The Rationale for Short Uncemented Stems in Total Hip Arthroplasty

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KEYWORDS

• Short stem implants • Metaphyseal-engaging implants • Uncemented total hip arthroplasty

KEY POINTS

- Metaphyseal fit and ingrowth can provide both rotational and axial stability without distal diaphyseal support.
- Bone remodeling on radiographic analysis of short stems of various designs show endosteal condensation and cortical hypertrophy in the proximal metaphyseal region of the femur.
- Functional Harris Hip Scores (HHS) and Western Ontario and McMaster Universities Arthritis Index (WOMAC) pain scores are equivalent in patients with metaphyseal-engaging short stems compared with stems of conventional length.
- Short stem metaphyseal-engaging implants enhance the preservation of proximal femoral bone stock as well as provide an adaptive alternative in minimally invasive anterior approaches.
- Metaphyseal-engaging short stems provide an alternative to bone preservation procedures with reproducible and reliable radiographic and clinical outcomes while maintaining a short learning curve.

INTRODUCTION

Total hip arthroplasty (THA) has proved clinically and functionally successful in the treatment of end-stage degenerative joint disease of the hip.[1–8] Porous-coated, uncemented femoral stems were introduced for use in THA in the early 1980s. Uncemented implants rely on diaphyseal or metaphyseal contact and, ultimately, bone fixation to ingrowth or ongrowth surfaces to provide long-term stability and dependable clinical results.[3,9–19] Uncemented, porous femoral implants are now routinely used in virtually all patients undergoing primary THA. Uncemented femoral components with a variety of shapes, metallurgy, and surface treatment have been developed to address the broad spectrum of proximal femoral morphology.[12,17,20–24]

Despite the documented success of these implants, current uncemented stems are used in patients whose size, age, level of physical activity, and bone quality present particular challenges for uncemented fixation technologies. These

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challenges include (1) the preservation of proximal femoral bone stock; (2) the potential need for effective, femoral component revision; (3) proximal-distal mismatch; and (4) the ability to insert implants safely, securely, and reproducibly with specific surgical approaches (eg, the direct anterior) that are currently being evaluated and promoted.

Short stem uncemented femoral implants have been developed to address some of these challenges while maintaining the current level of success achieved by uncemented implants of conventional length (Fig. 1). Short stem implants have been defined as 120 mm in length or less, which approximately correlates to the metadiaphyseal junction of the proximal femur.[25]

The purposes of this article are to (1) explain the evolution to short stem design, (2) describe the rationale and types of short stem implants, (3) provide the benefits of short stem implants, and (4) summarize the clinical results with these implants.

EVOLUTION TO SHORT STEM DESIGN

To understand the evolution of uncemented THA to short stem implants, femoral implant design and stability must first be reviewed. Successful THA relies on initial and long-term rotational and axial stability. The diaphyseal portion (cylindrical or tapered) of the femoral implant contributes to the initial stability. Cylindrical, extensively porous-coated implants (eg, AML) achieve durable fixation but can be associated with stress shielding and thigh pain. Cylindrical implants without porous-coated stems achieve varying degrees of initial axial and rotational stability through contact points in the diaphysis but rely on metaphyseal bone contact to enhance their initial rotational stability. Furthermore, these implants seek long-term fixation and stability through bone ingrowth or ongrowth at the metaphysis. Long-term clinical results of these implants have been satisfactory and reliable with an overall lower incidence of thigh pain and proximal stress shielding relative to their extensively coated counterparts. Early concerns with a cylindrical diaphysis, however, inspired investigators to produce tapered stems.

Tapered uncemented implants achieve primary axial fixation through a 3-point contact mechanism with the creation, and ultimate relaxation, of hoop stresses between a tapered stem and cylindrical femur. Rotational stability is achieved in the proximal femur through surface treatment, various shape geometries, and overall fit and fill. Secondary fixation depends on the extent of contact between the ingrowth/ongrowth surfaces of the implant and metaphyseal bone. Many studies have established the long-term clinical and radiographic reliability and durability of tapered femoral implants. These stems have been associated with little thigh pain compared with cylindrical stems.

In these designs, the tapered or uncoated cylindrical diaphyseal portion provides primary axial stability but varying degrees of rotational stability. Rather, rotational stability is attained from metaphyseal bone-implant contact.

Fig. 1. Young active man with Dorr type A bone.

DESIGN RATIONALE AND TYPES OF UNCEMENTED SHORT STEM METAPHYSEAL-ENGAGING FEMORAL IMPLANTS

Short stem metaphyseal-engaging implants achieve secure initial fixation in the metaphysis, theoretically making the axial and rotational stability provided by the diaphyseal portion of the femoral implant negligible. Metaphyseal ingrowth or ongrowth secures long-term fixation, with the pattern of bone implant contact varying by implant design. A variety of implants have been introduced over the past few years, leading to the development of a classification system by McTighe and colleagues.[25] The 3 main types of short stem implants are

1. Metaphyseal stabilized (standard neck resection) (Fig. 2A)
2. Neck stabilized (femoral neck sparing) (see Fig. 2B)
3. Head stabilized (resurfacing-type procedures) (see Fig. 2C)