog were placed in type II bone and that in this type of bone the different surfaces tested do not seem to influence the overall bone metabolic activity in a surface dependent fashion. Surface modifications may be more critical in less favorable situations when the bone density is lower.

A statistically significant difference in bone-implant contact was found between the TO modified and the CP-coated implants. The TO-modified surface exhibited higher bone-implant contact values suggesting that the porous surface enhances bone formation in a manner not expected for smooth, native TOs. When rough CP-coated or sandblasted/acid-etched or titanium porous oxide-modified implants have been compared to relatively smooth turned titanium implants, the level of osseointegration has been reported higher for the rough surface implants (Buser et al. 1991; Ericsson et al. 1994; Carr et al. 1997; Albrektsson et al. 2000; Gotfredsen et al. 2001; Qahash et al. 2002; Lima et al. 2003; Zechner et al. 2003). These data suggest that the effect of the surface microstructure on osseointegration may supersede that of the surface chemical composition at least for titanium and CP surfaces. However, using various animal models, others have observed higher bone-implant contact values at smooth and rough CP-coated surfaces compared with corresponding uncoated titanium surfaces pointing to the relative importance of the chemical composition of the surface (Hulshoff & Jansen 1997; Hayakawa et al. 2000, 2002; Vereaigne et al. 2000; Mohammadi et al. 2003).

In this study, both surface modifications exhibited high levels of osseointegration approximating 71% for TO-modified and 57% for CP-coated implants following an 8-week osseointegration interval. Although comparisons between studies have short-comings due to differences in protocol and technology, previous studies from our laboratories, also using the edentulated canine mandible model, have shown that rough surface titanium implants exhibit a mean bone-implant contact approximating 60% at 8 weeks, and ranging from 55% to 74% following a 16-
week osseointegration interval [Caplanis et al. 1997; Sigurdsson et al. 2001; Qahash et al. 2002]. The corresponding value for turned implants was 41% at 8 weeks, and ranging from 53% to 58% at 16 weeks [Sigurdsson et al. 1997; Qahash et al. 2002; Jovanovic et al. 2003]. It was further shown that turned titanium implants will increase their level of bone–implant contact [from 53% to 75%] following 12 months of functional loading with generally stable crestal bone levels and without loss of implants [Jovanovic et al. 2003]. Collectively these data suggest that the rough titanium implant surfaces achieve a higher level of bone–implant contact than their turned equivalents and that the level of osseointegration increases over time. In perspective, the consistent high bone–implant contact achieved already at 8 weeks in this study at the TO modified surfaces is suggestive of an accelerated osseointegration of these implants, which is of significant importance when implants are considered for early loading.

It must be emphasized that several characteristics of the TO-modified surface in this study are different from other surfaces used in studies referred to above. The smooth, rounded topography of the TO surface shall be compared with a relatively flat CP surface and often sharp-pointed features observed at acid etched and sandblasted surfaces. The porous structure with pores extending several µm in depth is clearly different from CP, acid-etched, and sandblasted surfaces. Therefore, it should not be surprising that osteoconductive properties of this TO surface are different from other TO surfaces such as acid-etched and sandblasted surfaces. However, it may be somewhat puzzling that the TO surface apparently stimulates bone formation similar to that observed at a hydroxyapatite CP surface. Then again, we note that the titanium dioxide surface is crystalline. Other studies have shown that crystallinity plays a role for apatite formation on TO surfaces [Wu & Nancollas 1998; Uchida et al. 2003]. If we assume that apatite is formed at the crystalline TO surface in vivo, it will then resemble the hydroxyapatite surface with respect to the chemical composition. Furthermore, we note that phosphates are partially covering the TO surface [Hall & Lausmaa 2000], and that similar phosphate groups exist at the hydroxyapatite surface. Such phosphates may also play a role in apatite formation.

Conclusion

We conclude that the TO surface exhibits osteoconductive properties exceeding that of the CP surface. One or several of the chemical and physical properties of the TO surface may result in the remarkable bone formation along its surface. This study indicated that crystallinity and/or chemistry may be important.

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Résumé

Les implants recouverts de phosphate de calcium (CP) sont habituellement considérés comme ayant des propriétés ostéoconductrices tandis que les implants titane avec une couche d'origine d'oxyde sont considérés moins ostéoconducteurs. Les oxydes de titane lisse sont comparés à des structures CP relativement rugueuses. L'objectif de cette étude a été d'évaluer l'ostéoconduction en comparant le contact os/implant à un recouvrement CP haute ment cristallin et relativement lisse avec une surface en oxyde de titane (TO, TiUnite®) modifiée et poreuse. Dix chiens Labrador hétérois ont servi pour cette étude. Quatre implants en titane [Nobel Biocare] recouverts de CP[2] ou avec surface modifiée [2] ont été placés douze semaines après les avulsions des molaires et prémolaires mandibulaires. Les implants étaient alternés à l’intérieur et entre les quadrants des animaux. Des lambeaux muqueux ont été suturés en enfonçant les implants. Les animaux ont reçu une injection de marqueurs osseux fluorescents à trois et quatre semaines après la chirurgie et avant l’eutanasie pour suivre la progression de la formation osseuse. Ils ont été euthanasiés huit semaines après la chirurgie et les biopsies en bloc ont été préparées pour l’analyse histologique et histométrique. Il n’y avait aucune différence marquante dans la formation osseuse et contact apparent os/implant en comparant les surfaces recouvertes de CP et modifiées TO. Cependant les contacts moyens mesurés os/implants étaient respectivement de 71 et 57% (P = 0.027) pour les implants modifiés TO et recouverts CP. La surface TO possède des propriétés ostéoconductrices excédant celles procurées par la surface en phosphate de calcium. Une ou plusieurs des propriétés chimique et physique de la surface TO peuvent résulter dans une formation osseuse impressionnante le long de sa surface. Cette étude indique que la cristallinité et la chimie ou les deux ont leur importance.

Zusammenfassung

Ziel: Oft wird behauptet, dass mit Calcium-Phosphat (CP) beschichtete Implantate osteoinduktive Eigenschaften aufweisen, währenden Titanimplantate mit der ursprünglichen Oxidschicht als eher weniger osteokonduktiv gelten. Sehr oft werden dabei glatte Titanoxidoberflächen mit eher rauen CP-Strukturen verglichen. Das Ziel dieser Studie war, die Osteokonduktivität zu untersuchen. Dabei verglich man den Knochen-Implantatkontakt von relativ glatten, hochkristallinen CP-Beschichtungen mit einer strukturierten, porösen Titanoxidoberfläche (TO, TiUnite®).

Material: Man verwendete dazu 10 erwachsene Labradorhunde (Bastarde). 12 Wochen nach der Ex traction der Unterkieferprämolare und -molare setzte man vier Titanimplantate [Nobel Biocare], zwei davon mit CP beschichtet und zwei mit TO-Oberflächen. Man wechselte bei jedem folgenden Tier die Implantatlösung, sowohl innerhalb wie auch unter den Kieferquadranten. Zuerst mobili sierte man Mukoperiostlappen und vernähte sie anschließend so, dass die Implantate transmukosal einheiten. 3 und 4 Wochen nach der Chirurgie, sowie direkt vor der Euthanasie injizierte man den Tieren fluoreszierende Knochenmarker, um die Knochenbildung mitverfolgen zu können. 8 Wochen nach der Chirurgie tötete man die Tiere, entnahm Blockbiopsien und präparierte sie für die histologi schen und histometrischen Analysen.

Resultate: Man fand zwischen den TO-Oberflächen und den mit CP beschichteten Oberflächen keine deutlichen Unterschiede, weder bei der Knochenbildung, noch im entstandenen Knochen-Implantat kontakt. Der durchschnittlich gemessene Knochen-Implantatkontakt war jedoch bei den TO-Implantaten 71% und bei den CP-Implantaten 57% (P = 0.027).

Zusammenfassung: Wir schliessen daraus, dass die TO-Oberflächen osteoinduktive Fähigkeiten besitzen, die besser sind als diejenigen der CP-Oberflächen. Eine oder mehrere der chemischen und physikalischen Eigenschaften der TO-Oberflächen führen wahrscheinlich zu der beträchtlichen Knochenbildung entlang dieser Oberflächen. Diese Studie zeigte, dass Kristallinität und/oder Chemie der Oberflächen wichtig sein können.

Resumen

Antecedentes: Se suele referir sobre los implantes recubiertos de fosfato cálcico (CP) como poseedores de propiedades osteoconductivas, mientras que los implantes de titanio con una cubierta de óxido

nativo se consideran menos osteoconductivos. Fre-

cuentemente óxidos de titanio suaves se comparan

con estructuras CP relativamente rágosas. El obje-

tivo de este estudio fue evaluar la osteoconducción

comparando el contacto hueso-implante sobre una

cubieta CP relativamente lisa, altamente cristalina

con una superficie estructurada, porosa modificada

de óxido de titanio [TO; TruTiute®].

Materiales: Se usaron diez perros Labrador mongrel. Se

instaló cuatro implantes de titanio (Nobel Biocare) con cubierta de CP [2] o con superficie modificada de TO [2] 12 meses tras la extracción de los premolares y molares mandibulares. Estos implantes se alteraron con y entre cuadrantes max-

ilor o premolares y molares. Estos implantes

se inyectaron con marcadores óseos fluorescentes a

modificada de TO (2) 12 meses tras la extracción e

histomorfométrico.

Se usaron diez perros Labrador mongrel. No

hubo diferencias remarcables en la

formación de hueso y aparentemente en el contacto

hueso-implante comparando las superficies TO

modificado y cubierta CP. De todos modos, el

contacto medio medió fue 71% y 57%

(p=0.002) para los implantes TO modificado

cubierto CP, respectivamente.

Conclusiones: Concluimos que la superficie TO

exhibe propiedades osteoconductivas excediendo

aquellas de la superficie de fosfato cálcico. Una o

varias de las de las propiedades químicas y físicas de

la superficie TO pueden resultar en una notable

formación ósea a lo largo de su superficie. Este estudio indica que la cristalinidad y/o la química pueden ser importantes.

要旨

背景: 健酸カルシウム (C P) コーティングのイン-

プラントは通常骨伝導性を有しているとされて

いるが、他のチャタン-イオンプラントは生体の酸化被

膜を持ち、骨伝導性は低いとされている。酸

化した酸性チャタンは比較的弱いとCP構造と比較され

ることが多い。本研究の目的は、骨-イオンプラント

の接触を比較的詳しく、高度に結晶化したCP

コーティング、構造化され、多孔性の酸化チャタン

(TO: TruTiute®) 修飾表面を比較し、骨伝導

性を評価することであった。

Materials and Methods: The study included

10 Labrador mongrel dogs. The study was designed

as a randomised controlled trial with four

implants of titanium (Nobel Biocare) with a CP

coating or TO surface. The implants were placed

in the premolars and molars. They were

implanted with and between quadrants max-

ilor or premolars and molars. They were

injected with osteogenic fluorescent markers at

12 months after extraction and

histomorphometry. Ten Labrador mongrel dogs

were used. There were no remarkable differences

in bone formation and apparently in the bone-

implant interface comparing the TO-modified and CP

coating. The contact mean was 71% and 57%

(p=0.002) for TO-modified and CP-coated implants,

respectively.

Conclusions: We concluded that the TO surface

exhibits osteoconductive properties exceeding

those of the calcium phosphate. One or several of the properties of chemical and physical nature of the TO surface may result in a notable bone formation over a long period of its surface. This study indicates that the crystallinity and/or the chemistry may be important.

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