The BCP surface treatment available with dental implants supports rapid and effective osseointegration. Its potential in terms of osteoconduction ensures early osteoblast differentiation, which facilitates mechanical fixation of the implant.
1. Influence of surface characteristics on bone integration of titanium implants. A histomorphometric study in miniature pigs.
2. In vitro biological effects of titanium rough surface obtained by calcium phosphate grid blasting.
   Authors: A. CITEAU, J. GUICHELX, C. VINATIER, P. LAYROLLE, T. P. NGUYEN, P. PILET, G. DACULSI
3. Biphasic calcium phosphate concept applied to artificial bone, implant coating and injectable bone substitute.
   Authors: G. DACULSI
4. A histomorphometric evaluation of bone-to-implant contact on machine-prepared and roughened titanium dental implants.
   Authors: I. ERICSSON, C. JOHANSSON, H. BYSTEDT, M. R. NORTON
5. Calcium phosphate ceramic blasting on Titanium surface improve bone ingrowth.
   Authors: E. GOYENVALLE, E. AGUADO, R. COGNET, X. BOUGES, G. DACULSI
   Authors: C. JOHANSSON, C., ALBREKTSSON
7. Surface treatments of titanium dental implants for rapid osseointegration.
   Authors: L. le GUEHENNEC, A. SOUEIDAN, P. LAYROLLE, Y. AMOURIQ
8. Osteoblastic cell behaviour on different titanium implant surfaces.
   Authors: L. le GUEHENNEC, M. A. LOPEZ-HEREDIA, B. ENKEL, P. WEISS, Y. AMOURIQ, P. LAYROLLE
9. Implant Surfaces
   Authors: D. A. PULEO, M. V. THOMAS
10. Evaluating and comparing the cyto compatibility of three implant surfaces.
    Authors: Dr. B. GROS obstacles & P. RENOU
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.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Surface Treatments</th>
<th>Characteristics of the treated surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1</td>
<td>Electropolishing</td>
<td>Smooth and even</td>
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<tr>
<td>G2</td>
<td>Sandblasting (fine grit) + acid</td>
<td>Linear deformation</td>
</tr>
<tr>
<td>G3</td>
<td>Sandblasting (coarse grit)</td>
<td>Rough</td>
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<tr>
<td>G4</td>
<td>Sandblasting (coarse grit) + acid</td>
<td>Slightly rough + fine secondary structure</td>
</tr>
<tr>
<td>G5</td>
<td>TPS</td>
<td>Rough and porous</td>
</tr>
<tr>
<td>G6</td>
<td>HA</td>
<td>Rough and porous</td>
</tr>
</tbody>
</table>
RESULTS

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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

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.

BCP (HA + β-TCP) surface that yields superior osseointegration rates as compared to the other test groups.
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:

- **Group 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.

**BCP surface. Osteogenic cells definitely bind to this rough surface with high affinity.**

- **All** implants promote osseointegration, contrary to the conventionally processed implants.
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 β-TCP/HA ratio, it is usually quite high. The β-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.

- Calcium phosphate concentration increases as CaP is dissolving.
- CHA (carbonate hydroxyapatite) is formed.
- Carbonate-rich apatite crystals associate with the organic matrix.
- 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 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.
- Implants promote the development of a bone-implant interface.

PURPOSE

This study describes the chemical reactions of BCP® on implant surface and on cells.
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 TiO2-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 TiO2-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 (TiO2-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.

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.

4 - Article: A histomorphometric evaluation of bone-to-implant contact on machine-prepared and roughened titanium dental implants


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

Dental implants have a BCP® (HA + β-TCP) surface. This rough surface enhances primary fixation so that implants are rapidly ingrown. Therefore, the surface treatment does promote osseointegration.

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

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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 promotes osseointegration, thus ensuring early fixation of the implant.
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.
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® grit-blasting
4. SLA

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

The studies conducted on the topography and wettability of implant surfaces consistently show that BCP® 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®-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®-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®) 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® 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® and SLA implants had uneven surfaces. BCP®-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®-treated or alumina grit-blasted surfaces.

The results further demonstrate that cell viability was much better on machined surfaces, and SLA and BCP®-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® groups.

CONCLUSION

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

BCP® grit-blasting is a surface treatment which produces an optimal surface roughness which enhances cell attachment.

Contrary to alumina grit-blasted surfaces (Straumann or Astra Tech), BCP®-treated surfaces are free of contaminants.

⇒ implants have a perfectly clean surface and do not impede osseointegration.

Cell viability is much better on BCP®-treated and SLA surfaces than on smooth or alumina grit-blasted surfaces.

⇒ implants promote cell development, thus optimizing osseointegration.
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
  - New bone forms on the implant surface

- **Contact osteogenesis** = formation of bone in direct apposition to the implant

**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 «osteconduction» 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 $R_s$ or $S_z$ (assess the average height on a profile or a surface). Other parameters may be analyzed: $R_m$ 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

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

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

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.
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.
Good osseointegration is key to a successful restoration!

**Osseointegration** is defined as a direct structural and functional connection between ordered living bone and the surface of a load-carrying implant [at a light microscopic level] [PI Brånemark et A Schroeder] 4,9.

In other words, it is the firm anchorage of a dental implant that is provided by the growth of bone all around it.

Several factors contribute to an effective osseointegration and a successful outcome:

- **PERI-IMPLANT ENVIRONNEMENT**
  - Insertion site
  - Bone density
  - General health condition of the patient
  - Buccal hygiene

- **SUCCESSFUL RESTORATION**
  - Implant surface
  - Implant design
  - Thread design

- **IMPLANT ANCHORAGE**
  - Insertion site
  - Bone density
  - General health condition of the patient
  - Buccal hygiene

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**BONE REMODELLING PROCESS**

Image showing attachment of an osteoblastic cell to the interface matrix.

The successful outcome of a dental implant depends on the interaction between hard and soft tissues. It is important to have soft tissue developing all around the implant to protect the bone-implant interface against microbiological attacks. It has been demonstrated in several studies that rough surfaces provide a stronger anchorage in the jawbone than smooth surfaces.

Several parameters need to be optimized to encourage cell activity and promote implant anchorage:

**Primary stability:**
- The cells that die during drilling are eliminated by the osteoclasts during the bone resorption process.

**Secondary stability:**
- The osteoblasts (which are responsible for bone formation) invade the interfacial space between the implant and the host bone and create a bone matrix.

  The first 21 postoperative days are decisive in the process of implant anchorage and optimal bone remodeling.

A good oral hygiene is indispensable to reduce the risk of infection from endogenous or exogenous sources, and to achieve good tissue healing. The aim is to minimize the risk of contamination and thus optimize the chances of success.
BCP® - BIPHASIC CALCIUM PHOSPHATE

BCP® is the one solution to achieve a perfect osseointegration!

BCP® is 100% biocompatible. It is 100% biocompatible. The composition is similar to the mineral component of human bone. Owing to its excellent solubility, it allows passivation of the implant without using a strong acid.

The guarantee of a successful osseointegration with no contamination of the adjacent tissue. The implant is subjected to a mild acid treatment, and thoroughly rinsed and dried.

► A PURE, BIOCOMPATIBLE SURFACE

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- Owing to its excellent solubility, it allows passivation of the implant without using a strong acid.

The guarantee of a successful osseointegration with no contamination of the adjacent tissue.

► AN OPTIMAL SURFACE ROUGHNESS

- Macro-roughness is obtained by propelling BCP® particles onto the implant surface.
- A fine and close texture is obtained by passivation.
- Ra ranges from 1.5 to 2.0 µm.

Excellent primary anchorage guarantees primary stability which is essential for a rapid osseointegration.
Wettability of BCP®-treated implant surfaces is much higher than that of surfaces blasted with silica sand or aluminum oxide.  

Bone-implant contact (BIC) exceeds 70%.

Enhanced cell attachment and higher cell proliferation.  

Source: Study performed by LMI Laboratory, Lyon (FRANCE)  

Cross-section of a rabbit femur. The BCP®-treated surface shows significant bone ongrowth.
BCP® surface treatment ensures:
- Purity, superior cleanliness and biocompatibility \(^5,8\),
- Enhanced implant anchorage,
- Increased cell development \(^8\),
- Consistent surface finish thanks to a fully controlled treatment process,
- Achievement of successful osseointegration in more than 99% of the cases.*