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学位論文題	Development and properties of multifunctional biomedical nanocomposites（多機能生体医療用ナノコンポジットの創成およびその特性に関する研究）
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論　文　内　容　の　要　旨

Tissue engineering is a promising alternative for treating bone defects caused by trauma, tumors, congenital malformations, degeneration, aging, or bone diseases. Scaffolds play a crucial role in tissue engineering because they represent an alternative to the conventional implantation of organs and tissues. They can provide an appropriate base for tissue growth and cell proliferation and of which the design can be improved to precisely match the irregular boundaries of bone defects as well as facilitate their clinical application. Shape memory polymers (SMP) are a well-known class of stimuli-responsive materials which can be controlled to hold a secondary shape but recover their permanent shape under an external stimulus. This property can be designed and altered by changing the structure, morphology, and various processing parameters of the polymer during fabrication. Hydroxyapatite (HAP) have been used in the bone tissue engineering field for bone filling due to its similar composition to the natural bone, excellent osteoconductibity and biocompatibility.

The purpose of these investigations is to design a three-dimensional porous nanocomposite scaffold which possesses high compression resistance, good shape memory recovery ratio and high biocompatibility. Good shape memory recovery ratio can lead the nanocomposite scaffold more precisely match the irregular boundaries of bone defects and the less time required for compression recovery can directly shorten the time of the operation. The significance of this investigation can lead to realization of advanced nanocomposite scaffold for application in minimally invasive surgery and bone defect repair.

(1) Four SMPU scaffolds (SMPU-200, SMPU-200-100, SMPU-100-50, and SMPU-50) with the three-dimensional porous structure were fabricated via a salt-leaching-phase inverse technique, a unique method to fabric porous structure. The use of different size of NaCl particles to obtain scaffolds with different apertures was investigated. With increasing of the aperture, the porosity of the scaffolds increased from 77.13% to 83.13% and their compression recovery ratio increased from 97.77% to 99.30% at room temperature, but their shape recovery ratio decreased from 95.0% to 91.1% at 55 ℃ higher than Tg. Moreover, all SMPU scaffolds promoted cell proliferation on their surface, and the ability increased with the aperture of the scaffold.

(2) nHAP particles were fabricated by the liquid phase precipitation method with a rod-like shape and their sizes were ca. 30-40 nm in length and ca. 10 nm in width. Four controllable porous SMPU/nHAP composite scaffolds (SMPU/nHAP-200, SMPU/nHAP-200-100, SMPU/nHAP-100-50 and SMPU/nHAP-50) with three-dimensional structure, which was important for cell growth, were fabricated via the salt leaching-phase inverse technique, a unique method to fabric porous structure. Their physical characteristics, mechanical properties and shape recovery behaviors were investigated. With the increase of the aperture of scaffolds, the porosity, the

compression strain (at the strength of 0.12 MPa) and compression recovery ratio of the porous SMPU/nHAP composite scaffolds were increased at room temperature, but their shape recovery ratio was decreased at 55 ℃ higher than Tg. Moreover, these four porous composite scaffolds had a cell proliferation promoting ability and the ability was increased with the increase of the aperture of the scaffolds.

(3) Five-step thermo-mechanical cycle test was used to investigate the shape recovery properties and the contribution of HAP particles was clarified. The effect of nHAP particles in porous SMPU/nHAP composite scaffold was found to enhance the compression resistance by 37%, shorten the compression recovery time by 41% and reduce the tensile resistance by 78%. From the thermo-mechanical cycle test, SMPU/nHAP composite scaffold had good shape fixity property which was more than 97% and higher shape recovery ability which reached more than 99% after 3th cycle of training. Meanwhile, the addition of nHAP particles improved the proliferation of cells by 13% after 7 days of culture which indicated that the larger the porosity of scaffold was, the easier it was for the cell to adhere to and proliferate on the scaffolds. These results revealed that in minimally invasive surgery and bone repair surgery, this porous composite scaffold could significantly reduce the operative time, promote the bone cell growth and precisely match the irregular boundaries of bone defects. Therefore, this porous SMPU/nHAP composite scaffold design has potential applications for the bone tissue engineering.