Comparisons of biocompatibility of TiNb alloy and Ti6Al4V by anodization and cathodization

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An orthopedic implant is a functional load transfer structure to substitute for skeletal repair. The requirements of ideal biomaterials using for implants need to satisfy both biomechanical and biocompatible properties. However, the conventional titanium-based alloys with uniform structure cannot meet all these requirements.

Ti6Al4V is most common titanium alloys used in orthopedic implant because of superior toughness, favorable mechanical properties and excellent biocompatibilit. However, Ti-6Al-4V would release the metallic ions, such as aluminum (Al) and vanadium (V), might result in the poor osseointegration and than induce clinical failure. Furthermore, the elastic modulus of Ti-6Al-4V alloy (112 GPa) is still higher than that of cortical bones (10~30 GPa), inducing the stress shielding effect between bone and implant. Therefore, the researches and developments of new β-type titanium alloys which have the low elastic modulus and consist of nontoxic elements are very enthusiastic.

In our previous research, the titanium-niobium (TiNb) alloy with the porous structure is a potential candidate biomaterial for medical devices[1, 2]. The porous structure can be developed using anodization followed by cathodic pretreatment [3].

In order to verify the biocompatibility of porous TiNb alloys with nodization followed by cathodic pretreatment, we compared the surface characterizations and cell difference of TiNb with common used titanium-based alloy. The finite element methods were used to evaluate the biomechanical behaviors of TiNb alloys. The TiNb and pure Ti6Al4V were used to evaluate in this work.

Figure 1 presents the surface morphology of the Ti and TiNb surface with electrochemical treatment. A three-dimensional nanoporous network structure is obtained from Ti6Al4V substrate, on the other hand, there are sub-microporous and nanoporous surface formed on TiNb surface.

From the TF-XRD patterns, numerous reflection peaks of titanium hydrides (δ-TiH, γ-TiH_2, and α-$TiH_{1.971}$) are clearly observed from Ti6Al4V surface and the peaks of $NbTi_4$ and $TiH_{1.971}$ appear on the TiNb surface. Additionally, TiO_2 peak is detected by following anodization on Ti surface and rutile-TiO_2 and $NbTi_4$ are recognized on TiNb substrate.

Figure 2 shows the von Mises stress distributions between the implant and surrounding bone for Ti6Al4V and TiNb screws. The maximum stress is located in the region between the first thread of screw and its head. The results indicated that screws with lower stiffness would provide with significantly higher biomechanical compatibility and better osteosynthesis

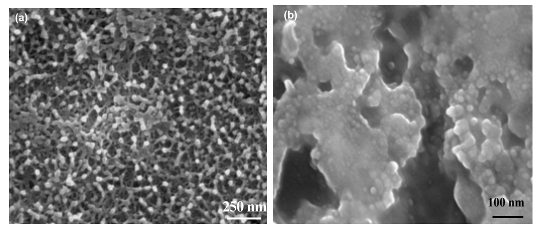

Fig. 1. SEM morphographies of a) Ti6Al4V and b) TiNb using anodization followed by cathodic pretreatment

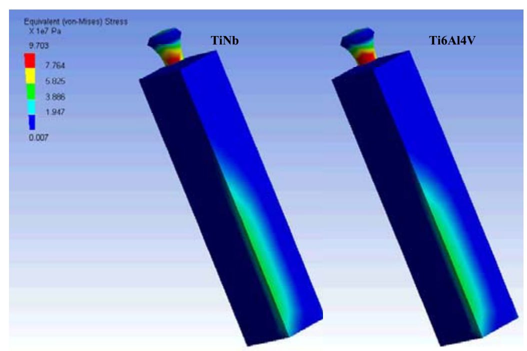

Fig. 2. The von Mises stress distributions between the bone and the screw for TiNb and Ti6Al4V

References

1. Hon, Y.H., Wang, J.Y., and Pan, Y.N., "Composition/Phase Structure and Properties of Titanium-Niobium Alloys". *Materials Transactions*, 2003. **44**: p. 2384-2390.
2. Peng, P.W., Pan, Y.N., and Ou, K.L., "Effect of porous oxide films on characterization and bioactivity of titanium niobium alloy". *ECS Transactions*, 2006. **3**(19): p. 27.
3. Cheng, C.C., Lin, C.T., Lee, S.Y., Lin, L.H., Hung, C.F., and Ou, K.L., "Biosensing of biophysical characterization by metal-aluminum nitride-metal capacitor". *Applied surface science* 2007. **253**(11): p. 5173-5178