INTRODUCTION

Impaction grafting for THA involves impacting morselized cancellous bone (MCB) into a cavitary defect, to build up bone stock. Ideally, the MCB is remodeled into a new cancellous lattice contiguous with the host bone. Although many investigators indicate that this remodeling of the impaction graft is desirable, others have questioned whether this bone remodeling is actually necessary for clinical success.

The purpose of this study was to determine the relative stability of femoral impaction graft constructs in which the MCB has fused (using a recent laboratory model of MCB fusion (Heiner et al., 2005)), versus the freshly-impacted nonfused condition. The hypothesis was that fused impaction graft constructs would have less micromotion and migration as compared to nonfused constructs. Clinically, this would translate to a more stable construct: the prosthesis would be more likely to stay in one position, construct interfaces would be less likely to fail, and cement fracture would be less likely to occur.

METHODS

Composite femurs were prepared in a standardized manner. A nylon abductor strap was attached to each femur. Cavitary defects were simulated by overdrilling the femoral diaphysis and removing all proximal cancellous bone. Impaction grafts constructs were then created by impacting human MCB into the femur (Figure 1a). A polished, collarless, triple-tapered femoral stem was then cemented into the impaction graft.

The MCB was either nonfused or fused. The nonfused MCB was defatted, typical of that used surgically. The fused MCB was defatted, dehydrated, and mixed with an amine-based epoxy adhesive just before the impaction grafting process; after the impaction grafting (and cementing) process is complete, the MCB-epoxy mixture fuses into a contiguous structure biomechanically equivalent to intact cancellous bone (Heiner et al., 2005), simulating the desired end-stage of an impaction graft.

Each impaction graft construct was loaded to 500,000 complete physiologic level walking and stair climbing cycles (with both axial and torsional loads) at 50% full-scale loading (Figure 1b). Three-dimensional motion between the femoral stem and the femur was measured at the proximal and distal stem with DVRTs. Micromotion and migration were calculated.

Figure 1: Femoral impaction graft a) before cementation and b) testing set-up.
RESULTS

At the proximal stem location, final level walking micromotion for the fused impaction grafts was 13.1 times less than for the nonfused grafts (1.9 vs. 25 µm; p = 0.018), and final migration was 12.6 times less (45 vs. 565 µm; p = 0.0007) (Figure 2, top). At the distal stem location, final level walking micromotion for the fused impaction grafts was 1.3 times less than for the nonfused grafts (2.2 vs. 2.8 µm; p = 0.19), and final migration was 2.7 times less (305 vs. 828 µm; p = 0.001) (Figure 2, bottom).

DISCUSSION

The measured migrations for the nonfused graft constructs at 250Kcyc and 500Kcyc were comparable to two 3- and 6-month clinical impaction grafting studies, for which <1mm average migration was recorded (Nelissen et al., 2002; van Doorn et al., 2002). Although for this study, the applied loads were 50% full-scale, in clinical studies weight bearing is typically restricted 6-12 weeks postoperatively.

The fused femoral impaction grafts were much more stable than the nonfused grafts at the proximal stem location, but MCB fusion had a much smaller effect on distal stem stability. This indicates that most of the opportunity to reduce femoral stem micromotion and migration is proximal, and that steps to enhance MCB fusion (e.g., BMP augmentation) are most effectively focused proximally.

REFERENCES


Figure 2: Series-average micromotion and migration results for fused vs. nonfused impaction graft constructs (n = 6), for the proximal and distal stem locations. For stem micromotion, the higher lines of dots for the fused and nonfused grafts indicate stair climbing cycles.