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Biodegradable Composites Made up of 3-Dimensional Braided Poly(L-lactic acid) Fibers

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Totally biodegradable composites as bone implants could obviate the need of secondary surgeries to remove them. These composites were widely studied in the last decade. Biodegradable polymers especially synthesized poly(α -hydroxy esters) were among the most studied. Self-reinforced poly(glycolic acid) (SR-PGA) and self-reinforced poly(L-lactic acid) (SR-PLLA) have been used as biodegradable screw, pin, tack, wire, etc.¹ Although SR-PGA and SR-PLLA exhibit good biodegradability and biocompatibility, they show relatively low osteoconductivity compared with bioactive ceramics, such as hydroxyapatite (HA). Biodegradable PLLA-HA composites have been well studied, but their relatively weak strengths limit their clinical applications although they show stiffness similar to that of bone.² In this paper, we attempt to prepare biodegradable braided composites made up of PLLA fibers with or without apatite coating. These totally biodegradable composites were tested for their biomechanical properties.

Experimental Methods

PLLA fibers with viscosity-average molecular weight of 120,000 were prepared by melt-spinning in our laboratory.³ The diameter was 113 ± 9 μm . Three dimensional (3-D) PLLA braids were fabricated by a 4-step braiding process using the above PLLA fibers. A group of PLLA fiber bundles was also studied. The PLLA braids and bundles were coated with poly(DL-lactic acid) (PDLLA) solution and compression molded in a rectangular mold at an elevated temperature under pressure. Before the molding process, the PDLLA coated PLLA braids were air-dried overnight and vacuum-dried to eliminate solvent thoroughly. Apatite coatings on PLLA braided fibers formed by a biomimetic process⁴ or solution method were used to fabricate the biodegradable PDLLA-apatite-PLLA composites.

Samples with 5 mm wide, 50 mm long and about 1.4-1.9mm thick were prepared. The bending properties were tested at room temperature using a 4 point-1/3 point bending setup in a Housfield tester. A 1000-N loadcell was used. Crosshead speed was 5 mm/min. The results were obtained from the average of three tests.

The morphology of the composites was viewed under a scanning electron microscope (SEM) (Model Stereoscan 440).

Results and Discussion

Two kinds of 3-D PLLA braids, designated as Braid-a and Braid-b respectively, were fabricated. They both had 8x11 braiding yarns and 7x10 uniaxial yarns. The void fraction for Braid-a was $63.3\pm 3.1\%$ and that for Braid-b was $61.3\pm 4.8\%$. The apatite percentage by weight was 2.19% for Braid-a by biomimetic method and 11.3% for Braid-b by solution method. Biomechanical properties of the prepared biodegradable composites were shown in Figure 1-2. There appeared to be no satisfiedly significant difference ($p>0.05$) between the braided composites with and without apatite coating. And there was no significant difference ($p>0.05$) between the braided composites and the bundled composites. However, significant difference ($p<0.05$) was tested between the bending strengths for the Braid-a and Braid-b groups.

SEM micrographs showed that the PLLA fibers remained their shape in the composites and the fibers were stuck together. There were no obvious interfaces between PLLA fibers from the section morphology of the composites. However, a boundary between fibers was clearly shown in the section micrographs of PDLLA-apatite-PLLA composites, where apatite might locate.

References

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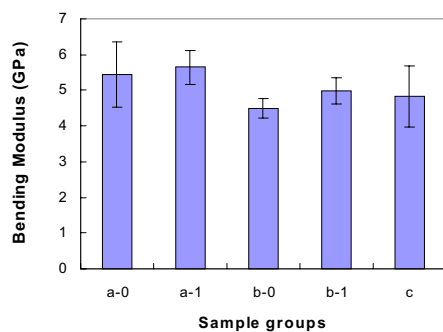


Fig. 1 Bending modulus. a-0: composites containing Braid-a; a-1: composites containing Braid-a with apatite; b-0: composites containing Braid-b; b-1: composites containing Braid-b with apatite; c: composites containing PLLA fiber bundles

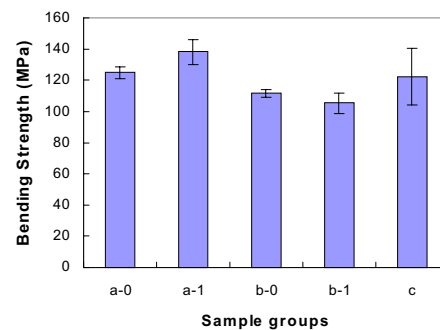


Fig.2 Bending strength. a-0: composites containing Braid-a; a-1: composites containing Braid-a with apatite; b-0: composites containing Braid-b; b-1: composites containing Braid-b with apatite; c: composites containing PLLA fiber bundles