FINITE ELEMENT ANALYSIS OF A TOTAL ANKLE ARTHROPLASTY OVER ONE STANCE PHASE

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INTRODUCTION

It is known in the biomaterials and orthopedics communities that excessive wear debris in orthopedic implants, in combination with excessive bone-implant interface stress can lead to osteolysis of the supporting bony structures. Osteolysis can cause component loosening, migration, and subsidence [1]. These are the biggest concerns to engineers and surgeons when providing total ankle joint replacements. In total ankle replacement (TAR) specifically, clinical follow-ups have shown the talar component to experience loosening and subsidence more frequently than desired [2].

The purpose of this project is to determine the maximum contact stresses present and maximum polyethylene (PE) deformation resulting between the talar component and polyethylene tibial insert of the size 4 AGILITY Ankle implant (DePuy Orthopaedics, Inc., a J&J co., Warsaw, IN) through one stance phase of the gait cycle under physiological loading. Maximum interface stress between the talar component and the supporting bone will also be investigated to determine the effect of torsion in the transverse plane.

METHODS

Physiological forces and displacements will be applied to the AGILITY components at every five percent of the stance phase of the gait cycle, resulting in 21 total models. A quasi-dynamic analysis of one movement through the stance phase of gait will result from the combination of these 21 models. Component models will be aligned in their respective positions (Figure 1) [3] in Unigraphics, from EDS Corp., Plano, TX.

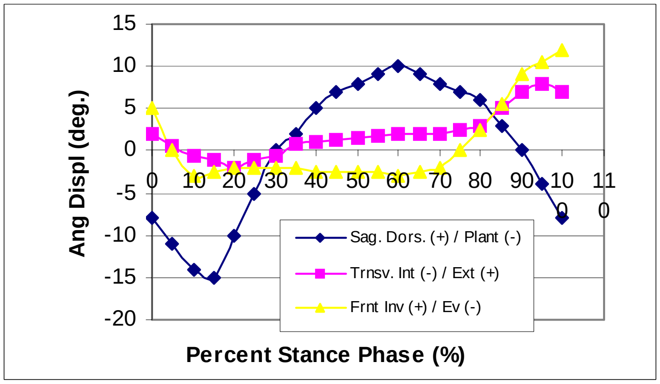

Figure 1: Talus Position in Sagittal, Transverse, and Frontal Planes over Stance Phase of Gait

The solid models will be imported into PATRAN, from MSC.Software Corp., Santa Ana, CA, where the boundary conditions, material properties, and mesh will be defined. Model 15 of 21 is shown below (Figure 3). A physiological varying torsional load will also be applied, although it is not shown.

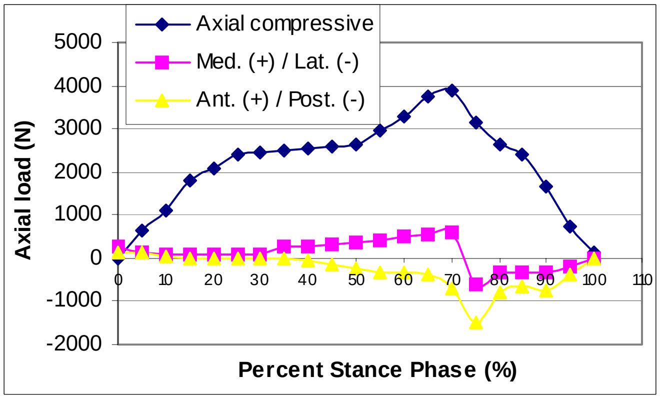

Figure 2: Loads on Ankle Joint in 3 Directions over Stance Phase of Gait Cycle

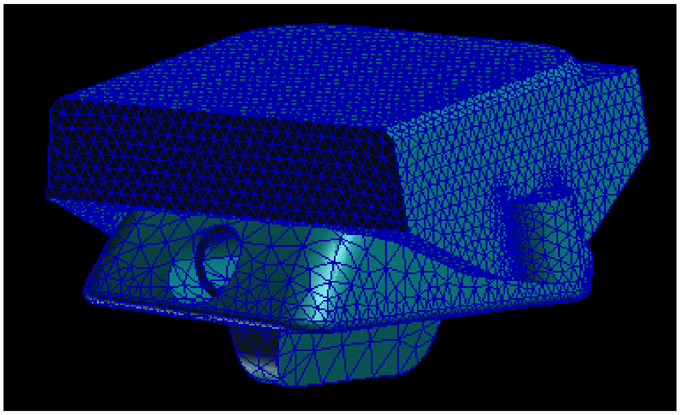

Figure 3: FE mesh of the AGILTY Ankle at 70% of the stance phase of gait: 8° dorsiflexion, 2° external rotation, 2° eversion

RESULTS AND DISCUSSION

Preliminary analysis has shown that maximum contact stresses and polyethylene deformation occur at 70-75% of the stance phase. This was expected, as axial loads (Figure 2) [4] are the greatest and dorsiflexion is also substantial. It is expected that areas of high contact stress and large PE deformation on each of the 21 discreet computational models will combine to closely resemble the wear patterns found on the clinical retrievals of PE tibial inserts. It is also expected that in positions under heavy torsional loading, large medial-lateral contact stresses will be observed in the talus, which may translate into possible large shear forces at the talus-bone interface.

REFERENCES

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