"Short Stems With & Without Modularity"

By
S. David Stulberg, MD
Professor, Clinical Orthopaedic Surgery, Northwestern University Feinberg School of Medicine, Chicago, IL

Introduction:

Cementless femoral stems of many designs, reflecting a broad range of bone attachment rationale, provide dependable long-term fixation. However, a number of Issues related to cementless stem fixation exist which might increase their safety, versatility and durability. These issues include the: 1) optimization of load transfer to the proximal femur to maximize bone preservation and restoration; 2) elimination of the potential for a mismatch in proximal-distal fit (Such a condition might –exist in the presence of an excessively bowed femur, or one deformed as the result of a fracture or developmental abnormality. Young, active, large patients, who require hip replacements, may have large proximal femoral metaphyses and very narrow intra-medullary diaphyses. The use of cementless implants with stems of conventional length in such patients carries with it the risk of early and/or delayed fracture); 3) facilitation of various minimally invasive surgical exposures, especially those incorporating an anterior exposure of the femur; and 4) the preservation of proximal femoral bone stock in young patients who might ultimately require revision of their primary components.

In order to develop short stem implants that achieve these goals, it is desirable and necessary to evolve from the principles that have been the foundation for the fixation success of cementless femoral implants with standard length stems.

The purpose of this presentation is to: 1) Describe the design rationale and characteristics of uncemented, metaphyseal (<100mm) primary THA femoral stems which incorporate these principles; 2) Present the initial 2-4 year follow-up clinical and radiographic results achieved using stems with these principles; and 3) Propose the characteristics of future, short, cementless metaphyseal stems based upon this initial experience.

Methods:

Two groups of patients have been studied in which stems with similar design characteristics have been used. In the first group, sixty-five custom-made uncemented metaphyseal engaging femoral stems were inserted in a sequential series of 60 patients between March 2004 and March 2005. The indications for inserting these implants were all patients less than 70 years of age. No patient was excluded based on femoral bone quality or body mass index (BMI). A minimum of two-years (average 32 months, range 24-44 months) clinical and radiographic follow-up was obtained for the patients in this study. The average age of the patients at time of arthroplasty was 56 (range 16 - 69). There were 37 procedures performed in men and 28 procedures performed in women. The diagnoses were osteoarthritis in 62 patients and avascular necrosis in 3 patients. The average BMI was 29.1 (range 26.3 – 54.6). The metaphyseal engaging femoral stems were customized to each patient based on preoperative computed axial tomography scans. The implant was designed to fit closely against the endosteal metaphyseal bone along the anterior metaphysis, medial calcar, posterior femoral neck, and metaphyseal flare at the bottom of the greater trochanter. The femoral stem was made of titanium alloy with a hydroxyapatite coating on a titanium plasma-spray in the proximal 1/3-1/2 of the stem. The average stem length was 90 mm (range 70-125 mm) and the average stem diameter was 14 mm (range 9-23 mm). A porous coated acetabular component was used in all cases. The bearing surface in was metal/highly cross-linked polyethylene. The femoral head size was 32 millimeters. All of the arthroplasties were performed through a less invasive posterior-lateral approach. Full weight bearing was allowed immediately. Clinical and radiographic data were collected preoperatively, in the early post-operative period, and at subsequent examinations. The clinical evaluation consisted of an assessment of pain, functional parameters, and a physical examination to provide a composite Harris hip score (HHS). Specific inquiries were made with respect to thigh pain at each visit. Standard anterior-posterior radiographs of the pelvis and lateral radiographs of the hip were obtained at all visits. The implants were evaluated for subsidence in a standardized fashion by measuring from the tip of the greater trochanter to a fixed point on the femoral stem. A modification of the criteria described by Engh was utilized to determine the stability of the femoral prosthesis. A stem was considered to be stable if there was evidence of bone bridging or endosteal condensation, no evidence of subsidence, and no lucencies or reactive lines surrounding the stem.

In the second group of patients, 230 off-the-shelf primary short stem implants were inserted in consecutive patients from January 2005 –March 2006. These stems were inserted in patients of all ages regardless of bone quality. The off-the-shelf implants had design characteristics based upon and very similar to the custom-made implants. The surgical technique for implantation, the peri-operative management and the post-operative surveillance were identical to the custom group.

Results:
In the custom group, the average preoperative Harris hip score was 49 (range 23-68). The average Harris hip score at most recent follow-up was 93 (range 73-100). There were no complications in this group attributable to the femoral stem. There were no intra-operative or postoperative fractures. Two patients underwent an acetabular cup revision for recurrent dislocations. At the time of revision surgery the femoral stem was noted to be stable in both cases. In the off-the-shelf group, the clinical outcomes were similar to those of the custom group. There was one intra-operative undisplaced intra-operative fracture which was recognized and treated and was associated with an uneventful post-operative course. There was one post-operative minimally displaced peri-prosthetic fracture, which was treated successfully non-surgically.

Preoperative radiographs were evaluated for the quality of bone based on the method described by Dorr. In the custom group, twenty-one hips (32 percent) were found to have type-A bone; 39 hips (60 percent), type-B bone; and 5 hips (8 percent), type-C bone. In the off-the shelf group, 30 per-cent of hips were Type A, 40 per cent were Type B, and 30 per cent were Type C. There was no radiographic evidence of subsidence on the postoperative radiographs. (fig. 1)

All stems were radiographically stable with no signs of reactive lines or loosening on the most recent radiographs. There was no evidence of calcar atrophy or lucencies surrounding the stem. The radiographic pattern that demonstrated bony ingrowth in these stems was that of bone bridging and endosteal condensation.

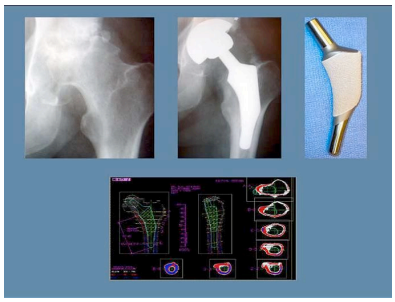

Fig 1: Custom made metaphyseal engaging short stem: Pre-operative x-ray, pre-operative c-t reconstruction with pre-operative plan, actual implant and post-op x-ray, 4 years post-op, demonstrating excellent bone remodeling.

Discussion:
Cementless metaphyseal engaging femoral stems with a proximal hydroxyapatite coated porous surface are associated with excellent clinical and radiographic outcomes at 2-4 years. The potential benefits of these short stems include: 1) increased ease of insertion (broach-only); improved proximal femoral bone remodeling; avoidance of proximal-distal femoral diaphyseal mis-match; ability to accommodate variations in proximal femoral diaphyseal anatomy, and facilitation of less invasive surgical approaches.
The stems used in this series were designed to identify the characteristics of short stems that would be necessary for successful, reliable results that were comparable to those achieved with currently available off-the-shelf cementless implants with stems of conventional length. Based upon this experience the next generation of short stems should include the following: 1) extensive femoral metaphyseal bone contact; 2) ingrowth and/or on-growth coatings in the metaphyseal engaging portion of the stem. Off-the-shelf short stems of the future are also likely to have modular necks and accommodate femoral heads of all sizes and materials (fig 2).

Instrumentation must be developed to assure that short stems are inserted accurately and reproducibly. In particular, the tendency to place these devices into varus must be minimized with proper instrumentation. Finally, to be truly bone conserving, instruments should be developed to remove these short stems with minimal proximal femoral bone loss.

Fig. 2
Small curved stem with modular neck will allow tissue sparing (hard & soft) techniques.

Selected Reading:
1) Min BW, Song KS, Bae KC, Cho CH, Kang CH, Kim SY. The effect of stem alignment on results of total hip arthroplasty with a cementless tapered-wedge femoral component. J Arthroplasty. 2008;23:418-423.

2) Morrey BF, Adams RA, Kessler M. A conservative femoral replacement for total hip arthroplasty. J Bone Joint Surg Br. 2000;82:952-958.

3) Röhrl SM, Pedersen E, Ullmark G, Nivbrant B. Migration pattern of a short femoral neck preserving stem. Clin Orthop Relat Res.. 2006;448:73-78.

4) Kim YH. Cementless total hip arthroplasty with a close proximal fit and short tapered distal stem (third-generation) prosthesis. J Arthroplasty. 2002;17:841-850.