

Effect of optimizing bone-implant contact on hip offset and rotation with three contemporary uncemented metaphyseal engaging implants

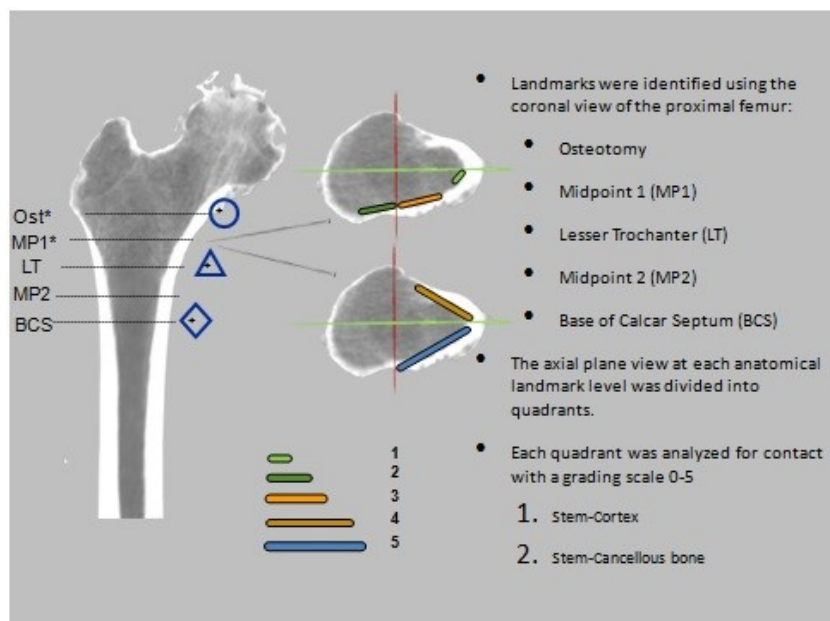
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Introduction: Cementless femoral components for total hip arthroplasty (THA) aim to achieve stable and durable fixation by maximizing bone contact and seek to optimize hip kinematics by restoring offset and anteversion. The wide variations in both the internal geometry of the proximal femoral neck and the extra-medullary orientation of the femoral neck require that cementless implant designs take into account both bone-implant contact and implant offset. In a companion study, 30 femurs were templated for 3 different contemporary metaphyseal engaging, uncemented stems according to the manufacturers' directions. The bone contact patterns within the femur were analyzed. The purpose of this study was to analyze the effect on offset and anteversion when these 3 stems had been placed to achieve optimum bone-implant contact.

Methods: The femurs of 30 patients were templated using a CT-based preoperative planning workstation (ORTHODOC, Curexo Tech, California) with three different metaphyseal-engaging stem designs: Straight tapered (Depuy-Tri-Lock), anatomical (Stryker ABG II) and curved femoral neck preserving (OmniScience ARC). Stem size was determined to optimize contact. Implants were positioned according to the manufacturers' design rationale. Five anatomical landmarks (levels) were identified from proximally to distally in the coronal, axial and sagittal planes (Figure 1). At each of these five levels, the axial plane was divided into quadrants. Each quadrant was analyzed for contact, defined as implant-bone distance $<0.5\text{mm}$. Measurements of contact were taken using two different density thresholds: 1) Linear Gray (endosteal cortex) and 2) Color (cancellous bone). Once the optimum position of each implant was established, the vertical and horizontal offset and version (ante- or retro) were measured. The ORTHODOC software calculated these data points based on the initial referencing markers placed on the native femoral head center and intercondylar axis. Anatomic anteversion was determined using Murphy's method.



Results: When comparing average "post-operative" anteversion to native "pre-operative" anteversion the ABG II increased the anteversion by 19.0 degrees and the Tri-Lock increased anteversion by 9 degrees (Table 1). The ARC with a neutral neck (0 degrees of anteversion/retroversion) most precisely restored native anteversion with a mean difference of 3.6 degrees. Analysis of the offset based on optimal implant positioning revealed great variability despite using available head and neck options. A majority of all implants had offset restored within 5mm (Table 1).

Stem		Tri-Lock	ABG II	ARC
Percent of stems that achieved vertical and horizontal offset	< ± 2 mm	53.3% (16/30)	10% (3/30)	40% (12/30)
	< ± 3 mm	73.3% (22/30)	26.7% (8/30)	63.3% (19/30)
	< ± 5 mm	96.7% (29/30)	70% (21/30)	83.3% (25/30)
Average Anteversion		25.6° (10.5° - 49.7°)	35.8° (16.4° - 61.5°)	20.4° (3.2° - 43.3°)
Anatomical anteversion		16.8° (-4.4° - 41.2°)		
Difference		8.8° (-2.6° - 19.6°)	19.01° (11.6° - 31.3°)	3.6° (-3.4° - 16.3°)

Table 1: Offset and Anteversion after placement of implants per manufacturer design rationale.

Conclusions: Uncemented, porous metaphyseal engaging femoral implants are now routinely used in virtually all patients undergoing primary THA. Having achieved successful femoral fixation, many orthopaedic surgeons are now turning their attention to the restoration of precise extra-articular anatomy, i.e. offset. The use of modular neck prostheses has been proposed as an approach for achieving the goal of precise off-set restoration. However, these devices have been associated with fractures, adverse soft tissue reactions, and increased corrosion. Very little information is available regarding the extent to which accurately implanted, metaphyseal engaging uncemented implants restore vertical and anterior-posterior offset. All 3 of the stems evaluated have been associated with successful, reliable fixation results in spite of variations in the extent of metaphyseal bone contact. The findings of this study indicate that when cementless femoral components are positioned to achieve successful fixation, the off sets that result may vary significantly from the original pre-surgical offsets. A surgeon using the stems evaluated may need to seek a compromise between optimal fit for fixation and optimal position for off-set restoration.

Clinical Relevance: The ARC stem with a neutral neck, placed, as prescribed by the manufacturer, in the sub- capital region of the femoral neck provided the most accurate restoration of femoral offset of the 3 stems studied. However, this stem was also associated, in our previous study, with the least extensive cortical contact in the metaphysis. The straight, non-modular Tri-Lock can be positioned to achieve reasonably accurate restoration of offset. This is accomplished, however, at the expense of compromising optimal contact. The lack of extensive circumferential metaphyseal contact permits the stem position to be altered in order to restore offset. The anatomic ABG II, on the other hand, achieves very extensive circumferential metaphyseal contact but its implanted position cannot be significantly changed in the attempt to match anatomic offset. Stems of anatomic design may need to provide both vertical and horizontal offset options if the goal of precise anatomic offset restoration is to be achieved. The results of this study indicate that if offset restoration is sought with non-modular neck uncemented implants that a compromise with regard to circumferential metaphyseal contact may be necessary.