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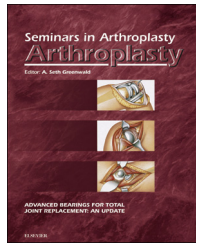

Not all cementless stems are created equal: A selection algorithm

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ABSTRACT

Patients, and their femurs, come in all shapes, sizes, and types. Fortunately, so do cementless femoral stems. Each surgeon should have a "go to" cementless femoral component that can address over 90% of cases. A simple approach is to separately consider (A) the part inside the bone and (B) the part outside the bone. The inner-cortical geometry (Dorr type) and bone density influence stem size (the part inside the bone) and influence femoral canal preparation. Femoral deformity or old hardware can occasionally necessitate the use of a short stem or a modular stem. Restoration of limb length and offset is a function of the neck angle and length (the part outside the bone). Undersizing of cementless stems increases the risk of aseptic loosening while restoration of limb length and offset favorably affects patient satisfaction and function.

1. The part inside the bone

There are several parameters to consider in a cementless femoral *component*. In general, this can be separated into the part *inside the bone* (the *stem*) and the part *outside the bone* (the *neck and head*). Femoral stem variables include the material, the shape, the length, and the surface for biologic fixation. Over the past 2 decades, there has been some convergence regarding stem material and, to some degree, stem shape. Cobalt chromium alloy is less frequently used for cementless stems today. Titanium alloy is preferred by most. Titanium alloy is less stiff and more biocompatible than cobalt chromium alloy. Further, there are relatively inexpensive surface treatments, such as grit blasting, that allow biologic fixation of a titanium alloy stem.

Tapered cementless stems are more commonly utilized than cylindrical stems. Tapered femoral stems can be described by their geometry and taper angle(s): single-taper, double-taper, and triple-taper. Single-taper stems have a reduction (taper) in medial-lateral dimension in the frontal plane, but have a constant antero-posterior dimension. Double-taper stems have tapers in the frontal plane and sagittal plane. Triple-taper stems include a reduction in antero-posterior dimension through the cross-section of the stem from lateral to medial (the third taper), in addition to tapers in the frontal and sagittal planes. The stems vary in length and degree(s) of tapering.

Cementless femoral stems have various surface finishes or coatings to promote osseointegration: grit-blasted, hydroxyapatite, plasma spray, or porous ingrowth. The trend is toward more proximal bioactive surfaces in order to promote proximal fixation (and easier extraction) [1]. There is also a trend toward shortening of cementless stems in an effort to be more bone sparing. Given similar geometry and surface finish, a longer stem will have greater initial stability. Regardless of the length, obtaining initial stem stability is the key to osseointegration and long-term stable fixation [2].

Some distinction has been made between systems that ream the canal before progressively rasping or broaching the

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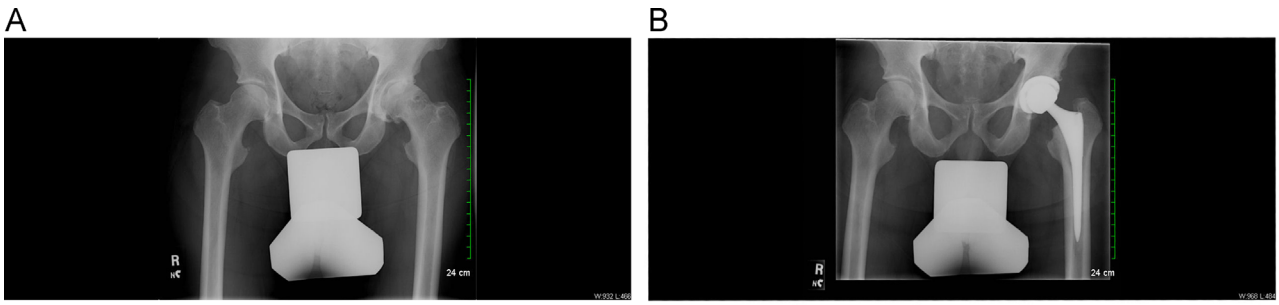

Figure 1 – (A) Mesomorphic male, 5′11″. 209 lb with osteoarthritis, dense bone, and Dorr Type A femur. (B) Post-operative x-ray of the same patient. Due to the dense bone and tight canal, a relatively small stem, with high offset, had a tight fit. Satisfactory limb length and offset restoration.

proximal femur and "broach-only" systems. A rasp can remove bone moving both distally and proximally in the femur while a broach removes or compacts bone only while moving distally. The need for any canal reaming is determined by the internal geometry of the femur and the length of the stem. When the femoral corticies are thick and the canal is small, there is a large metaphyseal flare and a relative mismatch between the size of the metaphysis and the canal (Dorr Type A femur) (Fig. 1). Such *proximal–distal mismatch* can present a challenge to proper fitting of a cementless stem. This is less of an issue for short stems that barely engage the diaphysis, compared to longer stems designed to be centered in, and stabilized by, the diaphysis.

Some systems recommend to first ream the canal to the diameter of the intended stem and then progressively rasp the femur to the corresponding proximal size. Other systems recommend preparing the femur with a progressively enlarging rasp- or broach-only technique. However, in cases with a proximal–distal mismatch, the tight canal and dense distal bone can lead to proximal (metaphyseal) undersizing of the stem. Undersized cementless stems have an increased risk of not osseointegrating [3,4]. The surgeon must be aware of proximal–distal mismatch and consider this variable when preparing the femur. In such cases, some reaming of the canal may be necessary, even with a so-called broach-only system, to avoid proximal undersizing of the stem. Conversely, in cases with a patulous femoral canal (Dorr Type C), there is no need to ream distally, even with so-called ream and rasp systems (Fig. 2).

2. The part outside the bone

The part outside the bone (the neck) is equally important, but not discussed as much. The part inside the bone determines fixation and load transfer. The part outside the bone influences function: biomechanics, limb length, offset, range of motion, and stability [5]. Many systems today have dual offset options, (a) constant neck angle or (b) variable neck angle. Systems with a constant neck angle increase the offset by direct lateralization of the stem. Variable neck angle systems increase the offset with a lower neck angle (i.e., 127°) for high offset and higher neck angle for lower offset (i.e., 132°). In general, neck geometries have evolved, become slimmer in the AP dimension, to allow greater impingement-free range of motion and better stability.

Most surgeons and patients can agree on what the post-operative limb length target should be. However, there is some debate regarding what the targets should be for the post-operative acetabular center of rotation and femoral offset. Regardless of a surgeon's preference on this issue, many cementless femoral components offer a broad range of limb length and offset options via a combination of dual offset stems and modular heads. It should be recognized that some large stature individuals have a relatively small femoral canal due to thick corticies (Dorr A; Fig. 1). Such a case may necessitate some canal reaming and the tight, stable stem (the part inside the bone) may be relatively small for that large stature individual. A high offset stem with a "plus" femoral head (the part outside the bone) addresses the anatomy of that patient. The converse can

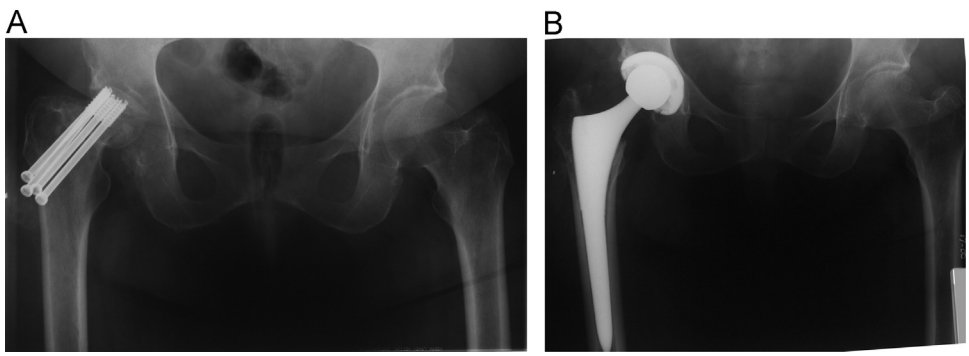

Figure 2 – (A) Pre-operative x-ray of an elderly female with history of femoral insufficient fracture and failed internal fixation. Dorr Type C femur. (B) Post-operative x-ray of the same patient. Satisfactory fit with a triple tapered titanium alloy stem. In such osteoporotic bone, a relatively large component is needed to fill the canal. Satisfactory limb length and offset restoration.