

Is the Use of a Femoral Stem Necessary with a Constrained Tibial Insert?

Introduction

The LEGION™ Primary Knee femoral component (Figure 1) is a design that does not incorporate a taper connection for the use of femoral stems unlike the LEGION Revision Knee femoral component (Figure 2). The design may be used in situations where the bone quality is good but the ligaments are compromised to the extent that the use of a constrained insert is necessary. It was theorized that the lack of a femoral stem may cause an increased stress condition in the tibial polyethylene insert and cement mantle. The purpose of this analysis was to compare the stress magnitudes and distributions in the cement mantle and constrained polyethylene insert for a construct with LEGION Total Knee System femoral components using finite element analysis (FEA). A physical test measuring the strains on a femoral stem with an implanted revision femoral component was performed to provide a baseline.

Materials and Methods

The construct for the FEA model was loaded with a 450 lbf (2002 N) load at 45° in order to induce a varus loading condition (Figure 3). The tibial polyethylene insert was fixed in all directions on the distal surface and the cement/femoral and cement/femur interfaces were modeled as rigidly fixed to simulate a well cemented construct. The bone cement mantle and constrained polyethylene insert were analyzed for stress magnitudes and distributions.

In laboratory testing, the femoral stem strains were measured by attaching strain gages along the length of the femoral stem (Figure 4). The femoral component and stem were implanted in a composite bone and loaded through the femoral head with a 450 lbf (2002 N) load (Figure 5) with the construct placed on a tibial insert. Three cases were tested: cemented, press-fit, and press-fit with a gap under the medial condyle to simulate bone resorption.

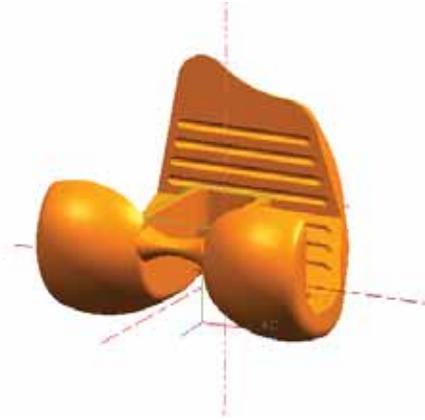


Figure 1 - LEGION Primary Knee femoral component



Figure 2 - LEGION Revision Knee femoral

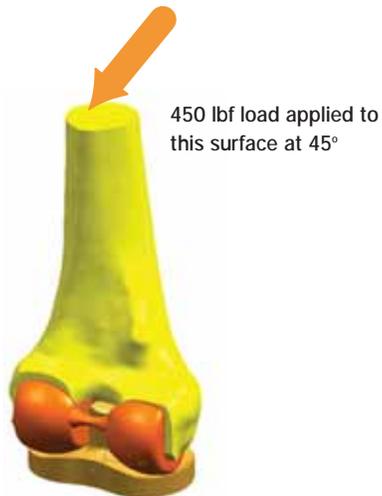


Figure 3 - Construct model

Results and Discussion

Based on the FEA, the polyethylene insert post stresses for the construct with the LEGION™ Primary Knee femoral component were only 7% higher than the construct with the LEGION Revision Knee femoral component (Figure 6). However, the resulting cement mantle stresses were generally higher with the revision femoral component. The stress distribution with the revision femoral component was concentrated in the central and posterior regions whereas the primary femoral component showed a relatively even distribution of stresses (Figure 7). The differences between the two constructs were due to the additional stiffness of the anterior femoral stem in the revision construct.

The laboratory testing found the majority of the femoral stem strains measured in the cemented case were the result of the bending of the composite bone. A 3% increase in femoral strain measurements was found for the press-fit case compared to the cemented case due to the reduced fixation at the bone/femoral interface causing an increase in the mid-shaft femoral stem strains. The stem strains increased by 11% when a gap under the medial condyle was introduced to simulate bone resorption. The femoral stem strains increased along the entire length of the femoral stem.

Conclusions

The finite element analysis indicates that for a well cemented femoral construct the lack of a femoral stem did not significantly increase the polyethylene insert post stresses or cause increased cement mantle stresses. The femoral stem strain measurements showed that in the case of a well-fixed component, the majority of the stem strains were the result of composite bone bending. The femoral stem load transfer became more significant as the fixation between the bone and femoral component was progressively compromised.



Figure 4 - Location of the strain gages on the femoral stem



Figure 5 - LEGION Revision Knee femoral component and stem implanted in a composite bone

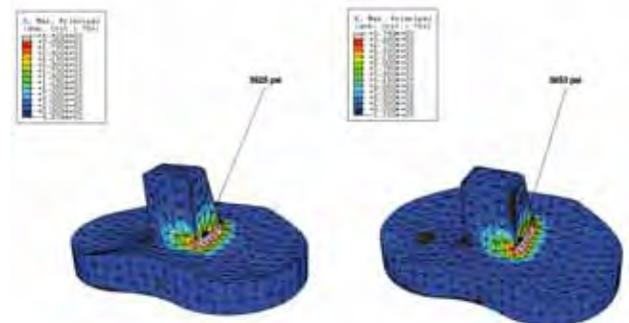


Figure 6 - Constrained polyethylene insert stresses (LEGION Primary Knee construct (left), LEGION Revision Knee construct (right))

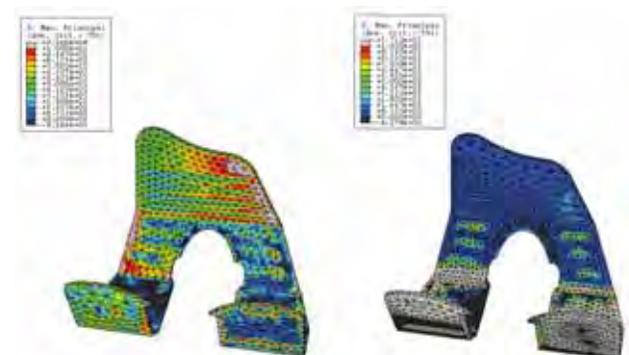


Figure 7 - Cement mantle stresses (LEGION Primary Knee construct (left), LEGION Revision Knee construct (right))

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