Development of Titanium Alloys for Biomedical and Dental Applications with Focusing on Young's Modulus

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For the use of load bearing implant devices such as artificial hip joints, dental teeth, and spinal fixation rods, the stress transfers preferentially through implant device because they are generally made of metallic materials such as SUS 316L stainless steel, Co-Cr-Mo alloy, and titanium alloys such as Ti-6Al-4V ELI because these metallic materials have much higher Young's moduli of 180 GPa, 210 GPa, and 110 GPa, respectively than that of the cortical bone showing around 10-30 GPa. This phenomenon is recognized as stress shielding. If the stress shielding occurs between implant device and bone, bone atrophy happens and good bone remodeling cannot be achieved. To inhibit the stress shielding between implant device and bone, the Young's moduli of implant devices, namely metallic biomaterials used for fabricating implant device should be as close to that of bone as possible: Young's moduli of the metallic biomaterials for the use in implant devices should be low. From the view point of the low Young's modulus, b-type titanium alloys showing lower Young's moduli than those of a- and (a + b)-type titanium alloys such as Ti-6Al-4V ELI are advantageous for fabricating implant devices Therefore, currently b-type titanium alloys composed of non-toxic and allergy-free elements with low Young's moduli have been developed or on the way of development. The authors have developed Ti-29Nb-13Ta-4.6Zr (referred to as TNTZ) composed of non-toxic and allergy-free elements showing a low Young's modulus of around 60 GPa under solutionizad conditions.

Very recently, partially Young's modulus changeable b-type titanium alloys are being developed to inhibit springback, which reduces the ability to keep the shape when the implant device is deformed by surgeons. The TNTZ have been modified by adding the fourth element for its Young's modulus to be changeable. NTZ is also expected to be used for fabricating artificial tooth roots.

Developments of TNTZ and modified TNTZ with changeable Young's modulus are discussed.