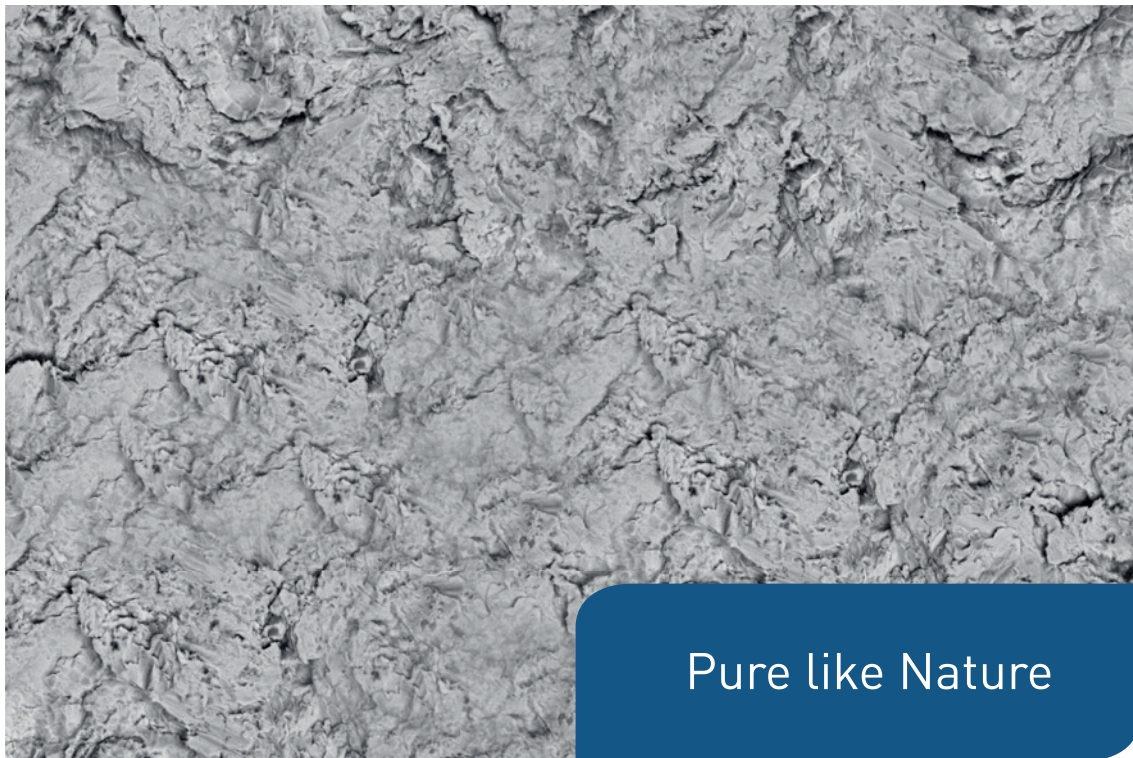


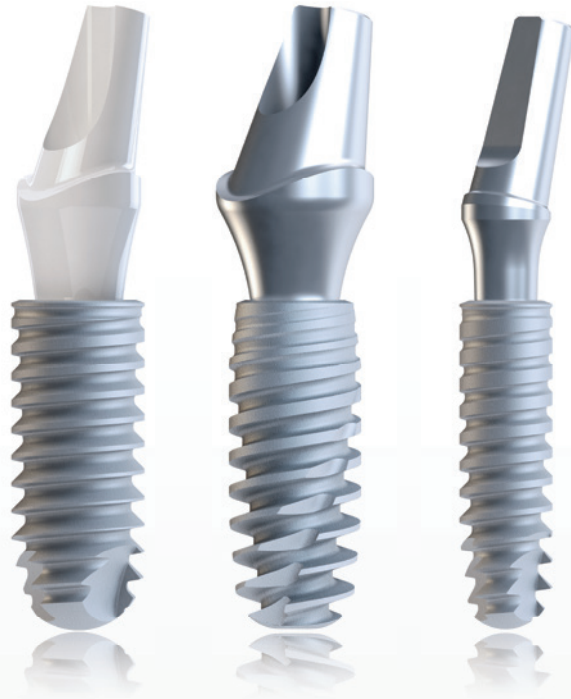
# BCP<sup>®</sup> SURFACE TREATMENT

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## BIBLIOGRAPHY



Pure like Nature



The **BCP**<sup>®</sup> surface treatment available with Anthogyr implants supports rapid and effective osseointegration.

Its potential in terms of osteoconduction ensures early osteoblast differentiation, which facilitates mechanical fixation of the implant.

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## 1 - ARTICLE : INFLUENCE OF SURFACE CHARACTERISTICS ON BONE INTEGRATION OF TITANIUM IMPLANTS. A HISTOMORPHOMETRIC STUDY IN MINIATURE PIGS.

**Journal :** Journal of Biomedical Materials Research, 1991, Vol.25, p.889-902

### PURPOSE

→ The purpose of this study was to evaluate the influence of different surface treatments on osseointegration.

### ABSTRACT

Implants were placed in the femurs of miniature pigs. After 3 and 6 weeks respectively, the implants were removed and analyzed. Significant differences were noted in the **percentage of B.I.C. (Bone Implant Contact)**.

Polished, sandblasted with fine grit, or acid etched implant surfaces had the lowest percentage of **B.I.C. (B.I.C. < 25%)**.

Grit-blasted (coarse grit) or **T.P.S.** (Titanium Plasma Sprayed) implant surfaces demonstrated mean bone-implant contact (**B.I.C. = 30 and 40%**).

Grit-blasted (coarse grit) and acid attacked implant surfaces, as well as **HA** (HydroxyApatite) coated implants had excellent results (**B.I.C. = 60 and 70%**).

**It can be concluded that surface roughness is positively correlated with osseointegration.**

### MATERIALS & METHODS

Six different types of implants were placed in the femurs of 12 miniature pigs.

The 6 implant groups are presented in the following table.

GROUPS	SURFACE TREATMENTS	CHARACTERISTICS OF THE TREATED SURFACE
G1	Electropolishing	Smooth and even
G2	Sandlasting (fine grit) + acid	Linear deformation
G3	Sandblasting (coarse grit)	Rough
G4	Sandblasting (coarse grit) + acid	Slightly rough + fine secondary structure
G5	TPS	Rough and porous
G6	HA	Rough and porous

## RESULTS

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Polished, sandblasted with fine grit, or acid etched implant surfaces had the lowest percentage of **B.I.C.** (**B.I.C.** < 25%).

Grit-blasted (coarse grit) or **T.P.S.** implant surfaces demonstrated mean bone-implant contact (**B.I.C.** = 30-40%).

Grit-blasted (coarse grit) and acid attacked implant surfaces, as well as **HA**-coated implants had excellent results (**B.I.C.** = 60-70%).

After 3 and 6 weeks respectively, osseointegration was far better in group 6 (**HA**) than in any of the other groups. Therefore, surface roughness definitely influences osseointegration. In group 6 (**HA**), **B.I.C.** is much higher, indeed, but bone resorption is also higher.

## CONCLUSION

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Rough surfaces definitely enhance bone-implant contact (**B.I.C.**).

Acid etching also has a marked positive influence on bone-implant contact.

It can be concluded that sandblasted, grit-blasted/acid etched, and **HA**-coated implants show real promise as compared to smooth or **T.P.S.** implants.

**Anthogyr implants have a BCP® (HA +  $\beta$ -TCP) surface that yields superior osseointegration rates as compared to the other test groups.**

**Authors :** A. CITEAU, J. GUICHEUX, C. VINATIER, P. LAYROLLE, T.P. NGUYEN, P. PILET, G. DACULSI

## 2 - ARTICLE : IN VITRO BIOLOGICAL EFFECTS OF TITANIUM ROUGH SURFACE OBTAINED BY CALCIUM PHOSPHATE GRIT BLASTING.

**Journal :** Biomaterials, 2005, Vol.26, p.157-165

### PURPOSE

- Measure the roughness of treated surfaces.
- Evaluate the biocompatibility of treated surfaces.

### MATERIALS & METHODS

Titanium discs were cleaned with acetone and then randomly distributed **3 groups**.

**Group 1 : Polished discs**

**Group 2 : BCP® grit-blasted discs passivated using nitric acid**

**Group 3 : Passivated discs**

To assess cell viability, cells were placed either on titanium discs or on plastic blades.

### RESULTS

#### Surface roughness

Surfaces in **group 1** were smooth and featureless. In contrast, surfaces in **groups 2 and 3** were rough and uneven. The results are highly significant and demonstrate that **BCP® treatment results in more erosion**. Erosion was less uniform (higher Ra) in the **BCP®** group (Group 2) than in the other 2 groups. Furthermore, **BCP®** had the lowest roughness crest area (which means a rougher and more aggressive surface).

**Group 2 (BCP®)**, displayed reduced titanium and carbon concentrations.

**Surface carbon contamination** was observed in **group 3**.

#### Morphology of osteoblastic cells.

Cell morphology varied across the groups :

**Groupe 1 (Tipolish = standard treatment) :** Cells were very much scattered and widely spread and had a lamellar morphology.

**Group 2 (Tiblast = BCP® grit-blasting + acid passivation):** Cells had a normal, round shape and exhibited few cytoplasmic extensions.

**Group 3 (Tipassiv = acid passivation):** Cells had a rather normal, round shape and exhibited many cytoplasmic extensions.

#### Viability of osteoblastic cells.

Whatever the surface treatment used, after 4 days cells began to senesce ( $p < 0.01$ ).

After 8 days, there was no significant difference between the cells in the control group (plastic blades) and the cells in the test groups.

**In the BCP® group, the osteoblastic cell activity was significantly reduced after 4 days.**

**But after 8 days and 15 days respectively, the difference became irrelevant.**

**The best results were achieved with the plastic blade and the acid treatment.**

**Anthogyr implants have a BCP® surface. Osteogenic cells definitely bind to this rough surface with high affinity.**

**→ All Anthogyr implants promote osseointegration, contrary to the conventionally processed implants.**

Author : G. DACULSI

### 3 - ARTICLE : BIPHASIC CALCIUM PHOSPHATE CONCEPT APPLIED TO ARTIFICIAL BONE, IMPLANT COATING AND INJECTABLE BONE SUBSTITUTE

Journal : Biomaterials, 1998, Vol.19 , p.1473-1478

#### PURPOSE

→ This study describes the chemical reactions of BCP® on implant surface and on cells.

#### ABSTRACT

Developing calcium phosphate ceramics and other biomaterials requires a perfect control of the processes of biomaterial resorption and bone substitution. A bioactive concept was developed using biphasic calcium phosphate (BCP®). This study describes the biomaterial-bone interface and the dynamic process which enables this interface to develop (i.e. cellular response, biodegradation, bioresorption).

#### INTRODUCTION

**BCP® consists of a mixture of calcium phosphate in its most stable phase and hydroxyapatite in the form of tricalcium phosphate (TCP) that will easily and rapidly dissolve in the peri-implant tissue.**

#### MATERIALS & METHODS

**BCP® is available as blocks or granules, with a dense or porous structure.**

**The characteristics of the surface (i.e. roughness, porosity) achieved after sandblasting influence the physico-chemical properties of the implant.**

Sandblasting uses biocompatible particles. Formerly, the surface treatments (mainly hydroxyapatite) used for implants were not considered to be bioactive and bioabsorbable. **The major advantage of BCP® is that it promotes bonding to bone tissue or intimate contact with bone, contrary to inert or bio-tolerant materials.**

#### RESULTS

Although the **BCP® resorption rate depends on the  $\beta$ -TCP/HA ratio, it is usually quite high.** The  $\beta$ -TCP resorption rate is much higher than that of HA.

**The formation of apatite crystals similar to natural apatite crystals indicates that a resorption process is taking place.**

Here is the sequence of events that are considered crucial factors in the formation of a strong interface between bone and a bioactive material :

- Acidification of the microenvironment due to interactions with the material.
- Dissolution of calcium phosphate resulting in the formation of carbonate hydroxyapatite (CHA) associated with the development of an organic matrix.
- Production of an extracellular matrix.
- Mineralization of collagen fibers and incorporation of the CHA crystals in the remodelling new bone.

**Therefore, the development of this interface is not a static, but a continuous dynamic process** that is influenced by biomechanical factors and bone maturation. **Implants coated with phosphate calcium have shown to promote bone ongrowth and to provide maximum contact area without fibrous encapsulation.**

#### CONCLUSION

The three different types of BCP® have similar interactions with the host tissue.

- **1.** Calcium phosphate concentration increases as CaP is dissolving.
- **2.** CHA (carbonate hydroxyapatite) is formed.
- **3.** Carbonate-rich apatite crystals associate with the organic matrix.
- **4.** Crystals dissolve in the collagen matrix.

**These chemical processes encourage the development of the tissue and cells that enhance the bone-implant interface.**

**BCP® is biocompatible and absorbable.**

→ **All Anthogyr implants have a BCP® surface. BCP® treatment is highly biocompatible with the peri-implant area.**

**BCP® treatment ensures a strong bond between the bone and the implant through the development of a collagen matrix.**

→ **Anthogyr implants promote the development of a bone-implant interface.**

Authors : I. ERICSSON, CB. JOHANSSON, H. BYSTEDT, MR. NORTON

## 4 - ARTICLE : A HISTOMORPHOMETRIC EVALUATION OF BONE-TO-IMPLANT CONTACT ON MACHINE-PREPARED AND ROUGHENED TITANIUM DENTAL IMPLANTS

Journal : Clinical Oral Implant Research, 1994, Vol. 5, p.202-206

### PURPOSE

- Assess the torque necessary to remove an osseointegrated implant.
- Compare the removal torque levels with the identified osseointegration level.
- This study compares the osseointegration capacity of an implant treated with titanium oxide versus machined implants.

### ABSTRACT

**Two types of implants** were used to replace maxillary **premolars in dogs**. **Osseointegration was evaluated at 2 and 4 months** respectively. **Machined implants and TiO<sub>2</sub>-blasted implants were tested**.

The overall success rate was 95%.

**The 4 month results show that the TioBlast technique ensures better osseointegration than standard machining.**

### STUDY

According to Albrektsson [1981], **osseointegration is defined as «direct contact (at the light microscope level) between living bone and implant»**. Implant anchorage depends on a variety of factors including material biocompatibility, surgical technique, placement site, and biomechanical factors. Initial stability is critical to osseointegration.

### MATERIALS & METHODS

**A total of 20 implants (10 machined implants, 10 TiO<sub>2</sub>-blasted implants) were placed** in five 2-year-old dogs. Subsequently, the teeth were extracted, and the extraction sites were closed using sutures which were removed 10 days later. **Each dog received 4 implants (2 standard implants (machined) and 2 treated implants (TiO<sub>2</sub>-blasted)**. Four months after the implantation, the dogs were sacrificed.

**The maxillary bones were removed and the implants were analyzed at 2 and 4 months respectively.**

### RESULTS

Out of the 20 implants installed, all but one were successfully integrated. At 2 months, there was hardly any difference in osseointegration between the two test groups. In contrast, whereas in the «machined» group, osseointegration was quite similar at 2 and 4 months (40% contact surface), in the «TioBlast» group there was a significant improvement in the osseointegration capacity (from 40.5% to 65.1%) at 4 months.

**Anthogyr implants have a BCP® (HA + β-TCP) surface.**

**This rough surface enhances primary fixation so that implants are rapidly ingrown.**

**Therefore, the Anthogyr surface treatment does promote osseointegration.**

**→ As compared to machined, non-treated implants, BCP®-treated implants ensure good osseointegration.**



Authors : E.GOYENVALLE, E.AGUADO, R.COINET, X.BOUGES, G.DACULSI

## 5 - ARTICLE : CALCIUM PHOSPHATE CERAMIC BLASTING ON TITANIUM SURFACE IMPROVES BONE INGROWTH.

Journal : Key engineering materials, 2008, Vols. 361-363, p.1351-1354

### PURPOSE

→ The purpose of this study was to evaluate both the osseointegration capacity of a BCP®-treated implant and the cytotoxicity of BCP® treatment.

### ABSTRACT

The **roughness** of an implant surface can be **obtained by blasting** with silica sand or aluminum oxide.

However, **one disadvantage of this technique is the release of cytotoxic ions into the peri-implant tissue.**

**BCP® blasting produces a biocompatible rough surface which is free of contaminants.**

**The results of this study show that BCP® surface treatment promotes fast and effective osseointegration, with no contamination of the adjacent tissue.**

### STUDY

The surface roughness of an implant affects the behaviour of bone cells. On the one hand, it enhances cell attachment, and on the other hand it alters cell function and activity.

**Grade V titanium implants were evaluated.**

### RESULTS

**Machined implants had a smooth surface.** At 6 weeks, **osteogenic cell attachment was not conclusive.** At 12 weeks, direct bone-implant contact was observed.

**In contrast, the BCP®-treated implants had a very rough and uneven surface.** In any case, whether it be at 6 or 12 weeks, **direct bone-implant contact had occurred, providing good initial stability for subsequent osseointegration. Furthermore, no calcium [Ca] or phosphorus [P] particulate debris were found,** which proved the superior cleanliness of BCP-treated implants.

**BCP® is a biocompatible, osteoconductive material. It does not involve contamination of the adjacent tissue with cytotoxic elements.** In addition, **cell activity and response seem to be preserved.**

### CONCLUSION :

Based on these results, it can be concluded that this **surface treatment ensures fast and effective osseointegration, with no contamination of the adjacent tissue.** It is definitely a good alternative for treating implant surfaces.

**Anthogyr implants have a BCP® (HA +  $\beta$ -TCP) surface that ensures rapid osseointegration, with no harmful contamination of the peri-implant tissue.**

→ **BCP® surface treatment promotes osseointegration and provides superior cleanliness.**

**Only Grade V titanium implants with the same composition as Axiom® Anthogyr implants were evaluated in this study.**

→ **The results achieved with our implants are consistent with those presented in this study.**

## 6 - ARTICLE : INTEGRATION OF SCREW IMPLANTS IN THE RABBIT. A 1-YEAR FOLLOW-UP OF REMOVAL TORQUE OF TITANIUM IMPLANTS.

**Journal :** The international Journal of Oral & Maxillofacial Implants, 1987, Vol.2, p.69-75

### PURPOSE

→ The purpose of this study was to evaluate the torque needed to remove a well fixed implant, and to establish the correlation between the torque level and the degree of osseointegration.

### ABSTRACT

Implants were placed in rabbit tibiae. After a healing time of 3 weeks, the average removal torque was evaluated at 1 month, 3 months, 6 months and 12 months respectively. **The results showed a gradual increase in the bone-implant contact area with time. It appeared that the longer the implantation time, the higher the torque level.**

### STUDY

The causes of failure may also be attributable to implant manufacturing defects or improper implants. The aim of the study was to evaluate the torque needed to remove a well fixed implant, and to establish the correlation between the torque level and the degree of osseointegration of Branemark titanium implants.

### MATERIALS & METHODS

Implants were placed in 25 rabbits (aged 9-12 months) which were distributed in 5 groups. The rabbits were sacrificed at 3 weeks, 1 month, 3 months, 6 months and 12 months respectively. At between 3 weeks and 1 year post-implantation, the sites were reopened. **A gauge manometer was used for direct reading of the removal torque. Subsequently, the tibiae were osteotomized to evaluate the bone-implant contact. A correlation between osseointegration and removal torque could be established by comparing the torque levels with the bone-implant contact areas.**

### RESULTS

Results show that the **torque required to remove a well fixed implant increases with time** (from 10.8 Ncm after 3 weeks to 88 Ncm after 1 year). The same goes for osseointegration; **results show that the bone-implant contact area increases with time** (from 20% after 1 month to 85% after 1 year). The discrepancies in the values suggest that skeletal maturation may vary among animal species. Besides, regarding cell activity, the results need to be put into perspective considering that bone maturation time was 3 months.

### CONCLUSION

There is indeed, a strong correlation between the degree of osseointegration and the torque required to remove the implant. **As a matter of fact, the torque level increases as the bone-implant contact area increases.** Previous findings stressed the importance of the post-surgical period when the implant is not loaded immediately. **But, more importantly, as shown in this study, a case-to-case approach should be the rule.**

**The correlation between osseointegration and torque has been demonstrated. If osseointegration occurs rapidly, the implant will be well fixed and removal will require more torque.**

→ The BCP® treatment used by Anthogyr promotes osseointegration, thus ensuring early fixation of the implant.

Authors : L. LE GUEHENNEC, A.SOUeidAN, P.LAYROLLE, Y. AMOURIQ

## 7 - ARTICLE : SURFACE TREATMENTS OF TITANIUM DENTAL IMPLANTS FOR RAPID OSSEOINTEGRATION

Journal : Dental Materials, 2007, Vol. 23, p.844-854

### PURPOSE

→ The aim of this study was to better understand the interactions between proteins, cells, tissue, and implant surfaces

**Surface roughness** supports bone growth over the surface of the implant and contributes to **biomechanical stability**. Calcium phosphate coatings promote bone resorption and rapid ongrowth.

Several factors such as **composition, wettability, and roughness of the implant surface** play a major role in the interactions **between the implant and the bone**, and therefore in implant osseointegration.

The vast majority of **implants** are made of **Grade IV titanium or Grade V titanium alloy** as titanium is known for its great strength. The more hydrophilic the implant surface, the better the osseointegration.

A number of studies have demonstrated that **rough surfaces** provide better **mechanical stability and primary fixation** than smooth surfaces. **However, excessive roughness** is associated with a potential risk of **peri-implantitis**.

It has been demonstrated in a clinical study that there is **no significant difference between an SLA implant (e.g. Straumann) and a TPS (titanium plasma spray) implant**. But, the bone-implant contact area achieved with a TPS implant is much smaller than with an HA-coated implant.

The sandblasting technique yields very good results.

**Three types of abrasives are commonly used :**

→ **Aluminum oxide - RESULTS : good osseointegration. HOWEVER, residues have been observed.**

→ **Titanium dioxide - RESULTS : better than with standard machining.**

→ **Biocompatible, absorbable material (e.g. BCP) - RESULTS : better bone-implant contact than with standard machining, BUT similar to that achieved with other sandblast abrasives. One important point is that no potentially cytotoxic contaminants are released (contrary to aluminum oxide).**

### ACID ETCHING AND PASSIVATION

**Acid attacked implant surfaces exhibit higher osteoconductive properties and promote the development of fibrin and osteoblastic cells.**

Furthermore, studies showed that **less bone resorption occurs with acid etched implants than with machined implants.**

Lastly, the hydrophilic properties of the implant surface affect (positively or negatively) the bone-implant contact.

**The more hydrophilic the implant surface, the better the contact.**

### FUTURE TRENDS IN SURFACE TREATMENT

In future, the development of surface treatments will no doubt focus on nanometric scale roughness. As a matter of fact, **nanometric roughness would seem to positively influence cell activity and development of osteoblastic cells.**

### ASSOCIATED DRUG THERAPY

An associated drug therapy in the form of **agents stimulating the development of bone proteins** may be a good strategy. The only known limitation to this therapy is the use of a time release drug. Moreover, an overproduction of proteins may have a deleterious effect once the healing and osseointegration processes have been completed.

Another option would be to **load the implant surface with a bone resorption inhibitor such as the biphosphonate**. Some studies reported the absence of negative or detrimental effects but **no real improvement in the osseointegration capacity**. Furthermore, the amount of molecules necessary to minimize bone resorption will have to be adjusted to the increase in the peri-implant bone density since the effects of biphosphonate are dose-dependent.

### CONCLUSION

A number of surface treatment options are available, and by and large, all those which produce a very rough surface are successful. The thing is, most studies are trial-and-error studies using non-standardized methods. In other words, the rationale for the impact of these treatments on osseointegration cannot be clearly established. Furthermore, very few comparative studies are available on the different surface treatments.

**Anthogyr implants have a BCP® surface, and therefore ensure a good bone-implant contact.**  
 → **All Anthogyr implants promote osseointegration, contrary to the conventionally processed implants. This owes to their excellent surface roughness and wettability.**

Authors : L. LE GUEHENNEC, M.A. LOPEZ-HEREDIA, B. ENKEL, P. WEISS, Y. AMOURIQ, P. LAYROLLE

## 8 - ARTICLE : OSTEOLASTIC CELL BEHAVIOUR ON DIFFERENT TITANIUM IMPLANT SURFACES

Journal : Acta Biomaterialia, 2008, Vol.4, p.535-543

### PURPOSE

→ The purpose of this study was to evaluate the behaviour of osteoblastic cells on four different implant surfaces.

### ABSTRACT

The degree of osseointegration of an implant is highly dependent on the interactions between cells and surface finish.

Four different types of surface treatments have been evaluated :

- 1. Machining and polishing
- 2. Alumina grit-blasting
- 3. **BCP**<sup>®</sup> grit-blasting
- 4. **SLA**

**The aim of this study was to evaluate the behaviour of osteoblastic cells on 4 different implant surfaces.**

The studies conducted on the topography and wettability of implant surfaces consistently show that **BCP**<sup>®</sup> implants have the roughest surface, alumina grit-blasted implants the most hydrophilic surface, and SLA implants the most hydrophobic surface.

Carbon and titanium dioxide residues were present on all tested surfaces.

**Alumina grit-blasted implants were contaminated with aluminum whereas BCP implants had a clean rough surface.**

**Groups 3 (BCP<sup>®</sup>-Ti) and 4 (SLA) displayed good cell activity** with a layer of cells covering the implant surface after 2 days. The cells exhibited extensions.

**Cell viability was similar in Groups 1 (machined/polished) and 2 (Alumina-Ti) and much higher in Groups 3 (BCP<sup>®</sup>-Ti) and 4 (SLA).**

### STUDY

**The big challenge is to attract and retain osteoblastic cells in order to optimize the bone-implant contact.** It has previously been shown that **attachment of the osteoblastic cells is directly correlated with surface roughness and energy.** The goal is to capture fibrous proteins.

**Alumina particles have been found.** These contaminants may impede osseointegration.

A biocompatible sandblasting technique (**BCP**<sup>®</sup>) using **absorbable materials** has been shown to provide an adequate surface **roughness**.

### MATERIALS & METHODS

The implants were machined and polished using silicon carbide paper. The **SLA** implants supplied by Straumann were treated with aluminum oxide. The **BCP**<sup>®</sup> implants were grit-blasted with a biocompatible, absorbable material consisting of **HA** and **β-TCP**.

All the analyses were repeated 4 times in each group of implants. Cell viability was assessed after 4 days, 8 days and 15 days respectively by a colorimetric assay system.

In all our tests, a probability level less than 0.05 ( $p < 0.05$ ) was accepted as statistically significant.

### RESULTS

Alumina grit-blasting produced a rough surface but released contaminants. **Both BCP<sup>®</sup> and SLA implants had uneven surfaces.**

**BCP<sup>®</sup>-treated surfaces were similar to alumina grit-blasted surfaces but the interesting thing is that they were free of contaminants.**

Cells spread less on rough surfaces than on smooth ones. **Cell extensions were more numerous on SLA surfaces than on BCP<sup>®</sup>-treated or alumina grit-blasted surfaces.**

The results further demonstrate that **cell viability was much better on machined surfaces, and SLA and BCP<sup>®</sup>-treated surfaces.** After 4 days, the cell activity was quite similar. But, after 8 days and 15 days respectively, both cell viability and activity were slightly higher in the **SLA** and **BCP**<sup>®</sup> groups.

### CONCLUSION

**All the analyzed surfaces had good cytocompatibility whatever the blast material used. The BCP<sup>®</sup> treatment ensures adequate surface roughness using an absorbable, biocompatible material. The behaviour of osteoblastic cells was similar on BCP<sup>®</sup> and SLA implants.**

**BCP<sup>®</sup> grit-blasting is a surface treatment which produces an optimal surface roughness which enhances cell attachment.**  
→ All Anthogyr implants have a BCP<sup>®</sup> surface.

**Contrary to alumina grit-blasted surfaces (Straumann or Astra Tech), BCP<sup>®</sup>-treated surfaces are free of contaminants.**  
→ Anthogyr implants have a perfectly clean surface and do not impede osseointegration.

**Cell viability is much better on BCP<sup>®</sup>-treated and SLA surfaces than on smooth or alumina grit-blasted surfaces.**  
→ Anthogyr implants promote cell development, thus optimizing osseointegration.

Authors : D.A. PULEO, M.V. THOMAS

## 9 - ARTICLE : IMPLANT SURFACES.

Journal : The dental clinics of North America, 2006, Vol.50, p.323-338

In the USA, an average of 300,000 implants are placed each year. Over 220 trade names have been identified, which means that approximately 80 competitors are present on this market with about 2,000 different items.

The main goal in implantology is to promote a fast, guided and controlled osseointegration of the implants.

Many articles published in orthopaedic reviews and journals report the presence of trace amounts of metals in the peri-implant tissue or in urine. The long-term impact of this contamination is still unknown. However, these microparticles may have a toxic effect and cause hypersensitivity reactions to metal ions.

There is no interaction between cells and a bare surface. Therefore, the success of the implantation will depend on the interaction between hard and soft tissues.

In the apical zone, the presence of bone all around the implant is an indicator of success. There are two types of osteogenesis :

- Distance osteogenesis = formation of bone from the mineralized surface toward the implant surface
  - Formation of an osteogenic cell matrix
- Contact osteogenesis = formation of bone in direct apposition to the implant
  - New bone forms on the implant surface

### OSSEOINTEGRATION VS OSTEOCONDUCTION

Osseointegration was initially defined as «direct contact between living bone and implant». Later on, it was referred to as «direct structural and functional connection between ordered, living bone and the surface of a load-carrying implant.»

An osteoconductive surface is one that permits bone growth on its surface. The term «osteoconduction» takes into account the chemical composition of the surface material. However, the term «osseointegration» is preferably used.

There are two types of characteristics:

- Physical characteristics (i.e. topography, morphology),
- Chemical characteristics.

The mechanical interactions between the bone and the textured surface of the implant may result in osseointegration. The chemical interactions between the bone and the implant surface result in osteoconduction.

### PHYSICAL CHARACTERISTICS - SURFACE TOPOGRAPHY

The most commonly used parameter of surface topography is  $R_a$  or  $S_a$  (assess the average height on a profile or a surface).

Other parameters may be analyzed :  $R_a$  and  $R_{max}$ .

For instance, porous materials have a high surface roughness with large pores.

The studies conducted on bioactive materials showed proper development of bone cells in small size pores. Furthermore, a more intense cell activity was observed.

### CHEMICAL CHARACTERISTICS - SURFACE CHEMISTRY

Most implants are made of CP (commercially pure) titanium, but new alloys are being introduced. When exposed to oxygen, titanium becomes an oxide that is biocompatible. This chemical reaction can be induced by immersing the titanium in an acid solution; this treatment is called passivation.

Passivation results in modification of the surface energy and generation of cell and tissue reactions.

Calcium phosphate has been the subject of extensive investigation as its chemical properties are very similar to those of mineral bone.

## COMMONLY USED IMPLANT SYSTEMS

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Machined implants like Branemark implants have years of proven clinical performance.

However, most of them are smooth or slightly rough.

Since in vitro and in vivo studies showed that surface roughness promotes osseointegration, rough surfaces have been brought to the fore.

Surface roughening is generally obtained by sandblasting, passivation, or both.

## SANDBLASTING TECHNIQUES

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TiUnite (Nobel) is titanium oxide rendered into an osteoconductive ceramic biomaterial through spark anodization. This technique ensures a gradual surface roughness from peak to valley. In a recent study, 100% success rate was reported at 18 months.

Dual acid etching (**D.A.E.**) combines sulphuric and hydrochloric acids. The uneven **D.A.E.** surface ensures a better bone-implant contact than a machined surface. The major advantage of **D.A.E.** implants is that they allow early loading.

The plasma spraying technique is used to produce hydroxyapatite (**HA**) coatings. It modifies the structure and chemical composition of the implant surface. **HA** coatings have been reported to yield successful clinical outcomes, and periodontal measurements are not much different.

Titanium plasma sprayed (**T.P.S.**) surfaces are among the roughest implant surfaces. However, this process has been associated with titanium contamination of the peri-implant area.

## SUMMARY

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Implants are available in a variety of shapes, sizes, lengths and materials.

The continuous research of an ideal bone-compatible implant is giving great consideration to the impact of modifying an implant surface.

It has been shown that the use of proteins results in accelerated bone growth where bone is in direct contact with the peri-implant tissue interface.

**The primary purpose of this study was to better understand and characterize the existing implant surface treatments.**

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## 10 - STUDY : EVALUATING AND COMPARING THE CYTOCOMPATIBILITY OF THREE IMPLANT SURFACES

Oral communication : Europerio, April 2012

### PURPOSE

→ The aim of this experimental study was to evaluate and compare the cytocompatibility of three implant surfaces.

Three types of titanium pellets (surface sandblasted with **BCP**®, particles, surface sandblasted with glass particles (rough), and pure titanium surface (smooth)) were placed in multi-wells plates in direct contact with cultured osteoblastic cells.

After 2, 5 and 8 days of culturing, a cell count was performed. In addition, 2 tests\* were carried out to assess cells viability.

Contact with the **BCP**® resulted in :

- significantly higher cell proliferation from Day 5;
- significantly larger amount of total proteins from Day 8 denoting an increased metabolic activity, and therefore a better cell viability;
- significantly greater number of viable cells from Day 2.

Scanning Electron Microscopy (**S.E.M.**) observations confirm that cells definitely bind to **BCP**® with high affinity. From Day 2, cells are widely spread in all directions, resulting in a denser network that may be comprised of several layers of cells in thickness. In contrast, on the other two surfaces, convergence occurs on Day 8 only.

### CONCLUSION

Testing has demonstrated that the **BCP**® surface has a much better cytocompatibility than smooth and rough titanium surfaces.

As the topography and composition of this biomimetic surface seem to promote implant biointegration, it might be interesting to associate the surface with an active agent that would enhance the bioactivity of the material and thus further promote osseointegration.

**BCP**® promotes cell proliferation as well as significantly greater number of viable cells.

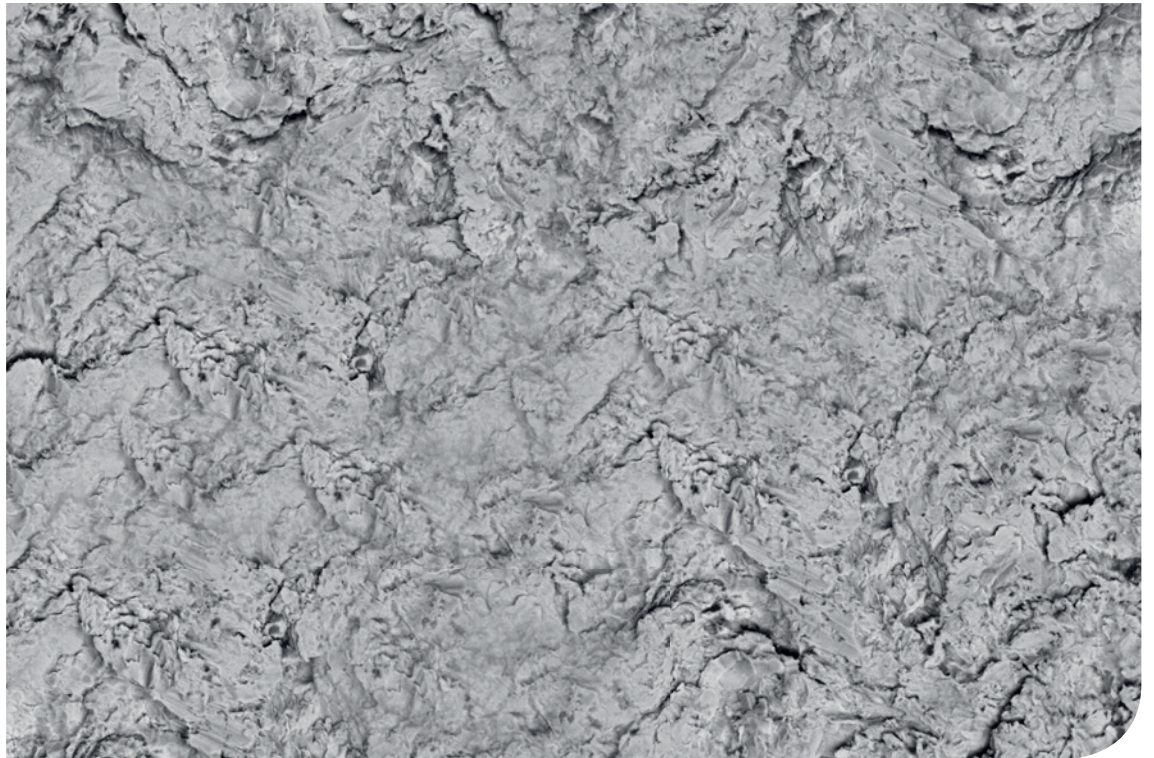
→ Anthogyr implants promote implant osseointegration.

**BCP**® surface allows a significantly higher number of cells that are widely spread in all directions.

→ **BCP**® treatment allows enhanced anchorage to Anthogyr implants.

\*Standard tests (ISO10993) were performed to evaluate cell proliferation and viability.





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