INFLUENCE OF COLLAGEN STRUCTURE ON THE MECHANICAL PROPERTY OF ARTICULAR CARTILAGE

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Biotribology; Friction; Modelling in Tribology, Polyvinyl alcohol hydrogel

ABSTRACT
[Introduction]

Articular cartilage shows excellent mechanical properties with unique structure formed mainly of collagen fiber. However, it is difficult to discuss the relationship between the collagen network and mechanical property in detail using actual cartilage specimens since the factors affecting the mechanical properties are diverse and complicated. In this study, using of fiber-oriented poly(vinyl alcohol)(PVA) hydrogel mimicking articular cartilage structure, we clarified the influence of changes in collagen structure change due to tissue maturation on the mechanical property of articular cartilage.

[Method]

As shown in Fig. 1, oriented PVA fibers were placed in acrylic mold. Twenty five wt% aqueous solution of PVA (polymerization degree: 1,500-1,800, Saponification degree: 98.4-99.4 mol%) was poured into the mold. And then, this sample was treated by 4-times repeated freezing-thawing method (freezing process: -20°C for 8 hrs, thawing process: 4°C for 16 hrs). Considering the collagen content[1)] and density[2)] of immature and mature cartilage, the interval of PVA fibers were 0.4 and 0.8 mm for the immature and mature models, respectively. In addition, fiber-free PVA hydrogel was prepared as a comparative control. Unconfined compression test was performed on the cartilage model at a compression rate of 5, 30, and 100 μm/s. Friction test was performed on the cartilage models against an alumina ceramic ball of 6 mm in diameter with a friction speed of 5.0 mm/s. The load was 0.7 N (maximum contact pressure: 0.28 MPa), and the total friction distance was 2.4m. Two friction directions were selected; perpendicular (⊥) and parallel (//) to the fiber orientation inside cartilage models.

[Result and Discussion]

The elastic modulus of mature model showed a tendency to be higher than that of immature model. In contrast, the coefficient of dynamic friction of mature model showed a tendency to be lower than that of immature model when sliding parallel to the fiber orientation (Fig.2). These findings suggest that changes in collagen structure due to maturation contribute to improvement of the mechanical property of articular cartilage.

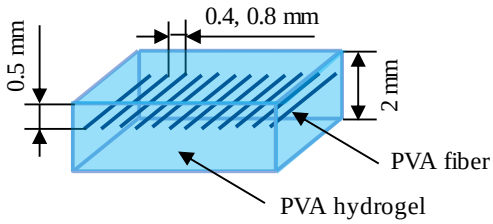

Fig. 1 Schematic drawing of a fiber-oriented PVA hydrogel as a cartilage model.

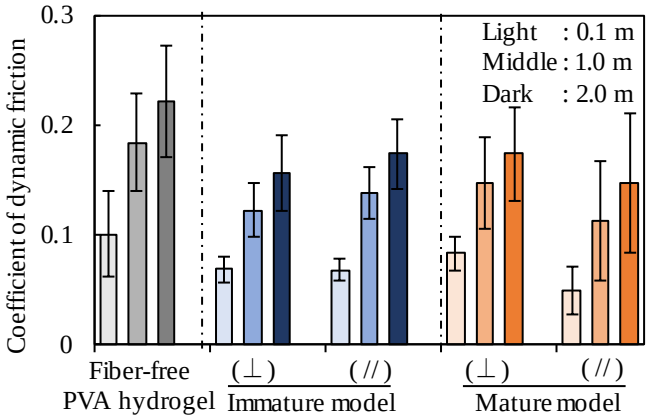

Fig. 2 Coefficient of dynamic friction of Fiber-free PVA hydrogel and cartilage models (Mean ± SD (n = 5), *: $p < 0.05$ in Tukey's HSD test).

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