Preparation and characterization of soft tissue-polymer complex for percutaneous device

K. Nam [a,b], R. Matsushima [a], Y. Shimatsu [a], T. Kimura [a,b], T. Fujisato[c], A. Kishida [a,b]
[a] Institute of Biomaterials and Bioengineering, Tokyo Medical and Dental University
[b] Japan Science and Technology Agency, CREST
[c] Faculty of Engineering, Osaka Institute of Technology

Introduction: Peritoneal dialysis is usually executed by implanting the flexible catheter directly the skin and peritoneal cavity [1]. However, the problem with the flexible catheter is that the compatibility of the polymer and the skin tissue is too low. This often causes the down-growth of the epithelial cells which eventually causes the infection or even avulsion of the device. We tried to overcome this problem by preparing a percutaneous device based of a "soft tissue-polymer complex", which possesses tissue compatibility and maintainability of the flexible catheter within the device at the same time. For the base material, the decellularized dermis was prepared by high hydrostatic pressure (HHP) method [2-3]. Then by complexation of the dermis with polymer, we obtained a soft tissue-polymer complex.

Methods: By soaking the methyl methacrylate (MMA) monomer, benzoyl peroxide and N,N-dimethyl-p-toluidine into the decellularized dermis, we polymerized MMA at room temperature to obtain a dermis-poly(methyl methacrylate) (PMMA) complex. The absorption of the polymer was measured by soaking water and MMA to the freeze-dried samples. In order to observe the morphology of the sample, the samples were fractured and freeze-dried overnight. The fracture surface of the complex was sputter-coated with gold and observed using a scanning electron microscope (SEM). Compression properties were measured by a creep meter. The samples were allowed to swell in water at room temperature for 24 h and then compressed at 0.05 mm/min. Each sample was measured at least five times, and the measurement results were converted to stress-strain curves.

Results: The dermis was thoroughly decellularized by HHP. It was shown that the dermis absorbed the MMA. This implies that the MMA which is hydrophobic monomer can diffuse into the soft tissue, ready for the polymerization. The SEM images showed that MMA had polymerized successfully, forming a stable complex with

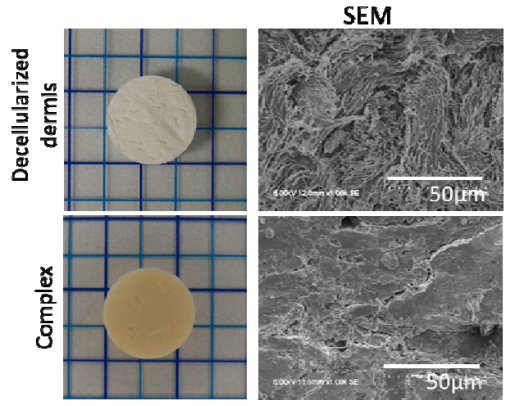

Fig.1 Photographic images and SEM images.

the collagen fiber within the dermis (Figure 1). The complexation induced the increase in the mechanical strength upon compression, showing rapid increase at the early compression stage.

In order to develop a percutaneous device suitable for suture, we controlled the polymerization area limiting the central part of the dermis, where the outer part is only composed of tissue substances. When this device was implanted into the rat, it showed that the strong adhesion to the native rat skin occurred and the cells could penetrate into the implanted device, until they encountered the PMMA complex part.

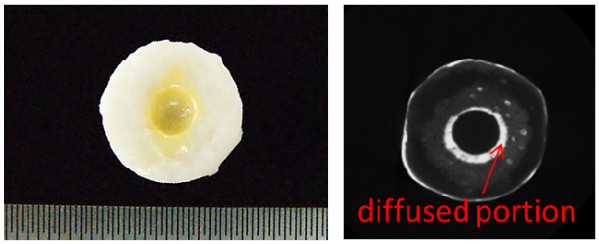

Fig.2 photographic image and 2-D images of complex scanned by micro focus X-ray CT.

Conclusions: We prepared a tissue-polymer complex with the flexible catheter firmly held by the stiff PMMA in the middle of the dermis. We believe this complex is a promising material for percutaneous device which can be brought to the clinics in the near future.

Acknowledgements

This work was supported by a Grant-in-Aid from the Core Research for Evolutional Science and Technology (CREST) of the Japan Science and Technology Agency (JST).

References

[1] Walboomers XF, Jansen JA. Effect of microtextured surfaces on the performance of percutaneous devices. J Biomed Mater Res 2005;74A:381–387.

[2] Hashimoto Y, Funamoto S, Kimura T, Nam K, Fujisato T, Kishida A. The effect of decellularized bone/bone marrow produced by high-hydrostatic pressurization on the osteogenic differentiation of mesenchymal stem cells. Biomaterials 2011;32:7060-7067.

[3] Negishi J, Funamoto S, Kimura T, Nam K, Higami T, Kishida A. Effect of treatment temperature on collagen structures of the decellularized carotid artery using high hydrostatic pressure. J Artif Organs 2011;14:223-231.