10-1-2014

Wear Characteristics of Wright State University Total Ankle Replacement Under Shear and Torsion Loads

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Society of Engineering Science 51st Annual Technical Meeting

1–3 October 2014

Purdue University, West Lafayette, Indiana, USA

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ABSTRACT

Introduction: Total ankle replacement (TAR) involves replacement of the damaged bone with prosthetic components and is usually performed in patients suffering with arthritis to relieve pain and maintain motion. There are several different factors that contribute to failure of TARs but aseptic loosening is the primary method of failure in total ankle replacements. Because of its superior mechanical properties UHMWPE is used as a liner material in TARs. Wear generated from the liner due to high contact stresses during gait causes osteolysis resulting in early loosening of the prostheses.

Most of the earlier studies have focused on wear due to axial loads. However, the aim of this study was to conduct finite element analysis for determining wear characteristics of Wright State University (WSU) TARs under shear and torsion loads which play a significant role in ankle joint motion.

Methods: WSU-patented TAR models were used for applying loads. Finite element analysis was conducted to determine the wear rate by deriving contact stresses generated in the liner during the gait cycle. Forces acting on the ankle joint during the gait cycle1, 2 were used to simulate the mechanical environment in the ankle joint for measuring the Von Mises and contact stresses developed in the liner by applying shear and torsion loads. Based on Hertzian contact theory and Archard's wear law, a wear equation (3) was used to determine the yearly wear rate in the liners based on contact pressure.

Results and Discussion: Shear loads cause significantly lower contact stresses and wear when compared with the axial load. Under torsion load, the stress values increased with an increase in the degree of rotation. The TAR models under torsion have shown significantly greater stress values when compared with stress values obtained under shear load.

Conclusions: Stress analysis on TAR showed that torsion load causes higher stress values than shear load. With increase in the degrees of rotation, the stress values were increased in the liner under torsion load. From this study it can be concluded that shear and torsion loads acting on the ankle joint during gait plays a major role in affecting the contact stresses, but the axial load plays a more significant role in generating wear.