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Periprosthetic Bone Remodeling After Novel Short-Stem Neck-Sparing Total Hip Arthroplasty

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ABSTRACT

Background: Short femoral stems have been designed with the aims of reducing proximal bone loss, improving load transfer, and increasing compressive loads at the medial proximal femoral calcar. This study examines bone mineral density (BMD) changes associated with a novel neck sparing short femoral stem design.

Methods: The study was a prospective, single-center, multi-investigator consecutive series, which assessed bone-remodeling changes after insertion of the MSA Stem (Global Orthopaedic Technology). Dual-energy X-ray absorptiometry scans were performed preoperatively and postoperatively at 6, 12, and 24 months assessing the BMD at the 7 Gruen zones. The secondary objectives assessed were the Harris Hip Score, 12-Item Short Form Health Survey preoperatively, and perioperative complications.

Results: Thirty-nine total hip arthroplasties were performed on 37 patients, with 27 patients completing the 24-month dual-energy X-ray absorptiometry scan. The overall preoperative baseline BMD was 0.2. At 6 months, the Gruen zone BMD had increased significantly in all zones in comparison to the preoperative mean BMD. Between 6 months and 24 months, there were only slight changes in the Gruen zones, with small gains in zones 1-2 and zones 4-6, with no zone showing a significant decrease. The Harris Hip Score improved from a preoperative mean of 39.7-75.3, whereas the 12-Item Short Form Health Survey score also improved from 32.6 to 49 at 24 months. However, 5 patients had aseptic loosening requiring revision surgery (4 femoral and 1 acetabular component).

Conclusion: Short-stem neck-sparing femoral stem prosthesis has the capacity to address the stress-shielding problem identified in femoral stems. However, the high early revision rate is a significant issue.

Bone mineral density (BMD) changes in the periprosthetic femoral region secondary to stress shielding in both cementless [1-3] and cemented total hip arthroplasty (THA) [4-7] have been well documented. This change in bone mineral distribution, although mostly occurring in the first 24 months [8], is a concern as it may lead to prosthetic loosening and decreasing bone stock for potential revision surgery.

Successive generations of cementless THAs have attempted to resolve this issue and restore functional loading of the proximal femur; however, this goal has yet to be achieved. In recent years, there has been an increasing interest in short-stem prostheses [9], which has shown early signs of being able to decrease the periprosthetic losses of BMD [10,11]. These stems, although showing promising results, are yet to be independently evaluated to assess their suitability for general usage.

The MSA Stem Total Hip System (Global Orthopaedic Technology, Bella Vista, NSW, Australia) is a novel neck-sparing short femoral stem designed with the aims of reducing proximal bone loss, improving load transfer, and increasing compressive loads at the medial proximal femoral calcar [12].

The femoral stem of the MSA prosthesis is made from a titanium alloy, whereas the neck is constructed from a chromium/cobalt alloy. It is modular with a geometric profile based on the rectangular Zweymuller design. Proximally, it is flared to prevent subsidence and conforming to the inner geometry of the femur.

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Hydroxyapatite (HA) coating is provided in the proximal 5th of the stem to aid in osteointegration. Distally, there is a sagittal slot, which adapts to the internal femoral geometry and affords a degree of elasticity in an attempt to reduce thigh pain, lateral cortical fractures, and distal stem loading. The neck is modular allowing for offset to be adjusted (Fig. 1).

Our primary study aim was to assess the periprosthetic BMD changes associated with this novel stem. Functional outcomes and complications were recorded as secondary outcomes. This study is the first to document the postoperative periprosthetic femoral BMD changes associated with the MSA THA System.

Methods

The study was designed as a prospective, single-center, multi-investigator consecutive series, which assessed bone-remodeling changes in the femoral neck after surgery. The inclusion criteria for the study were patients who had a preoperative BMD T score >−2.5, vitamin D level >25 nmol, body mass index (BMI) <40, noninflammatory degenerative joint disease, and femoral canal Dorr type A or B.

Patients who had severe obesity (BMI >40), vitamin D deficiency (<25 nmol/L), femoral head dysplasia, metabolic bone disease, prior hip fracture or Dorr C type femoral canal, and systemic disease requiring immunosuppression were excluded (Table 1).

All patients eligible for THA were assessed by anesthetic staff and deemed suitable for progression. Baseline demographics, comorbidities, vitamin D level, and radiographs (anteroposterior pelvis centered over symphysis pubis, Charnley view anteroposterior, and lateral cross table of hip) were collected preoperatively. Radiographs were taken postoperatively to examine implant position and wear.

Over 18 months, 37 patients underwent the MSA THA with a total of 39 THA procedures. The THAs were performed by nine surgeons using both the posterior and the lateral (Hardinge) approach to the hip. The same postoperative protocol was used consisting of weight bearing immediately with physiotherapy and mobilization.

Fig. 1. MSA total hip arthroplasty system design profile.

Table 1
Inclusion and Exclusion Criteria.

Inclusion criteria
Noninflammatory degenerative joint disease
Preoperative BMD (DEXA T score >−2.5)
Vitamin D >25 nmol/L
BMI <40
Femoral canal Dorr type A or B
Exclusion criteria
Abnormal femoral morphology
Avascular necrosis
Perthes
Pagets
Previous fracture
Systemic disease
Neuromuscular
Rheumatoid arthritis
Immunosuppression (including use of steroids)
Preoperative BMD (DEXA T score <−2.5)
Vitamin D <25 nmol/L
BMI >40
Femoral canal Dorr type C

BMD, bone mineral density; BMI, body mass index; DEXA, dual-energy X-ray absorptiometry.

Our initial aim was to collate data from 100 arthroplasties to analyze periprosthetic BMD. However, after 39 THAs were performed, recruitment for the trial was ceased because of concerns over the higher than expected early revision rate. The recruitment for the study was concluded on identifying the fifth patient requiring revision, thus fulfilling the 5% revision rate (5 of 100) terminating the trial as stipulated by the Human Research Ethics Committee.

The primary objective was to assess the changes to BMD after surgery. Dual-energy X-ray absorptiometry (DEXA) has been well documented as a reliable tool for the assessment of periprosthetic bone remodeling in hip arthroplasty [3,13]. The Hologic Discovery W scanner was used with a single technician performing all preoperative bilateral femoral DEXA scans as well as all postoperative investigations. A leg holder was used to ensure comparable rotation at each evaluation. The baseline BMD of the femoral neck was recorded as an overall mean score. Subsequent postoperative scans were performed at 6, 12, and 24 months using the 7 Gruen [14] zones, which were modified to fit the short-stem prosthesis (Fig. 2). Comparison was performed to the baseline preoperative scans and to the difference between the first postoperative scan at 6 months and subsequent postoperative scans using the Gruen zones.

The secondary objectives were to assess functional outcomes using the Harris Hip Score (HHS) and SF-12 preoperatively and postoperatively at 6 months, 12 months, and 24 months. Complications including dislocation, loosening, venous thromboembolism, and intraoperative issues were documented.

The data collected were analyzed using SPSS and represented as point estimates with 95% CIs. Results were considered significant if $P \leq .05$.

Results

Sixty-three patients with a total of 65 hip joints requiring arthroplasty were recruited and screened for eligibility of which 50 were deemed suitable. Of the 13 patients who were ineligible for the study, 2 had severe vitamin D deficiency, 1 had Paget's disease