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# Effective bioactivity enhancement of titanium alloy by novel plasma surface modification

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## Introduction

Metallic biomaterials have been widely adopted for bone fracture fixation, by which providing mechanical support to diseased bony structures and allow recovery. Titanium alloy (Ti-6Al-4V) is commonly used in implantation surgeries, as it demonstrates excellent biocompatibility and mechanical endurance. Unfortunately, the resultant implant loosening from the loss of surrounding bone volume after implantation remains one of the major challenges in orthopaedics and dentistry. Therefore, novel surface modification technique, by using plasma immersion ion implantation (PIII) was applied to remedy this post-operation complication.

## Materials and Methods

Twelve-week old male ICR mice were used in this study. Animals were implanted with untreated, carbon-PIII or nitrogen-PIII treated Ti pins into femoral cavity. *In vivo* changes in bone volume around implant were monitored weekly from week 0 up to week 12 by microCT. Implanted femurs were harvested 12 weeks post-operation and then processed for histological evaluations. Data were expressed as mean  $\pm$  S.E.M. ( $n \geq 6$ ). Area under the curve was expressed in arbitrary unit with mean  $\pm$  S.E.M. ( $n = 4$  to 6). Comparisons between two groups were performed by Student's *t*-test, and *p*-values of  $< 0.05$  were regarded as statistically significant.

## Results

Bone volume around treated and untreated implants changed biphasically with time: bone volume increased after surgery and peaked at week 1, then it gradually reduced (Fig.1). Significant bone formation was observed at week 1 on carbon-PIII ( $168.4 \pm 11.7\%$ ) and nitrogen-PIII ( $165.4 \pm 8.3\%$ ) treated implant surfaces when compared to the untreated control ( $115.1 \pm 1.8\%$ ). An increase in bone volume around nitrogen-PIII treated implant was measured  $137.8 \pm 17.2\%$  at week 12 when compared with time zero (100%), and it was measured  $103.3 \pm 9.9\%$  on carbon-PIII treated implants. On the contrary, bone volume was measured  $82.5 \pm 5.8\%$  on untreated implant surface (Fig. 2). The effect of Ti PIII surface treatment on changes in bone volume was evaluated by computing area under the curve (AUC) of percentage bone volume. AUC of nitrogen-PIII was the largest ( $17.2 \pm 1.5$ ), followed by that of carbon-PIII ( $15.7 \pm 0.8$ ) then the untreated control ( $11.2 \pm 0.6$ ).

## Discussions and Conclusion

Bone remodeling is a dynamic process of bone resorption by osteoclast activity and bone formation by osteoblasts, which continues throughout life. Homeostasis between activities of osteoclasts and osteoblasts determines bone architecture. PIII surface modifications of implant appeared to modulate bone remodeling, as (1) the increase in bone volume around treated implants was significant, and (2) rate of bone resorption may be altered (data not shown). In addition to the enhanced bone formation, the plasma treated Ti alloys are promising to reduce bone resorption after surgical implantation.

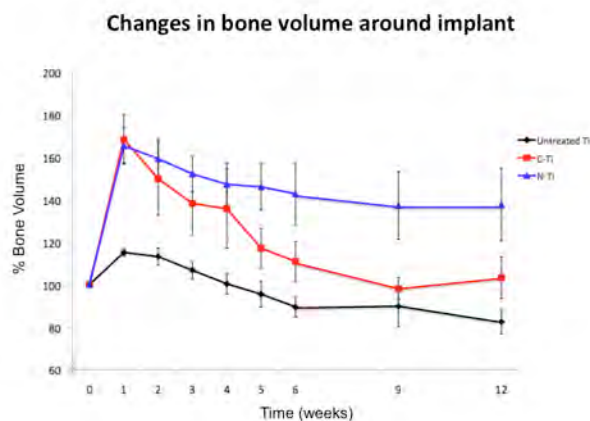


Fig. 1. Changes in bone volume on implant surface after surgery



Fig. 2. Reconstructed three-dimensional images of bone on implant surface: (A) untreated Ti; (B) carbon-PIII treated Ti and (C) nitrogen-PIII treated Ti

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## Reference

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