**Strain Distribution in a Calcar Deficient Femur Following Uncemented Revision Hip Arthroplasty**

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**Introduction**
Revision hip arthroplasty is often required due to stem failure, infection and loosening. Stress shielding following primary arthroplasty leads to periprosthetic bone resorption and can result in a calcar deficient femur. Consequently, revision stems require adequate distal fixation. The Wagner femoral stem is a cementless device that relies primarily on distal fixation. The use of the Wagner stem in calcar deficient femurs has reported marked new bone formation with regeneration of proximal bone stock [1]. The strain distribution following revision surgery in calcar deficient bone may provide the stimulus for bone regrowth to occur up the femoral prosthesis. The current study examined the strain distribution following primary and revision surgery in a human cadaver model.

**Methods**
Three human femora (mean age 57 years old) were obtained from fresh frozen subjects and radiographed in the anteroposterior and mediolateral planes to assess suitability for testing. The femora were templated to accept the uncemented Wagner SL revision stem (Sulzer Orthopaedics, Ltd., Baar, Switzerland). Eighteen TML triaxial strain gauge rosettes (Tokyo Sokki Kenkyujo Co., Ltd., Japan) were applied to the periostal surface of the femora with cyanoacrylate cement: 5 on the medial and lateral aspects, and 4 on the anterior and posterior aspects (Figure 1).

Mechanical testing was performed in 3 stages under identical loading configurations using a servohydraulic materials testing machine (MTS 858 Bionix, MTS Systems Corporation, Eden Prairie, MN). A load of -820 N was applied to the femoral head at an angle of 10° to the long axis of the femur. A force of 1100 N was applied to the greater trochanter to simulate the abductor muscle group. This loading condition was applied with the femora positioned at 0° (axial) and 10° posterior (ISO 7206-4 orientation) to the frontal plane. Strain gauge data was acquired using a 2100 System signal conditioner/amplifier and a Model 2000 analog-to-digital converter (Measurements Group Inc., Raleigh, NC). All measurements were done in triplicate.

Intact cortical strain distributions were measured in stage 1. Subsequently, the Wagner stems were inserted according to the manufacturers instructions by a qualified surgeon and radiographed in the AP and ML planes to determine implant position. The cortical strain distributions on the reconstructed femora were tested in stage 2. The medial calcar region was removed and the cortical strain distributions tested in stage 3.

**Results**
The stems were all fixed distally without any proximal cortical contact. The mean maximum principal strain distributions for the intact, pre-operative and reconstructed femora with the calcar region preserved (postop) and resected (calcar) with Wagner revision stem are shown in Figure 2. The proximal medial calcar retained approximately 20% of the preoperative strain without any cortical contact. An increased lateral tensile strain was evident proximally but did not continue to the distally with marked shielding compared to the preoperative values of nearly 60%.

**Discussion**
The Wagner revision stem exhibited medial stress shielding in the proximal part of the calcar intact femur, which is characteristic of the rigid distal fixation concept. The calcar deficient femur increased load transfer on the anterior, lateral and posterior aspects proximally. This altered strain distribution may provide an osteogenic signal and contribute to the regeneration of the observed proximal calcar bone stock.


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