Accelerated healing through the use of electrochemically deposited CaP BONIT® coatings
Osseointegration par Excellence

Background

The success parameters for joint replacement implants include rapid healing, optimal fixation, and long-term compatibility. Another key factor is osseointegration, whose rapidity and durability are determined by implant design, materials used and surface structure. Consequently, over the past few decades not only surface topography but also surface chemistry have been the major areas of focus for implant designers and users. In order to be deemed optimal, implant surfaces today must be macroporous and at the same time compatible with osteogenesis. This is where thin, bioactive calcium phosphate (CaP) coatings come into their own.

They imitate the mineral components of bone tissue, thus enabling these coatings to be integrated seamlessly into the bone tissue development process. As the boundary layer between the bone and implant, these coatings play an instrumental role in bridging the gap between them. The coating aids the healing process in osteoporotic bone.

CaP coatings optimise osseointegration even in lower quality bone and increase implant tolerance to micro movements. These characteristics make calcium phosphate coatings a helpful catalyst in connecting the patient’s tissue with the implant.

Technologies

The first CaP coatings that came on the market in the 1980s consisted of relatively thick (50 μm) and compact hydroxyapatite layers that were applied to the implant surface using the plasma spray technique.

Unfortunately, this process induces thermal degradation that has an adverse effect on coating quality. In addition, the so called “line of sight” spraying process is unsuitable for porous surfaces and complex implant geometries as only the external surfaces directly facing the spray gun are coated.

These factors, in addition to the limited bonding capacity and inhomogeneous solubility of these coatings, led implant developers to the realisation that for CaP coatings to provide long-term stability plasma sprayed coatings may not be necessary or even desirable. It has since been discovered that bioactive coatings on implant surfaces only need to last as long as it takes for implant osseointegration to be completed. Once this has occurred, the coating has fulfilled its purpose and should biodegrade to make way for new bone.

Thin, fully biodegradable and electrodeposited CaP coatings, are a further, essential development on plasma sprayed hydroxyapatite coatings. They, providing that they are endowed with good bioactive properties, eliminate the long term risks that are currently associated plasma sprayed coatings. The fluid-phase BONIT® coating process allows for the realisation of thin (approximately 20 μm) coatings with
an even and complete coverage on structured surfaces and complex implant geometries. The electrodeposition process produces a microporous structure with outstanding solubility and resorption characteristics. The electrodeposited BONIT® coating is manufactured at room temperature.

**Properties**

BONIT® is a composite of two thin microcrystalline CaP phases that have differing solubility characteristics. The more soluble phase (brushite) promotes short term bone synthesis, whereas the inner phase (microcrystalline hydroxyapatite) is resorbed more slowly and releases ions over a relatively long period.

This promotes bone formation. The coordinated bioactivity of these two phases greatly improves the healing process and fosters long-term implant tolerability.

The closely packed and almost perpendicular CaP crystals offer a large, open implant surface with a potent capillary effect on blood, beneficial for the adsorption of growth factors and for the attachment of bone cells.

The BONIT® coating process modifies the properties of the implant surface but has no effect on the chemical and physical properties or the biomechanical functionality of the implant material itself.

**Advantages at a glance**

- Outstanding biocompatibility
- Thin coating
- Microcrystalline structure, large open surface
- High solubility and controlled resorption area
- 100 percent and even coverage of porous surfaces and complex implant geometry
- Non-line of sight process
- No particle shedding or flaking

**SEM pictures of BONIT® coated surface**

- Coating thickness: 20 ± 10 μm
- Ca/P ratio: 1.1 ± 0.1
- Phase composition: Brushite and hydroxyapatite
- Fatigue strength: BONIT® has no measurable impact on this parameter
- Biocompatibility: Heavy metal content lower than ASTM F 1185 and ASTM F 1609 standards
Since BONIT® was first marketed in 1995, more than 2,300,000 orthopaedic and dental implants have been coated with BONIT® coatings.

Animal studies and clinical trials have provided impressive proof of the efficacy of BONIT® coatings. Accelerated implant healing, increased bone formation and improved mechanical implant anchoring have been observed especially in the early post-implant phases. This means that the load bearing properties of the implant are restored at an early stage. BONIT® coatings are completely resorbed in a controlled way (approximately six to twelve weeks following implantation) and are simultaneously replaced by bone.

The coatings are well tolerated and no inflammatory or rejection processes have been reported.

**Clinical results**

**Literature**

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