A MODEL TO EVALUATE IMPINGEMENT FATIGUE PERFORMANCE OF ACETABULAR COMPONENTS

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INTRODUCTION:

Total hip replacement range of motion is potentially limited by impingement of the femoral neck with the acetabular liner. Impingement can occur *in-vivo* at extreme ranges of motion. Prosthetic impingement may lead to many different failure mechanisms, two of which are: 1) dislodgment of the liner 2) cracking of the liner. The authors have not found a published laboratory impingement tests in the literature. Therefore, a laboratory impingement model for the evaluation of acetabular liners was developed. The motivation for developing the model was to evaluate acetabular liners comprised of the new highly cross-linked polyethylene, Durasul™.

METHODS:

The fatigue apparatus for testing the acetabular liners is illustrated in Figure 1. The acetabular assembly is placed into the fixture with the maximum screw hole density positioned below the femoral head and in line with the load line. This orientation creates the maximum amount of unsupported PE. Each assembly is submerged in Ringer's solution at 37°C (98.6°F). The acetabular component is held at a 40° angle from horizontal. Although inverted, this orientation corresponds to the shell at 40° abduction and 20° of anteversion. A neck facsimile is assembled with a head and the assembly is positioned to impinge (Figures 1 and 2).

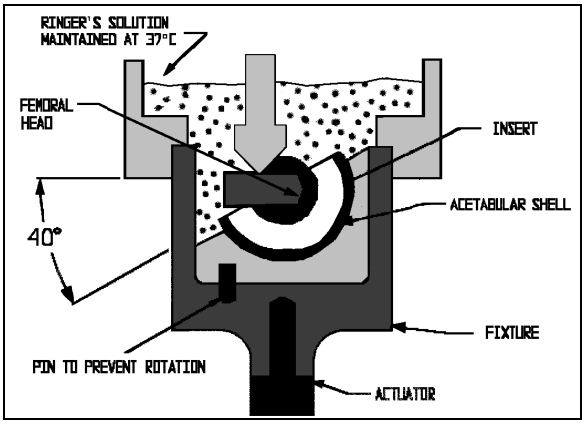

Figure 1: Impingement Fatigue Schematic

A 10,000 N-mm (88 in-lb) moment (Scifert *et al* 1997) is applied to the assembly by machining a notch in the neck, through which a load is applied. For example, for a 28 mm head a 10 mm (0.394 in) offset combined with a 1,000 N (225 lb) load creates the required 10,000 N-mm moment. The load is applied using a sine wave with R=0.1. This moment simulates *in vivo* impingement forces on the acetabular liner. Because impingement is rare during daily activity, the required cycle count (typically 5-10 million for fatigue tests) is reduced to 2 million cycles.

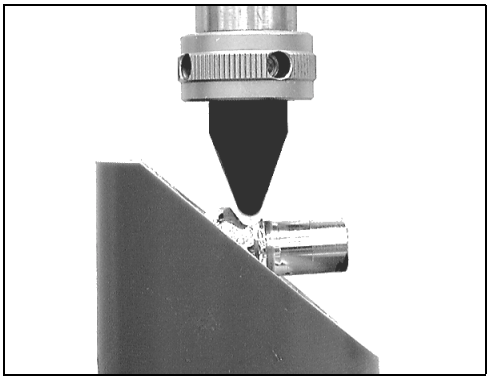
Figure 2: Impingement Fatigue Apparatus

MATERIALS:

This model was applied to six Durasul and six control liners. In-order to simulate a worst case scenario, size 49 x 28 mm and size 39 x 22 mm acetabular components were tested, because they possess minimal PE thickness. Acetabular shells with the maximum number of screwholes were selected. The femoral heads (28mm+8mm, 22mm+0mm) that created the worst impingement scenario were selected. Skirts on the femoral heads strongly effected the size selection.

Post-Test Evaluation

After testing, each acetabular system is inspected under a microscope and then disassembled. Freezing the liners with liquid nitrogen produced enough shrinkage of the PE to allow the liner to be removed with ease. Gross creep, gross wear, or penetration of the head/neck assembly into the liner that is visible to the naked eye, is evaluated. The liners are inspected for cracking under a microscope, particularly at the liner's rim where the PE is thin.

RESULTS:

A model for impingement was defined and evaluated by testing six Durasul™ Inter-Op™ liners (Sulzer Orthopedics) and six controls (Inter-Op UHMWPE liners packaged without oxygen). All acetabular assemblies, Durasul and Controls survived 2 million cycles with no adverse effects. All liners remained firmly attached to their respective shells. Small localized indentations from the femoral skirts were discovered in the PE liners (Durasul and Controls, size 49 mm and 39 mm) at the region of impingement. There was no other evidence of gross PE creep, wear, or penetration at any location. No PE cracking was detected.

DISCUSSION:

This test was successful in creating an impingement model in the laboratory. The physiological loads and angles represent femoral head/neck and acetabular liner impingement. The impingement model allowed a side-by side comparison of the two PEs. This test found the highly cross-linked Durasul and the Controls to perform equally. Aside from localized indentations, neither PE experienced gross creep, gross wear, cracking, or any other adverse effects when exposed to physiological impingement loads for 2 million cycles.

REFERENCES:

Scifert CF, Brown TD, Pederson DR, Callaghan JJ: The Effects of Cup Tilt and Anteversion on Dislocation Propensity in THA*: Orthopedic Research Society*, 1997.