MASTER'S THESIS DEFENSE

Can the Occurrence of Intraoperative Periprosthetic Fractures be Reduced?

Characterizing and Comparing Proximal Femoral Strain Patterns During Femoral Component Insertion and Initial Stability During Loading of Accolade and Secur-Fit Stems

By

Lindsey A. Sturgis

Wednesday, August 18th, 2010
UCHC, MARB Building, 4th Floor Seminar Room
1:00-3:00pm

Abstract:

Osteoarthritis is a degenerative joint disease resulting in pain and a decreased range of motion. It is a common indication for total hip arthroplasty (THA), during which the natural hip joint is replaced with a mechanical joint. For non-cemented stems, which rely on a tight interference fit, reports of a high incidence of intraoperative periprosthetic femur fractures have been found in the literature. These fractures result from high hoop strains in the cortical bone as the surgeon impacts the stem. Femoral fractures can lead to decreased stability and implant failure, ultimately requiring revision surgeries.

The purpose of this thesis was to characterize strains in proximal femur during insertion of an implant stem for THA, as well as to assess initial stability of the stem after insertion. A blade-type design (Accolade TMZF) and a dual-wedge design (Secur-Fit Max) were compared in this study. A cemented stem (Omnifit EON) was used for control. A trained orthopaedic surgeon impacted thirteen stems into foam cortical bone femur models until stable by feel. Twenty stems were impacted using a drop tower. The crosshead was dropped from 2.75 inches above the impaction plate 10-15 times or until less than 1.5 mm of total movement was observed over three consecutive impactions. The seating height after each impaction was recorded. The stability of each stem was then tested using an MTS. The specimens were initially loaded axially to 200 N, which was then increased in steps of 200 N and cycled 3 times at 0.5 Hz at each load up to 800 N. Then 15 N-m of torque was applied in 2.5 N-m increments. Axial loading was then increased and cycled to 2000 N. After loading, the twenty specimens impacted with the drop tower were then impacted to fracture by the surgeon. Fractures were documented photographically. Six strain gages placed on each specimen were used to collect strain measurements at a sampling rate of 10 Hz throughout testing. Two-sample t-tests and ANOVA were used to analyze and compare variables of interest.

Maximum and minimum principal strains at each gage location were calculated to find peak strain magnitudes and compare between the Secur-Fit and Accolade stems. On the medial surface of the bone, the highest strains resulted from the Accolade stem. On the anterior and lateral surfaces, the highest strains resulted from the Secur-Fit stem. The change in seating height from when the stems were stable to after axial and torsional loading was significantly lower for the Accolade stem than the Secur-Fit stem for both surgically impacted ($p=0.044$) and drop-tower impacted stems ($p=0.021$). The linear portion of each force vs. displacement curve was graphed to obtain the slope of the best-fit line, which represents interface stiffness. No significant difference was observed between the Accolade and Secur-Fit stems for torsional interface stiffness ($p=0.530$). However, the axial interface stiffness was significantly higher for the Accolade stems than the Secur-Fit stems ($p=0.038$). In terms of fracture patterns, the Accolade stems generally produced a single medial or anterior crack, while the Secur-Fit stems produced two cracks on the anterior and posterior aspects of the medial implant surface.

After analyzing all of the results of this study, it appears that the Accolade stem is more stable than the Secur-Fit and resulted in lower strains in this Sawbone specimen model. However, much more research needs to be performed to draw definitive conclusions. It is recommended that the study be repeated using human cadaveric femur specimens to determine if results similar to those from the foam models can be obtained.