

FROM MICRO-ROUGHNESS TO RESORBABLE BIOACTIVE COATINGS

S. Szmukler-Moncler¹, P. Zeggel², D. Perrin³, P. Becker², H.G. Neumann²

¹ Dpt of Stomatology & Maxillo-facial surgery, UFR 068, Salpêtrière Hospital, University of Paris VI, Paris, F

² DOT GmbH, Rostock, D; ³ Odontology Dpt, CHRU Dijon, Dijon, F

E-mail : ssm@bluewin.ch

Introduction

In dental implantology, bioactive coatings made of the calcium phosphate (CaP) family have been proven to foster bone healing and increase the tolerance to micro-motion during the healing phase. However, long-term concerns have been documented that can lead to late infections, heavy bone loss and implant removal. In order to eradicate the long-term potential problems of plasma-sprayed bioactive coatings, a resorbable bioactive coating has been developed, obtained by electro-chemical deposition.

Formulation of a resorbable bioactive coating should meet simultaneously several conditions, i.e., 1) enough solubility to be completely dissolved during the first months after implantation, 2) a dissolution kinetics capable of initiating the cascade of events that leads to bioactivity before having vanished, 3) the heavy release of Ca and PO₄ ions during the dissolution phase should not interfere with the on-going osseointegration process.

This paper deals with the issues related to resorbable coatings and the various in-vivo and human histology that have been obtained so far with this coating (BONIT / FBR / μ -CaP).

Material & Methods

Brushite is a precursor of HA, it has been chosen as a coating material because of its high solubility. This should guarantee complete dissolution within a short period of time. A consistent amount of brushite particles was found in the external periosteal callus of children by Cui et al. (1996). These authors suggested that children might heal faster because of the presence of brushite particles, a ion reservoir for bone matrix mineralization.

Coating characterization

The composition of the coating is mainly brushite, it is 15-20 μ m thick, with a Ca/P of 1.1 \pm 0.1 and plates 10-20 μ m long. The coating is highly porous, displaying a peculiar high capillarity effect that attracts blood in depth.

Bioactivity

Bioactivity of the coating has been demonstrated in-vivo. In a pig model, coated and non-coated Pitt-Easy implants were placed in the maxilla for 6 weeks. The bone-implant contact (BIC) was higher at the coated implants, 73.0 \pm 6.2 % vs. 49.8 \pm 16.4 % (+ 23 %). In a transcortical model in the mini-pig femur, Schwarz et al. (2003) found a higher amount of bone at the coated implants, 48.8 \pm 4.5 % vs. 22.4 \pm 4.5 % (+ 26.4 %).

Dissolution window

Dissolution has been investigated in the pig (6 w, 12 w), the mini-pig (12 w, 24 w), the dog (7 mo) and in human biopsies (8 w, 10 w, 12 w). After 6 weeks, over 99 % of the coating was dissolved, coating remnant was not found afterwards. Therefore, a 6-12 weeks dissolution window was assessed for this coating.

Clinical data on Early loading and Immediate loading (IL)

159 FBR-coated Pitt-Easy implants have been placed in 56 patients and restored after 7 weeks in the mandible and 12 weeks in the maxilla. The cumulative success rate after 30-month was 98.1 %. An IL study showed a cumulative success rate of 94.9 % after 24 months, for 156 implants placed in 55 patients. In 3 human biopsies, Massei et al. (2001) showed for IL implants a BIC of 54.4-70.1 % after 8w, 10w, 12w, with special neo-bone apposition between the implant spires.

Discussion & Conclusion

In contrast to dissolving plasma-sprayed HA, no activated macrophages or giant-cells were found upon dissolution at any time point. A distinct dissolution mechanism is foreseen to explain this difference. Dense particles are released from the plasma-sprayed HA after dissolution of the amorphous phase that require a cellular-mediated dissolution. The thin plates of Brushite are more soluble and have a high specific area, they are readily dissolved in the milieu without requiring cell mediation. This might explain the good tolerance to the high release of Ca and PO₄, without the deleterious response reported at plasma-sprayed HA coatings. After 6-12 weeks the coating seems to have completely dissolved, no unexpected bone response is further expected.

Clinically, the coating allowed shorter healing periods and a high predictability for IL implants. This resorbable coating combined the advantages of bioactive coatings without their long-term drawbacks. We can conclude that this resorbable electro-chemically deposited coating belongs to a second generation of bioactive coatings.

References

- [1] Szmukler-Moncler S, Zeggel P, Perrin D, Bernard JP, Neumann HG. (2003) From micro-roughness to resorbable bioactive coatings. In : Bio-Implant interface. Improving Biomaterials & Tissue Reactions. Chap 5, Ellingsen JE editor, Boca Raton, FL, CRC Press.
- [2] Schwarz ML, Kowarsch M, Rose SB, Jani L. (2003), 49th ORS Annual Meeting, poster 1378