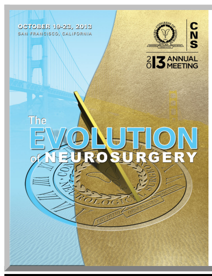

Histological, Biomechanical and Radiological Study of Titanium Foam in Osteoformation for Spinal Implant

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Introduction

Titanium (Ti) is an indispensable material in spine surgery because of good osteoformation. It also has several shortcomings, however, causing breakage of surrounding bones because its hardness is higher than that of bone itself. With the recent advance of technology, Ti can be transformed into a sponge-like, porous metallic material, termed “Ti foam.” Because of the high porosity, the resolution of the demerits and developing of merits might be expected. The objective of this study is to evaluate the effect of Ti foam on osteoformation by histological and radiological analyses.

Methods

Titanium foam

Ti foam possesses a sponge-like 3-D network structure consisting of “interconnected pores” (Fig. 1), i.e., pores that are connected to each other at all sides, without interruption.

Study design and surgical procedures

Surgical procedures were performed on 11 rabbits. Two round-shaped bone windows of 4 mm × 15 mm (d × l) were made in the femurs, and either of the three types of Ti foam implants, after being processed into a cylindrical shape was embedded in the bone windows. In this study, two types of Ti foam and Ti of 0% porosity (as a control) were used. The porosity of the two types of Ti foam was adjusted to 80% and 90% to impose yield strengths and elastic moduli close to those of human cancellous bone. After imaging by micro-CT, the harvested tissues were frozen and stored at -30 °C.

Investigated factors

- Biomechanical analyses:Push-out tests were conducted.
- Histopathological analyses:Stained specimens were prepared to examine the osteoformation.

Results

In the biomechanical analysis, 80% porosity group was more effective in osteoformation. Significant difference in the push-out strengths existed between the control group and 80% porosity group at 4 weeks (p=0.048) and at 12 weeks after implant (p=0.001)(Fig. 2). In the histopathological analysis, good osteoformation was confirmed in 80% porosity group, leading to the same result to the biomechanical analysis(Fig. 3).

Conclusion

Ti implants display various disadvantages such as high elasticity. It displays good biocompatibility, however, motivating its use as a medical implant. In the present study, Ti foam of 80% porosity, used in a spinal implant, was found to overcome these disadvantages and proved superior in osteoformation from both a histological and mechanical viewpoint.

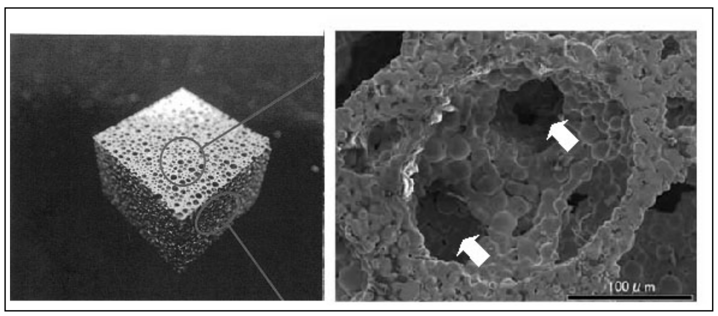

Fig.1: Optical images of the Ti foam (Left). Scanning electron microscopy images of Ti foam at 300 × magnification (Right). The characteristic "interconnected pores" (arrows) of the Ti foam are clearly visible.

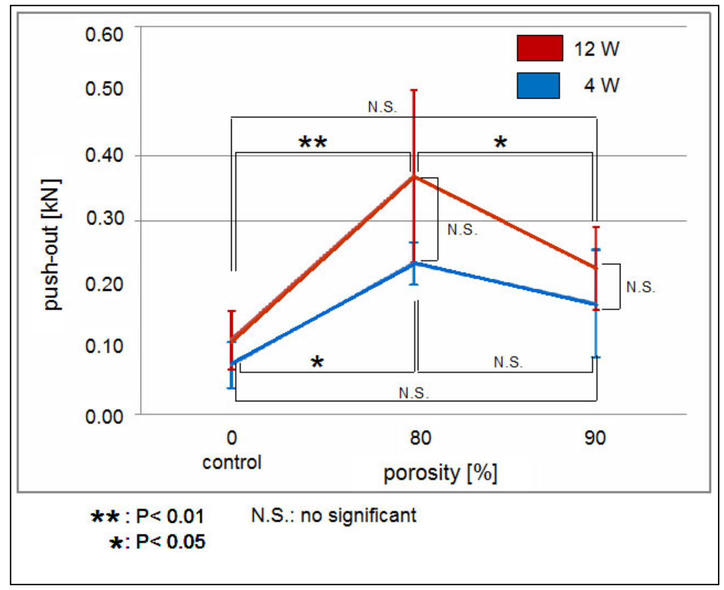

Fig.2: Result of the push-out test. After 4 and 12 weeks post surgery, significant differences in the average maximum load strength exists between the control and the 80% porosity group. No significant difference in maximum load existed between the control group and 90% porosity group at either time point, nor between 4 and 12 weeks post surgery, suggesting a decreased fusion time.

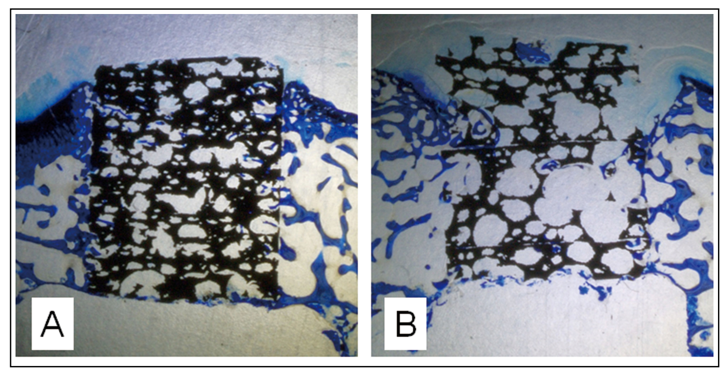

Fig.3: Histopathological specimens showing that osteoformation occurs rapidly for the 80% Ti foam (A), in contrast to the 90% Ti foam (B).