Changes in Condylar Friction Coefficient After Osteochondral Graft Implantation and Its Associated Reduction with Hyaluronan

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Introduction: As allogenic and autogenic grafts become more prevalent in the repair of cartilage defects, there is an increasing need for details of the healing mechanisms and changes to the biomechanical properties within the joint. Of particular interest are the changes made in cartilage surface friction as a result of mismatched osteochondral plug elevation. Finite element analysis suggests that inadequate placement of the osteochondral plugs may produce abnormal stress and strain distributions within the cartilage, and thus influence the regeneration of the injured cartilage site and the maintenance of opposing, healthy cartilage surfaces. While attempts are made to maintain a confluent surface elevation between host and implanted cores, it is quite challenging to align all edges when the core is allogenic or is derived from different anatomical regions of the knee joint such as the trochlear groove. At best, most allogenic core repairs are implanted to match the average elevation of the surrounding cartilage surface, leaving some sides proud and others depressed. It is expected that the core will remodel according to the mechanical loading environment with time. However, changes in surface structure introduce stress risers which directly impact the frictional coefficient and stress experienced at the cellular level. Indeed, an ideal cartilage plug fit may also be significantly damaged to the remodeling of the adjacent condylar surface to which it is bound. This leads to a generally poor outlook for confluent healing in the long term. In order to better understand the differences in cartilage coefficient of friction with an osteochondral repair, an assessment of dynamic loads has been developed using a goat knee model. Application of Hyaluronan (HA) was also assessed for its lubricative properties and resultant friction coefficient on the knee.

Materials and Methods: Ten caprine legs were used in this study: seven experimental and three controls. Additional legs were used for donor allograft plugs. Each leg was dissected and mounted into a custom jig attached to an Instron load frame for testing (Fig. 1).

A stress-strain curve was generated by cycling the load frame to rotate the knee via a cabling system attached to a flywheel. The experimental knees were tested in 5 modes: 1) a normal cartilage surface, 2) an empty 4.5mm defect hole, 3) a filled hole, proud 0.5mm, 4) a filled hole, flush with surrounding cartilage, and 5) a filled hole, depressed 0.5mm. Saline lavage kept the knees moist during testing. The effect of HA was evaluated after mechanical testing. Friction coefficients were measured relative to the normal, unaltered joint and then calibrated to account for friction of the system. The load frame was set to cycle between 60 and 90 degrees of rotation. The three control knees were used to establish whether changes in friction resulted from properties of the environment (ie. saline lavage, plug height and presence of HA).

Results: Proud placement of plugs in this study increased the COF by a factor of 4 compared with normal. Increases in COF were associated with saline lavage (0.006 to 0.046 over 60 minutes) and were used in the calibration of experimental measurements. Friction coefficients of the four test modes are seen in Fig. 2 with the corresponding reduction in friction after HA injection. Injection of HA into the joint following the last modality (depressed plug) reduced the COF to near normal levels.

Discussion: While repair with osteochondral grafts increases the COF in all cases, there is a significant increase associated with a plug being left proud. This is true even when one side is proud and the other depressed which is often the case when surgeons position the new plug at the average cartilage surface height. Interestingly, lavage with saline also increases COF when compared to normal. The increase is quite dramatic and can potentially cause damage to the knee when the patient begins articulating the joint after surgery. Treatment with HA following osteochondral graft treatment and lavage improves the lubricative property of the cartilage surface, approaching normal levels. To reduce the elevated friction coefficient observed after a surgical knee procedure a material with lubricating properties, such as HA, would be recommended following the results of this study. Further investigation into the use of lubricative materials is recommended.


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