Executive Summary: Design Excellence Award

An osteochondral allograft delivery system for a reduction of chondrocyte death

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Articular cartilage defects are detected in roughly 60% of patients undergoing knee arthroscopies (Widuchowski et al., 2007). These defects can lead to the development osteoarthritis and consequential dysfunction of the knee joint that is commonly treated with cartilage replacement surgical procedures. However, current osteochondral graft procedures only exhibit an estimated 80% success rate that is heavily influenced by the viability of donor chondrocytes. Failure of the implanted graft results in continued patient discomfort and can require another costly surgical grafting procedure. A higher success rate for osteochondral allograft procedures is necessary for increased longevity of knee grafts.

The current clinical procedure involves using a *Lesion Reamer*^{TM} to eliminate the diseased area of tissue and create the recipient site. The dimensions of this site are measured extensively and matched to a corresponding location on the donor condyle. A bone plug with healthy cartilage is then extracted from the donor condyle matching the dimensions and anatomical makeup of the recipient site. A tamp and hammer are used to deliver the donor tissue through compressive loads in the form of impaction. Rapid impaction continues until the bone plug lies flush with the recipient articular cartilage. This impaction leads to chondrocyte death and the loss of chondrocyte viability reduces long term success of the procedure. Hence, there is a need for a delivery method that reduces the normal forces applied to the cartilage surface of the plug in order to maximize cell viability and subsequent long term postoperative success. The proposed method relies on threading the cylindrical allograft and recipient site to allow for proper delivery through a clockwise rotation of the graft into its respective site until it is flush. Insertion of the graft through torsional means reduces the normal forces on the cartilage, and theoretically reduces chondrocyte death after the procedure.

To test the proposed delivery system, fresh bone plugs were extracted from the femurs of a euthanized pig. The plugs were grouped into impaction and threading experimental groups and a control. Surgical delivery was simulated on the two experimental conditions, followed by cartilage removal, staining with Calcein AM/Ethidium Homodimer-1 and imaged using a Nikon A1RS Confocal Microscope. Images were analyzed using ImageJ with cell counts from the independent live and dead stain channels and percent cell viability was calculated. While the design reduced normal forces on the cartilage, preliminary testing determined that cell viability was not improved in threaded samples relative to the impacted samples. Both sample groups also failed to exhibit a cell viability higher than the 70% threshold required for surgical success (Lightfoot et al, 2007). Furthermore, it was determined that threading increased difficulties with mating the allograft in the required configuration to match the threads in the recipient site.