Mechanical Engineering Department Seminar

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1130 Mechanical Engineering
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NiTi for Patient-specific Mandibular Fixation Surgery

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Nickel-Titanium (NiTi) shape memory alloys (SMAs) with near-equiatomic exhibit both a thermal shape memory and superelasticity. Both effects are based on a reversible martensitic phase transformation. This type of the effect primarily depends on the transformation temperatures, which can be adjusted through variation in the Ni-Ti ratio. Mandibular reconstruction surgery is a part of treatment for cancer, tumor, and all the cases that involve segmental defects. Due to the high stiffness of the Ti-6Al-4V fixation hardware in comparison with the mandible bone and the grafted bone, the loading distribution on the whole reconstructed mandible will be different from a healthy mandible. The high stiff fixation hardware carries a great portion of the loading and cause stress shielding on the grafted bone and the surrounding host bone. Based on the bone remodeling behavior, the stress shielding on the cortical bone causes bone resorption and may lead to implant failure. A solution to reduce the risk of implant failure is to use a low stiff biocompatible material for the mandibular fixation plates. In this seminar, we have evaluated the use of proposed fixation hardware by different comparisons with a case of a healthy mandible and a reconstructed mandible using the standard method. To this end, first different models including a healthy mandible, a reconstructed mandible using patient-specific Ti-6Al-4V fixation hardware, a reconstructed mandible using stiffness-match patient-specific hardware, and several prefabricated fixation plates were prepared. After verification of the models, the cases of reconstructed mandibles were used to simulate different periods, including during healing, and post-healing periods. Also, different loading condition including highest bite force on the first molar tooth, rest condition, and also highest bite force on a dental implant right in the grafted bone were simulated. Also, the theory of applying pretention to the fixation plates was evaluated using finite element method. We also designed and evaluated a set of prefabricated fixation kits with various stiffness and reduced stiffness option. After all these finite element simulations and having the CAD files of the porous fixation plates, the possibility of fabrication of the proposed hardware, in both forms of patient-specific, and prefabricated plates was evaluated using selective laser melting.

Bio: Mohammad Elahinia is a Professor of Mechanical, Industrial and Manufacturing Engineering (MIME). He serves as Director of the Dynamic and Smart Systems Laboratory as well as the Nitinol Commercialization Accelerator at UT. Dr. Elahinia's current research is focused on biomedical and aerospace applications of shape memory alloys. Dr. Elahinia is a Fellow of ASME and has received several awards, including the University of Toledo Outstanding Research Award, ASME Adaptive Structures and Material Systems Gary Anderson Early Achievement Award, and Virginia Tech Torgersen Graduate Research Excellence Award. Dr. Elahinia is an Associate Editor for Journal of Intelligent Material Systems and Structures, and Journal of Vibration and Control. He also served as the chair of the American Society of Mechanical Engineers Adaptive Structures and Material Systems Branch of the Aerospace Division.