The Journal of Arthroplasty 31 (2016) 512–516

Contents lists available at ScienceDirect

The Journal of Arthroplasty

journal homepage: www.arthroplastyjournal.org

Changes in Femoral Version During Implantation of Anatomic Stems: Implications on Stem Design

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ABSTRACT

Background: Component positioning in total hip arthroplasty (THA) is among the primary indicators for longevity and success. Acetabular component positioning has been discussed in literature at length; however, femoral component positioning is also important as it contributes to combined anteversion.
Methods: In this study, we examined the changes in femoral anteversion after the implantation of anatomic stem ABG II. A cadaveric study, a computed tomography–based computer modeling study, and a clinical study using a navigation system were conducted to document these changes.
Results: These studies demonstrated that the anatomic stem ABG II increased the postimplantation femoral version by approximately 7°. The postimplantation versions followed a bimodal distribution. The computed tomography and navigation data also highlighted that the patient population may roughly be divided into 2 groups: the first group that needs anteverted stem and the second group that needs little or no anteversion in the stem to recreate the desired version and offset.
Conclusion: Based upon our data, we propose a new anatomic stem design that is offered in 2 version angles of 0° and 7° to help create the desired version and offset.

Article history:
Received 3 June 2015
Accepted 8 September 2015
Keywords: anatomic stem, CT data, femoral anteversion, cadaver study, navigation, SOMA

Component positioning in total hip arthroplasty (THA) is among the primary determinants of longevity and success [1-4]. Historically, the focus has been on the acetabular component, but, recently, more attention has been given to the femoral component as it also contributes to combined version [1]. This has led to studies documenting changes in femoral version with the use of press-fit stems [2]. Component positioning becomes more crucial as the patient population for THA continues to get younger and want to live more active lifestyles [5]. At the same time, component positioning and combined version may also influence the incidence of dislocation after THA [6].

To achieve optimal reconstruction intraoperatively, modular neck stems were designed to allow for better control over the femoral stem positioning (valgus/varus and anteversion), especially in dysplastic hips [7-9]. These stems offer various neck versions and offsets that could theoretically help the surgeon to reproduce the native leg length, optimal offset, and version and potentially result in improved range of motion and increased stability. However, multiple reports of higher revision rates in recipients of these implants due either to fracture [10] or to adverse local tissue reaction secondary to fretting and corrosion [11,12] have severely reduced their popularity. Nonetheless, the clinical need to achieve correct version and offset is no less desirable, and anatomic stems may be helpful in fulfilling this need.

The goals of the present study were to observe changes in femoral version with the implantation of anatomic stems using a virtual computed tomography (CT) database, a cadaveric study, and patients undergoing THA. Based on the data obtained from these studies, the authors present the design of a new stem with 2 version offsets that may improve hip biomechanics after THA.

Materials and Methods

Three types of studies were conducted including a CT-based study to measure femoral anteversion angles in native and virtually implanted femurs, a cadaveric study to measure femoral anteversion angles, and a navigation system–based study to measure the postoperative femoral anteversion angles in patients. The CT study with a large number of patient data aimed to build upon the cadaveric study, which used limited

One or more of the authors of this paper have disclosed potential or pertinent conflicts of interest, which may include receipt of payment, either direct or indirect, institutional support, or association with an entity in the biomedical field which may be perceived to have potential conflict of interest with this work. For full disclosure statements refer to http://dx.doi.org/10.1016/j.arth.2015.09.008.

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http://dx.doi.org/10.1016/j.arth.2015.09.008
0883-5403/

number of specimens. The navigation study helped add clinical dimension to femoral anteversion measurement during hip arthroplasty.

Computed Tomographic Scan Study Using SOMA (Stryker Orthopaedics Modeling and Analytic)

Recent developments in 3-dimensional CT technologies have enabled detailed analysis of patient scans to understand physiological characteristics in various populations. One such CT technology is SOMA (Stryker Orthopaedics, Mahwah, NJ), which comprises a large database of CT scans [13]. The SOMA program includes both anatomical analysis and implant fitting tools. These tools help the user perform automated measurement and analyses (such as femoral neck angle, native/implanted anteversion measurements, and conformity of the implants with the bone) across whole populations to gain insight into the statistical variations that may exist within large groups. This technology has already been used to design a tapered wedge hip stem whose design rationale and short-term excellent outcomes are published in the literature [14,15].

In this part of the study, CT scans were obtained from the SOMA database, which included approximately 1000 femurs. The database was filtered for whites and skeletally mature patients with age older than 18 years. This filtration resulted in 506 CT scans, which were finally used for this study. The Murphy method was used to measure the native femoral version of all femurs (Fig. 1) [16]. This method uses the centroid at a cross-section at the base of the femoral neck to define the intersection of the femoral axis and the neck axis. The centroid was used in conjunction with the center of the femoral head and the intracondylar axis of the knee to establish the reference plane of which the native femoral version was measured (Fig. 1). Subsequently, various sizes of ABG II monolithic stems (Stryker Orthopaedics) corresponding to the CT bones were virtually implanted in 506 femurs (Fig. 2). The ABG II monobloc proximally *hydroxyapatite*-coated cementless stem was introduced in 1997. This stem was the successor of the ABG I stem and featured a shorter length, a better metaphyseal fit, and a thinner highly polished distal portion. The rationale of the design of the new stem was to allow better proximal load transmission and prevent stress shielding. This stem has built in anteversion in the neck and the proximal body amounting to a total of 12° of anteversion. The stems were virtually implanted by matching the rotation of the implant to the femur through the widest medial to lateral planes at the seating height defined according to the surgical protocol. Femoral version was subsequently measured after virtual implantation.

Cadaveric Study

A collection of 25 human femurs was used for the cadaveric portion of this study. The samples were photographed and CT scanned before and after the implantation of the same ABG II anatomic hip stems. The procedures on the cadavers were performed by 2 experienced orthopedic

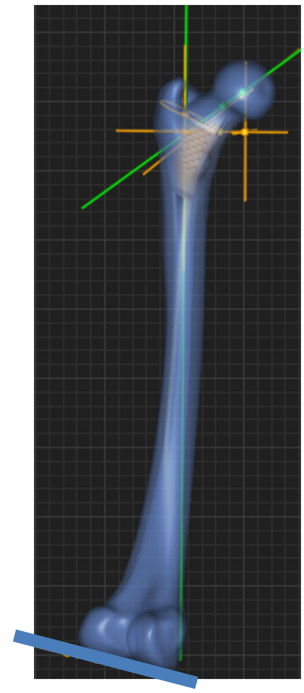

Fig. 2. ABG II monolithic stem virtually implanted in a typical CT bone.

surgeons in accordance with the surgical technique recommended by the manufacturer. The photographs and the images of the CT scans were used to determine native and stem anteversion angles using the Murphy method as described above. The goal was to assess any changes that may occur in the proximal femur orientation after the implantation of anatomic stems. A typical photograph is shown in Fig. 3. The location of the bones was controlled by securing them with screws/vice etc. This ensured that the measurements of the native head center can be directly compared to the implanted head centers.

Navigation System Study

The navigation portion of the study included 182 osteoarthritis patients who received ABG II stems. These stems feature a metaphyseal shape designed to allow for primary stability as well as polished distal tips. Anteversion is also built into the stem. There were 103 females and 79 males with an average age of 66 years. The right hip was involved in 92 cases; and the left hip, in 90 cases. All the patients were operated by the same surgeon through a posterolateral approach. This study used the Navigation System III (Stryker, Kalamazoo, MI) both for the cup and for the stem implantations, and the embedded software program in the navigation system was used as well. The sagittal plane

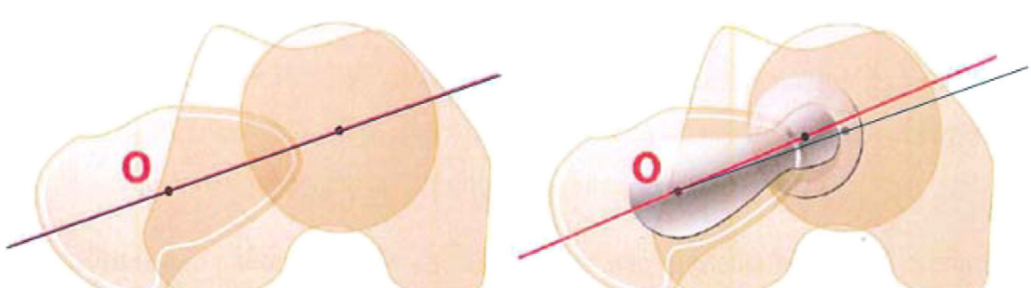

Fig. 1. Native and operative representation of femoral version measurements using the Murphy method.