CALIFORNIA STATE SCIENCE FAIR
2004 PROJECT SUMMARY

Name(s)
Prem N. Ramkumar

Project Number
J0228

Project Title
Mobility through Materials: Handicapped No More!

Abstract

Objectives/Goals
My objective was to understand how total hip replacement joints worked, and the design factors that improve patient mobility and quality of life. My scientific question was the following: What are the key factors that drive the design of knee and hip replacement joints, and artificial limbs? How do the materials in these designs improve a patient#s mobility and quality of life?

Methods/Materials
Three hip joint tests were conducted using the accelerated test setup in the Los Angeles Orthopedic Hospital (LAOH) test facility, and many ongoing tests were observed. Three UHMWPE acetabular cups and Co-Cr femur caps were used in these tests. Tests were conducted in accordance with the industry standard ASTM F-1714-96 method using the LAOH support fixture, Paul in-vivo loading profile, and cyclic loading equipment. Tests were conducted to be representative of fast jogging at 1.75 Hertz and a maximum load of 4500N. The LAOH bovine fluid was replaced by olive oil for my tests. Volumetric wear of the UHMWRE cup was measured using the LAOH Coordinate Measuring Machine (CMM). The CMM measured spatial coordinates at 300 points on the cup, before and after 500,000 load cycles, to compute the extent of wear. Gravimetric wear was measured using the LAOH test equipment. Testing was recorded using a digital camera. Test results were recorded in an Excel database. Results were analyzed and compared to other LAOH observations and data published in the open literature to draw conclusions.

Results
Test results revealed that UHMWPE (polyethylene) is a very durable acetabular cup material with a mean wear rate of ~ 300 mg/million cycles against a Co-Cr femur cap. These results and data in the open literature supported my hypothesis (the best designs use biocompatible materials that closely match the stiffness and strength of the natural body parts they replace, and improve the wear resistance at the joint location) and identified wear-resistant interfacial materials as the best solutions for hip and knee replacement joints and artificial limbs.

Conclusions/Discussion
Biocompatible materials enable robust design concepts for knee and hip replacement joints and artificial limbs that are impacted primarily by the wear performance of interfacial materials. The days of the wooden leg are long gone and advances in materials technology have mobilized patients to a higher quality of life!

Summary Statement
My project determines, specifically, which two materials in a total joint (the pelvis) replacement can mutually coexist at the interface to yield the least amount of wear, making it a more efficient joint replacement.

Help Received
My parents helped me with the background research, transportation to and from the test facility at the Los Angeles Orthopedic Hospital, and the documentation of my testing. Mr. Bill McGarry helped me set up and run the tests at the LAOH test facility and take wear measurements on the CMM and the gravimetric