Introduction: Tissue adhesion is a severe complication in clinical treatments. It is hoped to create a novel biomaterial which does not impair tissue healing and effectively prevents tissue adhesion. Then we used 2-methacryloyloxyethyl phosphorylcholine (MPC) polymer that is our original biocompatible polymer whose side chain is composed of phosphorylcholine that resembles phospholipids of biomembrane [1], and created an anti-adhesion material of spontaneous forming hydrogel from mixture of aqueous solutions of poly (MPC-co-α,ω-butylation-methacrylate-co-p-vinylphenylboronic acid) (PMBV) and poly (vinyl alcohol) (PVA) [2]. We designated the hydrogel “PMBV gel”. The condition of PMBV gel is maintained by reversible covalent bonds between PMBV and PVA. The mechanical property and dissociation speed of the hydrogel are controllable by changing the concentration of the polymers. The present study investigated the effects of the PMBV-gel application on tendon healing and adhesion.

Materials and Methods: (1) The ability of PMBV gel to prevent cell adhesion was investigated using cultured mouse fibroblastic cell line NIH3T3. The cells were cultured for 6-36 h on dishes with or without the PMBV-gel coating, and cell adhesion was evaluated microscopically.

(2) To evaluate the dissociation of PMBV gel in vivo, chambers containing PMBV gel were subcutaneously implanted in rats. Macroscopic and scanning electron microscopy (SEM) observations were performed after one and three weeks.

(3) The ability of PMBV gel to prevent tendon adhesion was determined using a rabbit flexor tendon injury model. After a FDP tendon was cut at Zone 2 and repaired by a modified Kessler suture, the hydrogel was applied to cover the injury site and the wound was closed. After 3 weeks of external fixation by casting, tendon healing and adhesion were evaluated by microscopic, histological and mechanical observations. In the microscopic evaluation, we counted the number of fibrous adhesion tissue between the tendon and surrounding tissues, and observed the continuity between the tendon stumps. In addition, blood flow of the tendon injury site was observed by a laser blood flow meter. In the histological evaluation, we observed the tendon collagen fibers of the injury site and adhesion tissues. In the mechanical evaluation, we measured maximal tensile strength and work of flexion.

This study was approved by our institutional review board.

Results: (1) The NIH3T3 cells adhered to a non-coated plastic dish after the seeding and proliferated during the culture up to confluence; however, PMBV gel markedly inhibited the adhesion so that little no cell remained after 36 h (Fig. 1).

(2) PMBV gel partially remained undissociated for three weeks, partially dissociated to PMBV and PVA. The SEM image showed that PMBV gel maintained a honeycomb structure even after three weeks.

(3) In the rabbit flexor tendon injury model, the microscopic finding of the repaired tendons after 3 weeks showed the similar continuity of the tendons between the control group and the PMBV group. There was severe adhesion in the control group, while little or no adhesion was observed in the PMBV group (Fig. 2 and 3). In addition, the blood flow at the tendon injury sites recovered similarly in both groups. The histological finding by HE staining of the repaired tendons showed that the gap of the tendon in both groups was similarly filled with granulation and bridged by collagen fibers. There was tenacious fibrous adhesion tissues in the control group, while little or no adhesion tissue in the PMBV group was observed. The mechanical findings presented no significant difference between the maximal tendon tensile strength (Fig. 3) and significant difference between the work of flexion of both groups.

Discussion: Despite many studies for prevention of tissue adhesion, there is yet no definite solution. The conventional anti-adhesion materials are not good at biocompatibility and handling especially in a small operative site. Since MPC polymer provides a biomembrane-like surface, its application suppresses biological reactions such as foreign body reaction, cell adhesion, and protein adsorption. Some medical devices with MPC polymer have already been authorized by the Food and Drug Administration (FDA). In addition, PMBV gel can easily be used to a operative site which has intricate shape because it can form spontaneously in not only dry but also wet condition.

In conclusion, PMBV gel can be a safe and effective solution to prevent adhesion without impairing tissue healing. Further studies on its clinical application are now underway.