Tissue engineering approaches to cartilage repair are currently thought of as the “Holy Grail” strategy for biologic joint replacement techniques. While these techniques hold great promise and potential as a “better” form of treatment for cartilage defects, joint trauma, and osteoarthritis, clinical applicability is largely unrealized to date. The major limitations in progress towards clinical applicability include attaining functional material properties of tissue engineered cartilage, construct integration to bone and surrounding cartilage, the joint environment, and regulatory considerations. Of these, integration and the joint environment appear to be the biggest impediments. These impediments highlight the fact that the joint is an organ and requires the integrated and synergistic function of multiple intra- and extra-articular tissues for pain-free use to occur.

Tissue engineering relies on the manipulation of cells, scaffolds, bioactive factors, and bioreactors to try to achieve the goal of functional regeneration of diseased or injured tissues. Tissue engineering approaches for cartilage repair currently in clinical use include cell-based (autologous or allogeneic) strategies with or without a scaffold or matrix, including autologous chondrocyte implantation (ACI), MACI, DeNovo NT and CAIS. While each of these techniques can be associated with successful outcomes in certain indications, none fully overcomes the major impediments of full integration or treatment of more than just the cartilage. As such, their utility and success are limited, especially with respect to use in the ankle. Therefore, we have pursued an approach focused on functional tissue engineering of osteochondral constructs aimed and resurfacing of entire joint surfaces.

In collaboration with the Cellular Engineering Lab at Columbia University, our research team has been optimizing tissue processing, chondrocyte culture, tissue loading, construct composition, and implantation strategies for creation of patient-specific tissue engineered osteochondral implants for resurfacing shoulders, hips, knees and ankles of dogs and humans. Our current methodology involves CT or MRI of the affected joint in order to create computer-assisted design renderings of molds, which are subsequently fabricated for tissue engineering the construct. Once the mold is created, allogeneic chondrocytes from an organ donor are loaded into it in a 3-D agarose gel. This chondral gel layer is integrated with an osteo-layer and the construct is cultured in a specific medium while dynamically loaded in the mold in our bioreactor.
such that biochemical and biomechanical properties of the osteochondral construct can be optimized prior to implantation into the harsh environment of the osteoarthritic joint. Our team has shown that chondrocytes can be used to produce engineered cartilage with mechanical properties and composition similar to healthy cartilage; that multiple types of clinically-relevant scaffolds can be used to create functional osteochondral constructs; and that these constructs can be successfully implanted into animal shoulders, knees and ankles using currently available surgical techniques and instrumentation with safe and effective short-term outcomes.