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Design and Development of Osteogenic Coatings for Titanium Implants

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ilerimplant OSSEOUS AND DENTAL IMPLANTOLOGY

Topic: Implant therapy outcomes, prosthetic aspects

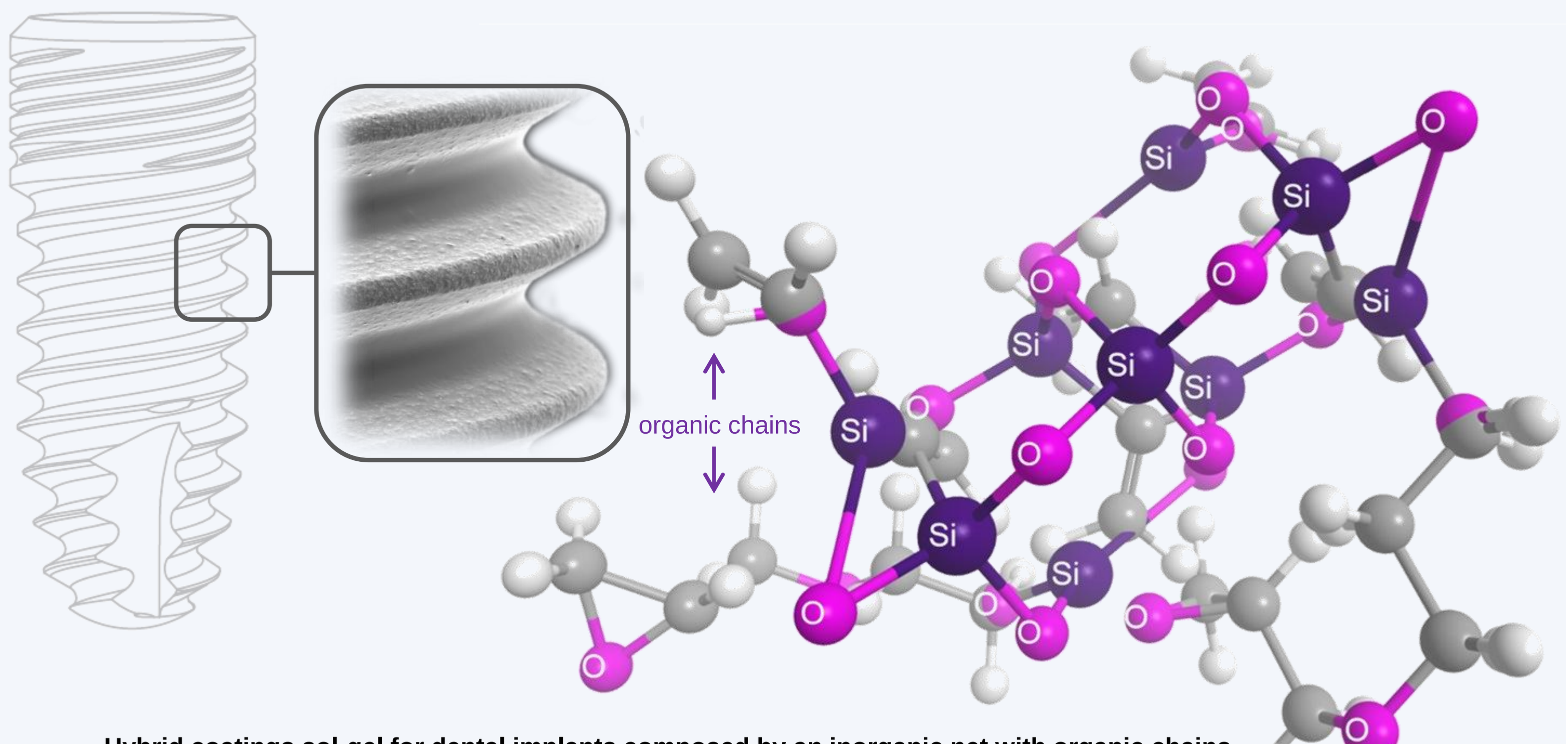
Abstract

One way to enhance the osseintegration of Ti implants is to modify their surface properties. With this end, hybrid coatings based on Silicon were developed via sol-gel, characterized and studied under in vitro and in vivo conditions. We demonstrated that the coating obtained is highly biocompatible and allows osteogenic cells proliferation. After two weeks of implantation in rabbit tibia, the coated samples showed new bone formation surrounding the implant while the Titanium screw did not show bone neoformation.

Background and Aim

The main reason for failure of dental implants is the wrong anchor with the bone and the fact that osseointegration is a long process. One way to avoid these problems is the development of coatings to improve the bioactivity of metallic implant that allow creating direct and strong linkages with the bone.

We propose the development of hybrid coatings obtained via sol-gel, to increase the osteogenic capacity of titanium implants and improve the osseointegration. Biological responses of the coatings will be evaluated through *in vitro* and *in vivo* studies.



Hybrid coatings sol-gel for dental implants composed by an inorganic net with organic chains

Methods and Materials

The sol was prepared by the acid catalysis method. Different types of alcoxysilanes were used. The coatings were physicochemically characterized (NMR, Si release, degradation test, AFM....).

Biological evaluation was carried out through *in vitro* and *in vivo* studies. *In vitro* tests of the proliferation of adipose mesenchymal stem cells (AMSCs) were performed. The presence of calcium deposited by osteogenic differentiated AMSCs was analyzed by Alizarin Red Test. The best cellular behavior was used to to screen the materials used as coatings to *in vivo* phase. Titanium coated implants were evaluated *in vivo* through osseointegration model of implantation in rabbit tibia during 1, 2, 4 and 8 weeks. Samples were processed to histological analysis.

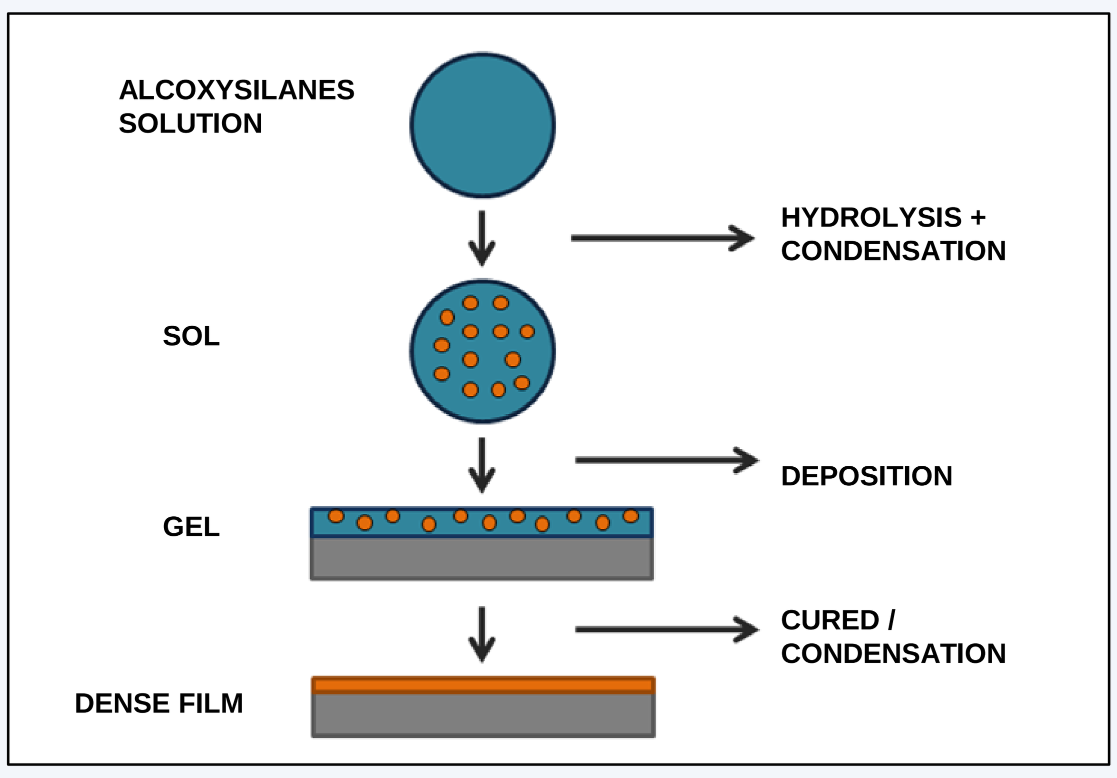


Diagram of obtaining process of sol-gel organic-inorganic hybrid coatings through acid catalysis method to prepare *in vitro* and *in vivo* samples.

(a)

Weeks	Coating 1	Coating 2	Coating 3	Control
1	5 implants	5 implants	5 implants	5 implants
2	5 implants	5 implants	5 implants	5 implants
4	5 implants	5 implants	5 implants	5 implants
8	5 implants	5 implants	5 implants	5 implants

(a) Experience design of *in vivo* implantation in rabbit tibia.

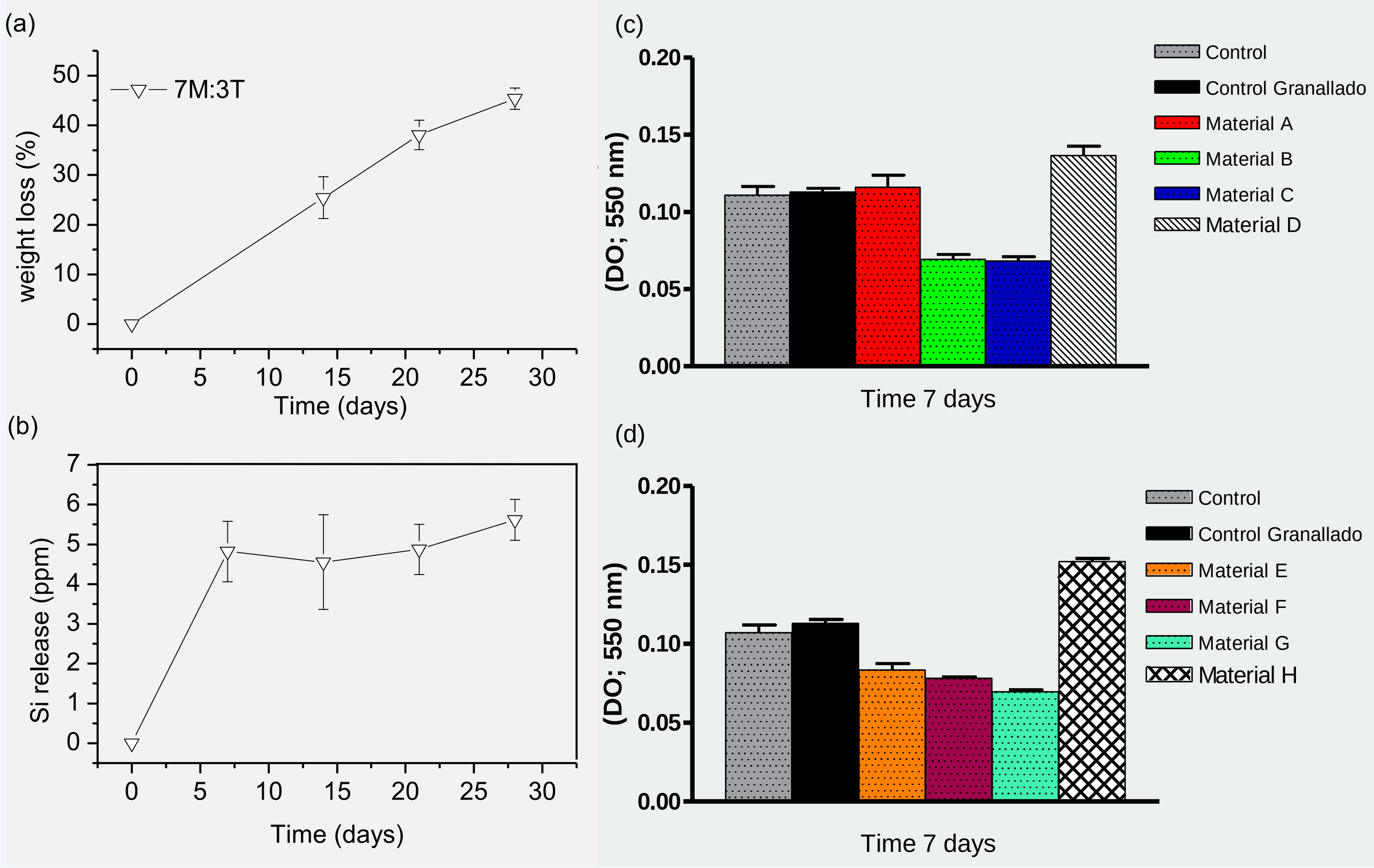
(b) Light microscopy image of *in vivo* samples, obtained through EXAKT® cut and Gomori Trichrome stain.

(b)

Results

The chemical characterization confirms the formation of a well-structured Si-O-Si network. The weight loss of the coatings measured in the degradation assay is directly connected with the Si release. The *in vitro* results of proliferation of the adipose mesenchymal stem cells show better results than those found in the titanium control. The Alizarin Red test reveals that all the coatings form calcified extracellular matrix. In vitro assays were used to optimize the best coating because its biological response. The study *in vivo* of implanted samples indicates that the osseointegration response is significantly improved in short times (1, 2 and 4 weeks) in the coated implants compared to Titanium controls. Histological analysis shows the formation of trabecular bone in only seven days in the case of using the optimal coated titanium implant. It is possible to design the degradation rate of the coating with chemical parameters. An osteoinductor coating that completely disappears after 8 weeks when in contact to trabecular bone zones is obtained.

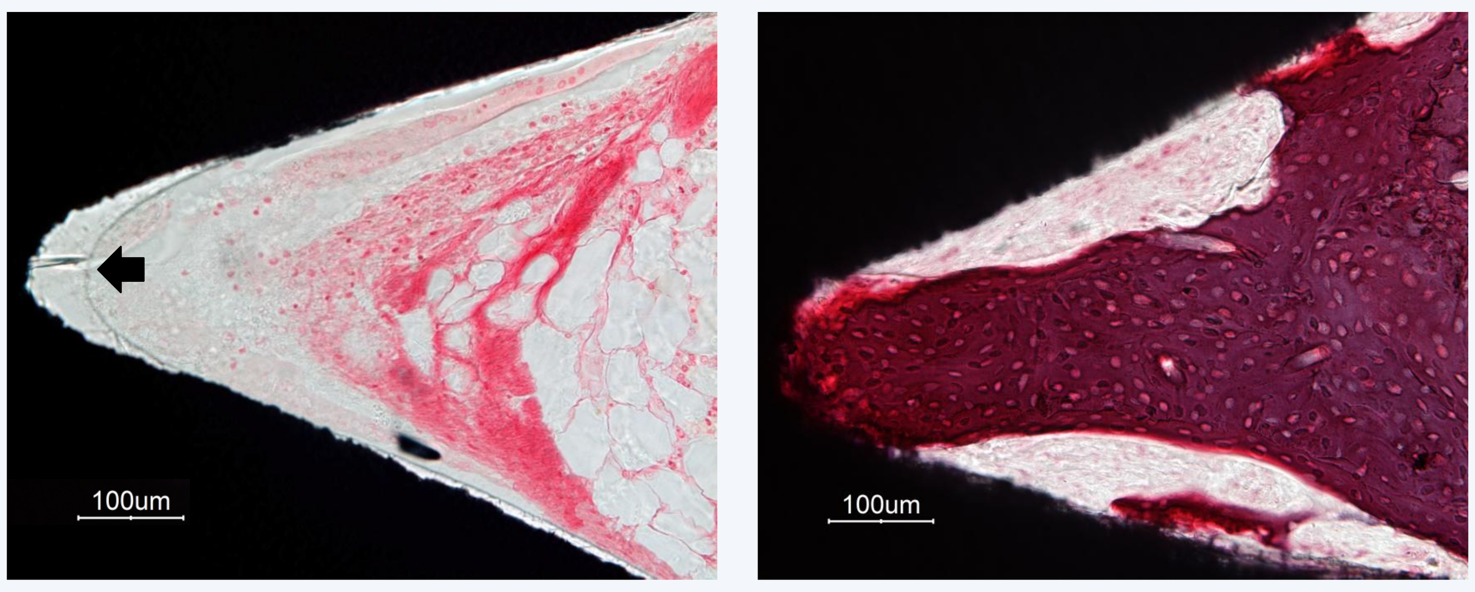
Chemical characterization — ***In vitro* study; Red Alizarin Test**



(a) Weight loss graphic of sol-gel in vitro degradation as a function of immersion time. (b) Si release graphic due to hydrolytic as a function of degradation time of sol-gel.

(c, d) Quantification of calcium deposits through Red Alizarin Test after 7 days of AMSCs culture in osteogenic medium as a sign of materials capacity of extracellular matrix mineralized induction.

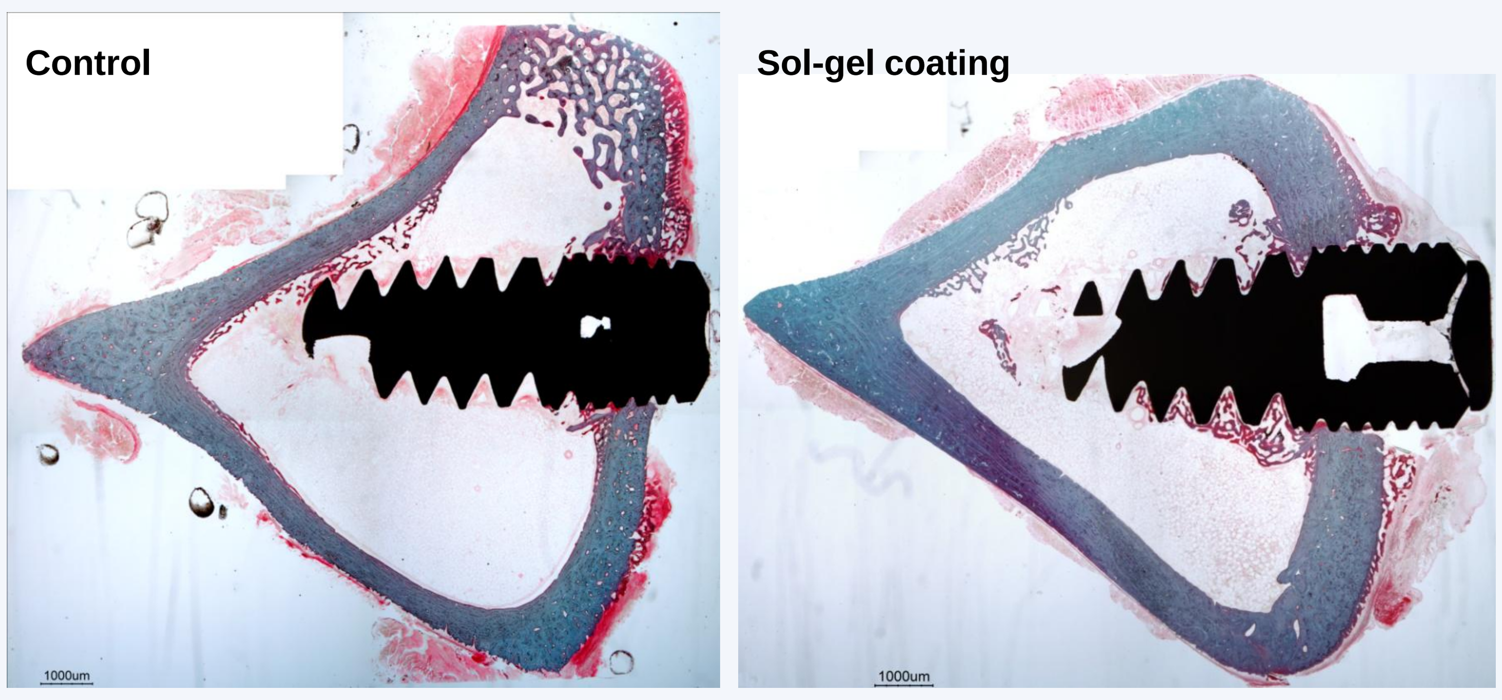
In vivo study



Light micrographs of rabbit bone tissue response. The arrow (left) shows the sol-gel coating that remains after 8 weeks of implantation in medullar space contact. Completely degradation of sol-gel coating at 8 weeks of implantation was observed in contact to trabecular bone (right).

Conclusions

Bioactive sol-gel coatings with a well-structured Si-O-Si network were obtained. The *in vitro* studies showed that the materials enhanced the proliferation of the mesenchymal stem cells and the activity of the osteogenic cells and improved its behavior compared to titanium control. The *in vivo* studies indicated that the coatings were able to improve the osteogenic capacity and could constitute a future vehicle for bioactive molecules to develop implants to specific and particular clinical patients.



Light micrographs of rabbit bone tissue response to coated screw (right) in compared to control (left) after two weeks of implantation. Progressing healing of the defect via trabecular bone growth was observed for titanium dental screw, qualitatively improved by the sol-gel coating.

References

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