Periprosthetic Proximal Femur Fracture: Comparison of Well-Fixed vs. Loose Femoral Components

Harris, B; Owen, JR; Garland HE; Wayne, JS; Jiranek, WA
Orthopaedic Research Laboratory, Departments of Orthopaedic Surgery and Biomedical Engineering
Virginia Commonwealth University, Richmond, VA
Senior author jwayne@vcu.edu

BACKGROUND:
Periprosthetic fracture frequently occurs in association with a loose femoral component (1,2) but whether this results from compromised biomechanical characteristics is unknown. The purpose of this study was to compare the torsional strength of the construct and the resulting fracture patterns between a well-fixed and loose femoral component in both synthetic and cadaveric bones. We hypothesized that a loose cemented stem construct would fail at a lower degree of torsion and result in a different fracture pattern.

METHODS:
Sixteen polyurethane foam/cortical shell left femora (Sawbones Model 1121-3, Pacific Research Laboratories, Vashon WA) were divided into two groups. The first group consisted of well-fixed cemented size 5 Endurance stems (DePuy Inc., Warsaw IN). Prior to testing, the fixed stem was tapped out and reseated for consistency of preparation with the second group. The second group consisted of femora prepared for the same cemented stem as the first group; this stem was removed and replaced with a size 3 Endurance stem (smaller), thus creating a reproducible instability of the stem within the cement mantle. Also, ten fresh-frozen cadaveric femora (five pairs; range 46–67 years; average 60 years) were identically prepared as matched pairs.

Each specimen was mounted in custom-designed fixtures on an Instron 1321 biaxial servohydraulic test machine (Instron Corp., Canton MA) retrofitted with MTS TestStar™ II digital controller (MTS Corp., Eden Prairie MN). Rotational instability was measured by rotating specimens internally and externally to a fixed torque (2N-m). Specimens were then tested in rotation to failure at 1deg/sec in a direction simulating internal rotation of the femur. Stiffness from 5 to 20 N-m of torque for sawbones, or 5 to 40 N-m of torque for cadaveric, and torque at failure were analyzed by t-test for sawbones data and by paired t-test for cadaveric data (p<0.05). Resulting fracture patterns were also examined.

RESULTS:
For the sawbones specimens, stiffness was decreased by 54% for a loose stem (p<0.0001) (Figure 1). Torque at failure was reduced by 38% for a loose stem compared with the well-fixed group (p=0.0001) (Figure 2). Loose specimens reached failure at an average of 35.7 deg (SD 5.5deg) compared to 24.1 deg (SD 2.9deg) with well-fixed stems (p<0.001). Fracture patterns consistently demonstrated a proximal spiral pattern in loose specimens while well-fixed stems resulted in fracture patterns centered more distally. No fractures entirely distal to the stem were noted in either group (Figure 3).

For the cadaveric specimens, stiffness of loose specimens was decreased by 70% (p=0.003) (Figure 1). Torque to failure was reduced by 58% for the specimens in the loose group compared with the well-fixed group (p<0.02) (Figure 2). Rotation to failure of loose specimens at 18.8 deg (SD 3.4 deg) was 72% greater than that of the well-fixed specimens at 10.9 deg (SD 5.4 deg) (p<0.02). Fracture patterns in the cadaveric groups also demonstrated fracture patterns more proximal for loose stems compared with well-fixed specimens (Figure 3).

DISCUSSION:
Both synthetic and cadaveric specimens demonstrated the same reduction in biomechanical performance with a loose femoral component in comparison to a torsionally stable component, which is important for two reasons. First, a patient presenting with a proximal femur periprosthetic fracture (proximal Vancouver B) is more likely to have a loose implant requiring revision of the prosthesis than to have a well fixed implant amenable to fracture fixation alone.

Second, treatment of periprosthetic fracture is associated with significant patient morbidity and costs (3,4), thus, given the demonstrated lower torque to failure of a loose prosthesis, radiographic evidence of loosening may warrant closer monitoring or earlier revision, even if the patient is asymptomatic.

REFERENCES:

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