Influence of Patella Alta on Patellar Tracking in the In Vitro Stifle Joint
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Introduction:
Patella alta describes a postoperative complication characterised by a vertical migration of the patella to an abnormally high position by an apparent 10% or more. This positional alteration of the patella has been associated with patellar instability (subluxation) and anterior knee pain [1]. It has been demonstrated that patella alta is associated with altered patellar alignment and retropatellar contact mechanics. Specifically, a cohort of patients presenting clinically with patella alta were found to exhibit changes in tilt and medial-lateral displacement of the patella [2]. It has been postulated that changes in patellofemoral joint loading may be the catalyst for degeneration of patella cartilage leading to anterior knee pain.

Because of comparable biology, anatomy and biomechanics with that of the human knee, the ovine stifle joint has become an increasingly utilised and widely-accepted model in orthopaedic research. This has been the motivation for a considerable body of research into the in vitro kinematics of the ovine stifle joint [3-5].

We developed a device used in combination with transection of the native PT to induce controlled 1mm increases in PT length, L_P, and examined the ensuing effects on the patellar tracking. This study was conducted to test the null hypothesis that patella alta would not result in changes to the patellar tracking pattern.

Materials and Methods:
8 ovine hindlimbs (4 paired) were obtained from animals (18 months, 54±1.4 kg) sacrificed for other unrelated experiments in our laboratory and immediately frozen. These animals had not received any surgical intervention to the lower extremities and all were free from any gross abnormalities.

The specimens were defrosted and rigidly fixed into a knee loading frame and 50N load applied along the line of action of the rectus femoris muscle using a weight/cable/pulley system. Passively-induced Knee kinematics were continuously measured throughout the range of motion of the knee using a magnetic tracking system, 3Space IsoTrack II (Polhemus, Colchester, VT). Receivers were attached to the patella and tibia using polyethylene bone screws. Prior to and following the testing sequence the patellar receiver assembly was transferred to a third screw implanted in the femur for the purpose of femoral registration.

Each leg was disarticulated and all bones CT-scanned (anisotropic voxel resolution of 250µm x 250µm x 500µm) with the registration block portion of the receiver assemblies engaging the relevant bone implants. DICOM outputs were used to generate 3D surface representations of the bones and associated registration blocks which were subsequently imported into ProEngineer where body-fixed coordinate systems were created using bony landmarks in accordance with the Joint Coordinate System (JCS) of Grood and Suntay [6]. The necessary coordinate transformations were then obtained from assemblies in which parametric models of the complete receiver assemblies were aligned with datum features based on the surface representations of the registration blocks. Matlab (MathWorks, IL) was used to transform the raw data into translations and rotations as per the JCS. Kinematic data was analysed using a repeated-measured ANOVA. A Dunnett’s test for multiple comparisons against a single control was used for post hoc testing to identify statistically significant changes caused by artificial lengthening of the PT. Differences were considered significant where P<0.05.

In our previous work we have demonstrated that there is a high degree of correlation between the tibial and patellar flexion angles when using the JCS to model stifle joint motion. That is, the patellar flexion angle can be used reliably as an indicator of stifle flexion angle. Accordingly and for the purposes of this study, we have presented patellar tracking data as a function of patellar flexion angle referred to the femoral coordinate frame.

Results:

![Figure 2 Patellar spin as a function of the patellar flexion angle (Mean±SD)](attachment)

Analysis of control kinematic data confirmed the existence of a strong positive correlation between patellar and tibial flexion (r=0.987, p=0.001). Patellar flexion lagged tibial flexion by a mean 32%. Patellar tracking data was therefore presented in this way.

In all knees tested the mean percentage increase in L_P was 9%. This level of contracture was associated with a significant decrease (P<0.05) in medial patellar spin in the early part of tibial flexion (70-100°). Simulation of patella alta was also associated with a mean net lateral patellar displacement (2.5mm). No other patellar tracking parameters were affected by the simulated increase in L_P.

Discussion:
A novel device was developed and used in this study in combination with transection of the PT to induce controlled changes in L_P and simulate the effects of patella alta on patellar tracking. Patella alta was associated with significant changes in the patellar tracking pattern. Specifically, persistent changes in patellar tilt and a net lateral displacement were detected. The results of this study compare well with those reported clinically [3], which suggests suitability of the ovine stifle joint for biomechanical research as it relates to the human population.

References: