

Using nanotechnology to regenerate the enthesis

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In the United States, there are approximately 100,000 reconstructive surgeries performed on the anterior cruciate ligament (ACL) per year. The failure rate of ACL surgery ranges from 5 to 25% depending on the criteria for failure used in the study, with an additional 8% of patients reporting recurring instability in the joint. However, there are more complicated joints for which surgery is even less successful. For example, surgery to repair torn rotator cuffs has a failure rate ranging from 30 to 94%, with approximately 75,000 surgeries occurring every year in the U.S..

It is believed that high failure rates for the surgical repair of tendons/ligaments are due to removal of the tendon-to-bone transitional zone known as the enthesis. The enthesis disperses stress concentrations at the tendon-to-bone insertion site (TBI) using a gradient of tissue across four zones (tendon, fibrocartilage, calcified fibrocartilage, and bone). The four zones blend into a continuous gradient to provide a smooth transition of mechanical properties – bone is very strong in compression, whereas ligament has high tensional strength. However, due to avascularity, the enthesis is incapable of repairing itself in the event of an injury. Therefore, it is worthwhile to investigate the development of a structure that is capable of restoring functionality to the enthesis by guiding regeneration of the tissue surrounding the tendon-bone insertion site (TBI).

The proposed enthesis construct is composed of a polymer scaffold (PLLA) mineralized in a graded fashion with nanoparticles of hydroxyapatite (HA) and nanoparticles of magnesium. Figure 1 shows the shape of the construct (using the ACL as the ligament of interest), which allows the tendon graft to pass through the center of the ring before being secured within a bone tunnel.

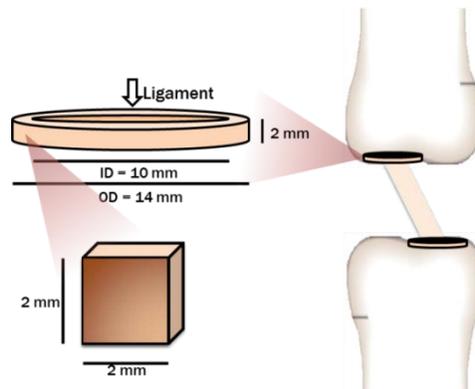


Figure 1. Schematic of o-ring-shaped artificial enthesis, showing its position in the joint (right) with a cross-section depicting graded mineralization (bottom left). The inner diameter (ID) shown is the average diameter of an ACL graft.

This talk will focus on factors important for the selection of appropriate scaffold materials, techniques for their synthesis, and methods used to test the effectiveness of these materials. Future experiments will characterize the proliferation and differentiation of mesenchymal stem cells (MSCs) seeded to the scaffold to determine the effectiveness of each construct for regenerating the transitional tissue at the TBI and subsequently dispersing mechanical loads.