SOLDENT: A NEW OSTEOINDUCTIVE PRODUCT FOR DENTAL IMPLANTS

Authors: Romero F[1], Araujo N[1], Coso, A[2]

[1] Castellón University, Spain

[2] Ilerimplant – GMI, Spain

INTRODUCTION:

Titanium and its alloys are widely used in dental implantology due to their low density, high resistance to corrosion, good mechanical properties and its biocompatibility [1]. However, sometimes patients are considered unsuitable for these interventions due to different reasons, some of them related to poor bone regeneration capacity. A better bone growth and therefore, a high implant osseointegration, can be achieved by implant surface functionalization through the application of bioactive coatings [2]. In this sense, new silica hybrid sol-gel coatings with biodegradable and osteoinductive characteristics were developed and applied onto Ti dental implants. This osteoinductive capability is attributed to their ability to release silicon compounds during the hydrolytic degradation of the sol-gel network [3]. Silicon is directly related with metabolic processes associated with the formation and calcification of bone [4]. It develops a biological crosslinking agent role, contributing to the resistance architecture and generation of connective tissues. Moreover, the silicon released in the $Si(OH)_4$ form promotes the synthesis of collagen type I and enhances osteoblastic differentiation [5,6].

Herein, we describe a new silica hybrid sol-gel coating, Soldent, regarding its osteoinductive properties, high biocompatibility and good *in vivo* behaviour.

MATERIAL AND METHODS:

Soldent was synthesized through the sol-gel route, employing methyl-trimethoxysilane (MTMOS) and tetraethyl-orthosilicate (TEOS) as precursors. Both the hydrolytic degradation and the Si release kinetics were evaluated by immersing the coatings in Milli-Q water at 37ºC for 2, 4, 6 and 8 weeks. The Si release was analyzed using inductively coupled plasma mass spectrometry. Ti dental implants (Ilerimnplant - GMI Frontier model®) and Ti discs were supplied by Ilerimplant SL. The titanium surface has undergone the Advanced Doubled-Grip treatment (ADS®). The samples were coated with Soldent by dip-coating. The resulting coating topography was characterized using scanning electron microscopy. Proteomic assay was conducted by incubating the discs with human blood serum for 3 h at 37ºC. Non-adhered proteins were removed through several washes. Proteins attached to the Soldent surface were eluted with a SDS-DTT solution. Finally, eluted proteins were evaluated through mass spectrometry (LC/MS/MS). *In vivo* experimentation was carried out by implanting sol-gel coated dental screws in the rabbit proximal tibia.

RESULTS:

Both the synthesis of the sol-gel material and the coating application were correctly developed (Fig. 1).

Fig.1. Implant coating process.

It was possible to achieve homogeneous and well adhered coatings, as it can be seen in Fig. 2 where SEM micrographics of the titanium surface are shown before and after coating.

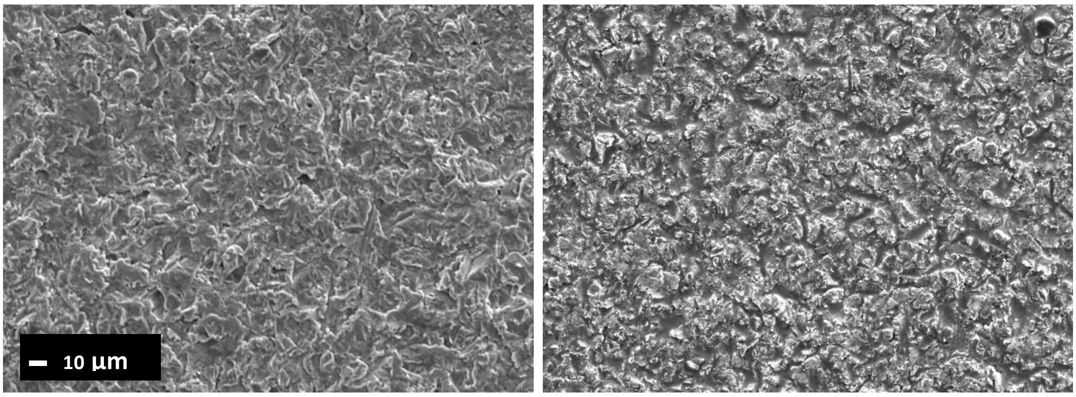

Fig.2. SEM micrographics: left image - uncoated ADS titanium surface; right image – Soldent coated titanium.

Soldent displayed an adequate degradation rate, reaching degradations of 35% after 8 weeks of incubation. Moreover, it is able to release silicon after a short time. After 8 weeks of immersion this material achieved the release of 10 ppm of Si (Fig. 3).

The LC-MS/MS analysis of the protein layer adsorbed onto the coating through proteomic assay resulted in the identification of a variety of proteins. It was found that some of the identified proteins were positively involved in bone metabolism and regeneration like APOE [7], PLMN [8] or VTNC [9]. Also proteins related with the coagulation system were identified, within this group were identifiable proteins as FA5 and FA12 [10] . The *in vivo* outcome displays an increase on the osseoinduction at short periods (2 weeks) on the implants coated with Soldent coating, extending and improving the generation of new bone tissue from the trabecular bone to the cortical bone on the implantation site, compared to non-coated titanium. In summary, it is clear an enhancement on the osteogenic activity in the coated implants at short time periods.

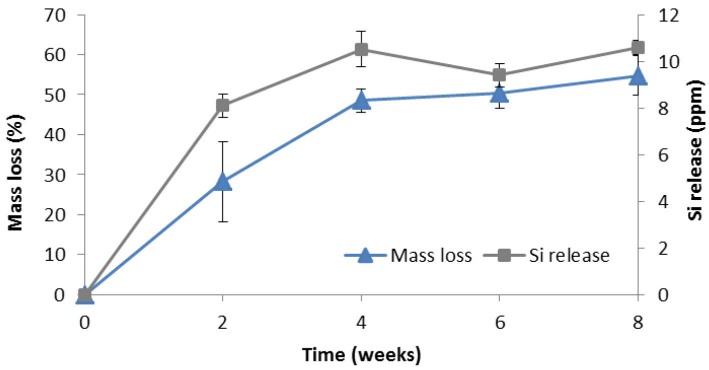

Fig.3. Soldent hydrolytic degradation and Si release.

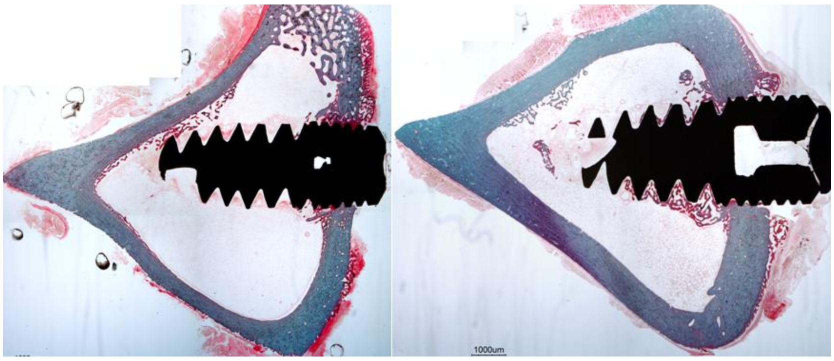

Fig.4. *In vivo* histology of: left image - titanium control screw; right image – Soldent implant.

CONCLUSIONS AND CLINICAL IMPLICATIONS:

Sol-gel hybrid coatings (Soldent Ilerimplant - GMI) on Ti dental implants were characterized regarding its potential as a biomaterial with promising results. The results described above suggest that the Soldent biomaterials have the potential of achieving a good performance on clinical pratices by improving the osseointegration ability of the implants. The improvement on the osseointegration compared to non-coated titanium implants regarding factors like good biocompatibility and better *in vivo* outcome could be related to the attachment of certain types and quantities of proteins onto the biomaterial that may enhance the generation of new bone tissue. This material could open the door to patients who are considered not fit to implantation procedures to be eligible to this kind of surgeries. Therefore, Soldent may represent a future, better and accurate alternative as a biomaterial coating for dental implants.

REFERENCES:

[1] S. Prasad, M. Ehrensberger, M.P. Gibson, H. Kim, E.A. Monaco, Biomaterial properties of titanium in dentistry, J. Oral Biosci. 57 (2015) 192–199.

[2] L. Le Guéhennec, A. Soueidan, P. Layrolle, Y. Amouriq, Surface treatments of titanium dental implants for rapid osseointegration, Dent. Mater. (2007).

[3] M. Martínez-Ibáñez, M.J. Juan-Díaz, I. Lara-Saez, A. Coso, J. Franco, M. Gurruchaga, et al., Biological characterization of a new silicon based coating developed for dental implants., J. Mater. Sci. Mater. Med. 27 (2016) 80.

[4] E.M. Carlisle, Silicon: A possible factor in bone calcification, Science (80-.). 167 (1970) 279–280.

[5] D. Arcos, M. Vallet-Regí, Sol-gel silica-based biomaterials and bone tissue regeneration., Acta Biomater. 6 (2010) 2874–88.

[6] A.F. Khan, M. Saleem, A. Afzal, A. Ali, A. Khan, A.R. Khan, Bioactive behavior of silicon substituted calcium phosphate based bioceramics for bone regeneration, Mater. Sci. Eng. C. 35 (2014) 245–252.

[7] M. Shiraki, Y. Shiraki, C. Aoki, T. Hosoi, S. Inoue, M. Kaneki, et al., Association of bone mineral density with apolipoprotein E phenotype., J. Bone Miner. Res. 12 (1997) 1438–45.

[8] L. Mao, N. Kawao, Y. Tamura, K. Okumoto, K. Okada, M. Yano, et al., Plasminogen activator inhibitor-1 is involved in impaired bone repair associated with diabetes in female mice., PLoS One. 9 (2014) e92686.

[9] R.M. Salasznyk, W.A. Williams, A. Boskey, A. Batorsky, G.E. Plopper, Adhesion to Vitronectin and Collagen I Promotes Osteogenic Differentiation of Human Mesenchymal Stem Cells., J. Biomed. Biotechnol. 2004 (2004) 24–34.

[10] S. de Maat, C. Maas, Factor XII: form determines function, J. Thromb. Haemost. 14 (2016) 1498–1506.