INTRODUCTION

Wear and fracture of patellar components has been reported in the literature as a failure mode for both cemented and press fit patellar components [1-5]. Malalignment of the patellar components can cause higher contact stresses, which can lead to excessive wear, delamination, and/or fracture of the component. Therefore, in vitro testing of the patella in a clinically relevant malaligned condition is necessary to demonstrate adequate performance of the patellar component and to assess the endurance of its fixation features under severe loading conditions. As a result, the purpose of this study was to develop an in vitro malaligned patella test model using a knee joint simulator.

MATERIALS AND METHODS

A 6-station MTS (Eden Prairie, MN) knee joint wear simulator was used for testing. A lubricant of Alpha Calf Friction serum (HyClone Labs, Logan, UT) diluted to 50% with a pH-balanced 20-mMole solution of deionized water and EDTA was used (protein level = 20 g/l) [6]. The patellar implants used for development of the model were asymmetric, all-polyethylene components, with a thickness of 11 mm (Duracon®, Stryker Orthopaedics, Mahwah, NJ). Appropriately sized cobalt-chrome femoral components articulated against the patellae. The patellae were cemented to delrin fixtures which placed the patella in 10 degrees of lateral tilt (Figure 1). This angle was chosen based on the work of Huang et al which was one of the larger average tilt angles reported in vivo [7]. Replicating this scenario in vitro allows for observation of what may occur as the femoral component maintains contact strictly on the thinner lateral edge of the patella, concentrating both the axial and shear loads on a small area of polyethylene.

The loading and kinematic profiles used for testing were published previously, and use a maximum axial load of 2450 N and a maximum patellofemoral angle of 54 degrees [8]. Variations of the loading profile were studied by evaluating the effects of heavier patients, which increased the maximum axial load to 3100 N (250 lb patient) and 3750 N (300 lb patient) (Figure 2). Lateral offset was also introduced into the model to further evaluate the effect of malalignment. Increments of 1 mm were analyzed starting from the neutral position, eventually reaching a maximum lateral offset of 5 mm.

A 6-dof load cell was placed beneath the patella fixturing to capture dynamic loads (ATI, Apex, NC). The axial load and medial/lateral shear load captured by the load cell were then used to calculate the resultant medial/lateral shear force being applied to the patellar pegs.

RESULTS

The results of using both a heavier loading profile and increasing lateral offset are shown in Figure 3. At neutral alignment, the effect of increasing the axial load caused an increase of about 10% in resultant shear force. At 5 mm of lateral offset, the increase in loading caused the shear force to increase by approximately 16%. With each loading profile, increasing the lateral offset from 0 mm to 5 mm caused the resultant shear force to increase two-fold.

DISCUSSION

The development of this test model allows for an aggressive method of testing patellar implants. It includes several variables which allow for adjustment of the severity, including lateral offset and increases in the joint reaction force. It is important to note that these results are specific to the device used since the results will be dependant on the function and design of the patella/femur track.

Since patellofemoral complications have been reported to be as high as 39%, new methodologies which simulate possible in vivo malalignment conditions can be useful in the development of new components [9]. In addition, the increase in loading to simulate heavier patients may become a necessary change as the average BMI of joint replacement candidates continues to increase [10].

REFERENCES


Figure 1: The patellar component in 10 degrees of lateral tilt.

Figure 2: The kinematic profiles used for testing.

Figure 3: The resultant shear force using various testing parameters.