

Enhanced osteointegration by biochemical surface modification: covalent linking of collagen I to intervertebral metal disk surface

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INTRODUCTION: In a recent paper¹ Cunningham suggested that, among the major areas on which the long-term successful performance of total disc arthroplasty is based, the most important and most challenging aspect is for the implanted device to encourage osseointegration at the bone-metal interface while preserving the biomechanical properties of motion. To enhance osteointegration, present models of intervertebral disks rely mostly on micro-mechanical, titanium-based approaches or ceramic coatings. Contemporary biomaterials surface science points to the immobilization of biological molecules that can direct events at the tissue/implant interface as a promising new approach to osteointegration². In this communication, we present our result on *in vivo* evaluation of immobilization of collagen type I to metal surfaces and its application to an existing vertebral disk.

METHODS: Ti samples were modified as reported in² by a process involving deposition from propene plasma, followed by acrylic acid grafting and collagen type I (Kensy Nash, Lot. No. 24903) covalent linking. Six rabbits were used for bone implantation. The femur middiaphyses was exposed and samples were transversally implanted, up to a total of 12 implants for each material. Animals were sacrificed at 4 weeks. Evaluation was performed by histomorphometry and measurement of push out force using a MTS apparatus. The same surface modification process was applied to a Charite intervertebral disk, to evaluate suitability to intervertebral disks coating.

RESULTS: Results of *in vivo* testing are reported in Table 1. Histomorphometry data show that both bone to implant contact and bone ingrowth are significantly higher on the collagen coated sample. Also functional evaluation by the measurement of push out force shows a significant improvement on the coated sample. Figure 1 shows the Charite disk after the coating process. Sample was toluidine blue stained to disclose the presence of the collagen layer.

Table 1. Results of in vivo testing at 4 weeks

	Control	Collagen coated	<i>p</i>
Bone to Implant contact (%)	62.7±23.4	77.7±17.8	<0.01
Bone ingrowth(%)	85.3±11.7	91.8±6.8	<0.01
Push out Force (Mpa)	13.6±4.0	20.7±6.8	0.003

Surface analysis, by X-ray Photoelectron Spectroscopy, confirms the homogeneous coating by collagen molecule on the disk surface.



Fig. 1: Charite disk bearing a covalently linked layer of collagen.. Toluidine blue staining shows coating homogeneity

DISCUSSION & CONCLUSIONS:

Collagen type I coating of titanium, obtained by specific surface functionalization and covalent linking², shows enhanced bone ingrowth and bone implant contact, together with enhanced mechanical performances, in a rabbit model. The same process can be applied to existing intervertebral disks, yielding a metal disk that presents a homogeneous collagen-rich surface layer. Moreover, the surface layer can entrap charged molecules like growth-factors, opening the way to a multifunctional type of surface, combining biochemical function and drug release. These findings show that emerging methods of biochemical surface modification² can contribute to the development and improvement of intervertebral disks.

REFERENCES: ¹ B. W. Cunningham (2004) *The Spine Journal* 4:219S–230S. ² M. Morra et al., (2003) *Biomaterials* 24:4639-4654