Titanium implant with PCL^{Col}/PVA^{HA} coaxial nanofiber coating enhanced implant osseointegration in a rat model

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Statement of Purpose: Failure of osseointegration (direct anchorage of an implant by bone formation at the bone-implant surface) is the main cause of implant failure and loosening. The aim of this continuation study was to determine the osseointegration efficiency of PCL^{Col}/PVA^{HA} nanofibers (NF) as an implant coating in a rat tibia implantation model.

Methods: A total of 32 rats (300g-400g) were used in this study. Rats were divided into 2 groups (Table). A pilot hole was drilled through the intercondylar eminence and a 1.0-mm titanium (Ti) wire was gradually inserted from the proximal tibial metaphysis into the medullary canal. Titanium (Ti) wire deposited with PCL^{Col}/PVA^{HA} NFs were inserted into the channel until beneath the growth plate. Rats were sacrificed at 4, 8 and 16 weeks after surgery, respectively.The outcome measurements include histology, mechanical push-in test and uCT scan. The preparation of NF was described elsewhere[1].

Rat groups

Group	n	Description	Period (week)
I	8	(control, Ti no-NF)	8
II	24	NF-coated Ti	4, 8, 16

Results: As shown in **Fig.1,** NF coated Ti wire was well exposed by trimming off the femur head. The maximum friction force (the peak push-in force) for pin movement was recorded to reflect the interface osseointegration. The elevation of maximum friction force from 4 to 16 weeks of implantation indicates the osseointegration occurs between interface of NF and bone tissue.

As shown in **Fig.2**, image analysis of tissue sections stained with hematoxylin and eosin showed that new bone formation around implant were characterized by increased (H&E +, red) osteoblast proliferation. It was observed that NF coated Ti wire significantly increased osteoblasts proliferation as compared with uncoated Ti wire. Quantitative image analysis, as shown in Fig.2(c), revealed that NF coatings significantly induced osteogenesis ($P < 0.05$).

As shown in **Fig.3**, Micro CT scanning was performed in interested area around implant-bone interface. Bone volume fraction (BV/TV) with NF-coated implant was significantly enhanced after implantation for 4 and 8 weeks.

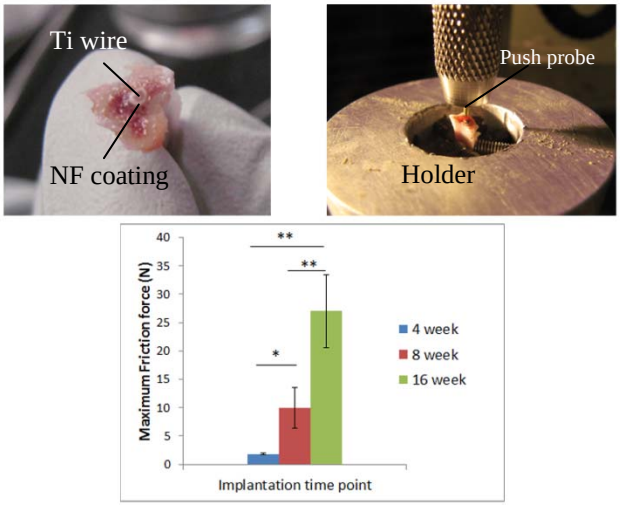

Fig. 1 Push-in test of NF coated Ti wire from harvested femur from different time points. n=3, *p< 0.05, **p< 0.005

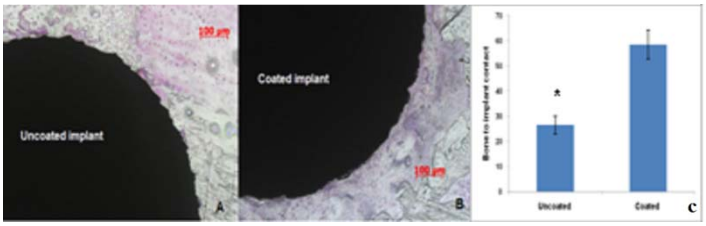

Fig. 2 Histological images of the bone/Ti wire interface 8 weeks after implantation (a, Uncoated; b, coated; H&E stain, original magnification ×100); and results of the BC (c) in histomorphometry. Data are expressed as mean ±SD, n =3 per group. *p< 0.05.

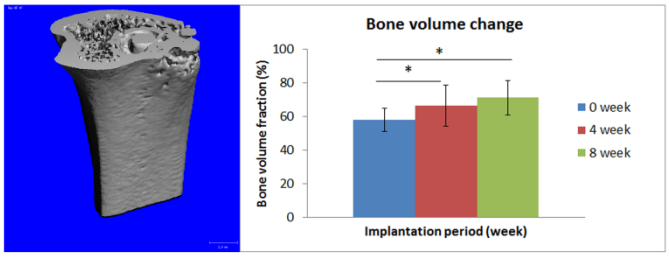

Fig. 3 MicroCT analysis of NF-coated Ti wire after implantation. (Left) Representative 3D image of rat femur with implanted Ti wire. (Right) Quantitative results of Bone volume fraction (Bone volume/Total volume) during implantation from 0 week to 8 week. Data are expressed as mean ±SD, n =3 per group. *p < 0.05 (ANOVA).

Conclusion:

Our study demonstrated that PCL^{Col}/PVA^{HA} NF represents promising coating materials in enhancing implant osseointegration, thus to prevent bone implant failure and loosening.

REFERENCE
1. Song W, Yu XW, Markel DC, Shi T, Ren WP. Biofabrication 2013; 5(3).