THE EVALUATION OF ADHESION BETWEEN ELECTROSPUN COLLAGEN LAYERS AND DIFFERENT TITANIUM SUBSTRATES

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Introduction

The local antibiotic treatment of prosthetic joint infection as opposed to the use of systemic antibiotics enjoys the advantage of achieving high antibiotic concentrations, which exceed the minimum inhibitory concentration without increasing the level of systemic toxicity [1]. The aim of our project is a development of nanostructured collagen carrier of antibiotics that will provide a bone/implant bioactive interface, which will enhance the physiological healing process, will be capable of filling bone defects, and will act as a powerful antibacterial agent against microorganisms. The collagen/antibiotic layer is applied to titanium surface directly by electrospinning. The performance of such surface layers is affected by the adhesion between the coating and substrate. This paper presents an assessment of adhesion of pure collagen electropsun layers to differently prepared and treated titanium surfaces.

Materials and Methods

Two kinds of surfaces currently applied to improve the osseointegration of orthopaedic implants were used as substrates for deposition of collagen electrospun layers (FIG. 1), namely titanium plasma sprayed (*S*) and titanium 3D printed (*P*) commercial trabecular surfaces (ProSpon, Ltd., CZ). Prior to electrospinning, all surfaces were chemically treated.

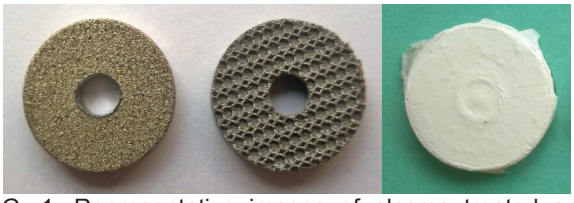

FIG. 1. Representative images of plasma treated and printed titanium samples before and after application of collagen/antibiotic layer (right).

First group of samples (**1**) was degreased by acetone in ultrasound bath (UB) for 10 min. Second group (**2**) was degreased (acetone, 10 min, UB), immediately followed by immersion in PBS (10 min), rinsed with deionized H_2O, dried in a hood. Samples from the third group (**3**) were degreased (acetone, 10 min, UB), etched for 2 min in solution of 5 g Na_3PO_4, 0.9 g NaF, 1.6 g (50wt% HF) supplemented by water up to 100 g, rinsed with H_2O (5 min) followed by fast drying (70°C) and immediately impregnated by diluted collagen/water solution (1/10, w/w) containing N-(3-dimethylamino propyl)-N'-ethylcarbodiimide hydrochloride and N-hydroxysuccinimide (EDC/NHS) (Sigma Aldrich) at a weight ratio of 4:1. After cross-linking in situ, samples were washed in the 0.1 M Na_2HPO_4 (2 × 15 min), followed by rinsing using deionised water (5 min) and dried in a hood. Finally, samples from the fourth group (**4**) were degreased (acetone, 10 min, UB), dried impregnated by diluted collagen/water solution (1/10, w/w) containing EDC/NHS (4/1, w/w) and washed after cross-linking as described above (3). Untreated samples were used as controls (**0**). After these procedures, all samples were immediately coated with collagen by means of electrospinning (1 hour) of collagen solution (8wt% in ethanol/PBS (1/1, w/w) and application of 30 kV, feeding rate 1 ml/hour. The effect of chemical treatment on adhesion of electrospun layers was determined by shaft-loaded blister test (FIG. 2) [2]. The adhesion was quantified based on calculating the maximum bond stress (σ_f) required for layer separation.

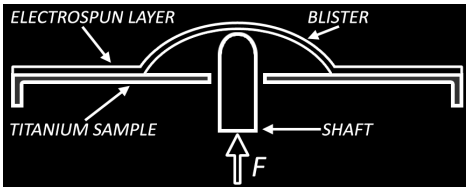

FIG. 2. Scheme of the shaft-loaded blister test, modified from Ref. [2].

Results and Discussion

In terms of bond stress, no differences were found between the plasma-sprayed and 3D printed surfaces (FIG. 3). Various chemical treatments had different effect on adhesion improvement. A very simple method as degreasing or degreasing/PBS immersion can significantly improve the adhesion between collagen electrospun layers and plasma-sprayed substrates. The expected effect of etching was demonstrated in the case of both kinds of substrates. In the case of 3D printed samples, only treatments with impregnation step had a favourable effect on adhesion improvement, while impregnation didn't have any effect in the case of plasma-sprayed substrates.

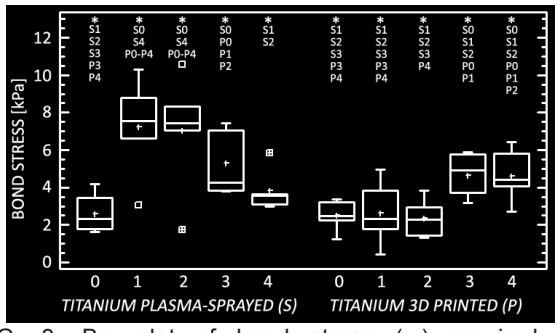

FIG. 3. Bow-plot of bond stress (σ_f) required for separation of collagen/antibiotic layers from differently prepared titanium surfaces. * denotes statistically significant differences (Fisher's LSD, 0.05).

Conclusions

Our results suggest that the adhesion between collagen/antibiotic electrospun layers and titanium plasma-sprayed surfaces as well as titanium 3D printed surfaces can be improved by chemical treatment of titanium surfaces.

Acknowledgments

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References

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