Wear and Friction Characteristics and Crosslinked Properties of Genipin and Photochemical Crosslinked Articular Cartilage

by

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Cartilage disease and injury are major public health problems that affect millions of individuals of all ages. However, there are few current treatments to prevent or slow the progression of disease. While not the only factors, mechanical wear and biochemical degradation of the cartilage surface are major contributors to the progression of joint disease. The primary objectives of this dissertation were to investigate wear characteristics and biochemical degradation of both healthy and impact damaged cartilage and to determine if genipin and photochemical crosslinking improves these characteristics.

Previous studies have shown that genipin crosslinking of healthy, intact cartilage resulted in increases in unloading stiffness measured via indentation and wear resistance with increasing concentration. The indentation stress relaxation tests were further analyzed by fitting the relaxation portion with a finite element model and a standard linear solid model, which produced similar results. The instantaneous stiffness increased with crosslinking in a similar fashion to the unloading stiffness, the equilibrium stiffness did not significantly change between concentrations, and the relaxation time constant decreased with increasing genipin concentration. Furthermore, genipin crosslinking decreased the amount of collagenase digestion at the articular surface but did not alter cartilage friction. It was determined that a 2 mM concentration had nominal toxicity, but a 10 mM concentration resulted in abundant cell death.

Cartilage was damaged via a single, blunt impact which resulted in an increase in the friction and wear compared to an undamaged control. However, there was no difference between impact damaged cartilage and undamaged cartilage in terms of the amount of collagenase digestion at the articular surface. Genipin crosslinking after impact did not alter the friction characteristics, but improved cartilage wear and decreased collagenase digestion at the articular surface.

Photochemical crosslinking of healthy, intact cartilage resulted in improved wear resistance with no change in friction for a nontoxic protocol similar to genipin crosslinking. It was determined that crosslinking before impact does not change the topographical amount of fissure formation. Finally, a four week culture study resulted in less wear in the photochemical crosslinked group and no cytotoxicity differences between the crosslinked and control.