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The Influence of Hip Rotation on Femoral Offset Following Short Stem Total Hip Arthroplasty

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ABSTRACT

Short stem total hip arthroplasty (THA) is thought to be an advantageous surgical option for young patients. Femoral offset has been identified as an important factor for clinical outcome of THA. However, little is known on functional implications of femoral offset after short stem THA. Importantly, hip rotation influences the projected femoral offset and may lead to significant underestimation. Therefore, a novel method to identify and account for hip rotation was applied to a prospectively enrolled series of 37 patients (48 radiographs) undergoing short stem THA. Repeated measurements were performed and intraobserver and interobserver reliability was assessed and femoral offset was corrected for rotation. Based on this study, rotation-correction of femoral offset is of highest relevance for the correct interpretation in future studies.

Background

Short stem total hip arthroplasties (ssTHA) present a promising alternative to conventional femoral components in young patients [1,2]. The preservation of bone stock in the proximal femur helps to restore the individual torsion of the femoral neck and is thought to be advantageous in revision arthroplasty [1].

Femoral offset (FO) has been identified to be a clinically relevant factor for functional outcome and implant survival following THA [3,4]. However, in ssTHA, there is a paucity of knowledge regarding functional implications of FO [5]. Additionally, no standardized method to measure FO in radiographs following ssTHA has been introduced. While the projected femoral offset (FO_P) can be directly measured in calibrated plain radiographs of the hip or pelvis, its projection can be significantly shortened due to hip rotation [4,6,7]. According to Lechler et al [6], the rotational influence can be eliminated by employing a formula based on the difference between the projected and true neck-shaft angle of the femoral component. While Weber et al [8,9] recently validated the method for THA using standard femoral components, the effect of hip rotation on the projected femoral offset and rotation-corrected femoral offset has not been studied following ssTHA.

Due to the particular design of ssTHA, the long axis of the stem does not necessarily follow the long axis of the femoral shaft resulting in a wide range of acceptable varus or valgus positions. Therefore, contrasting standard THA, the postoperative FO of the prosthesis may vary significantly from the FO of the native femur. The necessity to identify hip rotation and correct the FO has been shown in previous publications [6,8]. However, this method has not been applied to ssTHA before. For the correct interpretation of FO in postoperative radiographs, it is necessary to address the effect of hip rotation.

The present study aimed to analyze the reliability of the method for radiological rotation-analysis and the calculation of rotation-corrected femoral offset following short stem total hip arthroplasty. The method allows the correct identification of FO and therefore adequate clinical correlations in future studies on ssTHA.

Materials and Methods

A consecutive series of 52 patients was treated with a short stem total hip arthroplasty (OHST Medizintechnik AG, Rathenow, Germany;

Abbreviations: AC, acetabular component diameter; CF, calibration factor; ECM, external calibration marker; FO, femoral offset; FO_P, projected femoral offset; ICC, intraclass correlation coefficient; nFO, native femoral offset; nNSA, native neck-shaft angle; NSA, neck-shaft angle; NSA_T, true neck-shaft angle; NSA_P, projected neck-shaft angle; PACS, picture archiving and communication system; pFO, prosthetic femoral offset; pNSA, prosthetic neck-shaft angle; ssTHA, short stem total hip arthroplasty; THA, total hip arthroplasty.

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Conflict of interest: Smith & Nephew Orthopaedics AG (Baar, Switzerland) acted as the sponsor of this study, granting financial compensation for expenses.

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distributed by Smith & Nephew, Baar, Switzerland) at a single center and prospectively included in a clinical and radiological study. A chart review was performed and demographic and operative data including implant size were acquired. Complete sets of preoperative and postoperative radiographs of 37 patients were available. Some patients underwent more than one postoperative radiograph. Therefore, 37 preoperative and 48 postoperative radiographs were included in the analysis. Preoperative and postoperative radiographs of the pelvis were retrieved from the picture archiving and communication system (PACS) and analyzed following a standardized protocol by two independent orthopedic surgeons. Repeated measurements were performed by one observer 6 months after the first measurement, blinded to the previous results. Radiological analysis was performed with a PACS client (IMPAX EE, AGFA HealthCare GmbH, Bonn, Germany). In preoperative radiographs, a 25 mm diameter external calibration marker was used for calibration; in postoperative images, the implanted acetabular shell was used for calibration. Patients were in a lying position in the antero-posterior radiographs of the pelvis with the crosshair of the beam centered to the pubic symphysis. The feet were internally rotated by approximately 15°.

The study protocol was approved as an amendment to a prospective study protocol by the local ethics committee (Number 5588). All patients gave their written informed consent prior to inclusion in the prospective study. The following radiographic parameters were measured as part of the analysis: the diameter of the THA head, the native neck-shaft angle of the femur (nNSA) and the prosthetic NSA (pNSA) of the THA stem, the diameter of the acetabular shell and the diameter of the external calibration marker. The femoral offset was defined as the perpendicular distance from the femoral axis/stem axis to the centre of rotation and was assessed for the native femur (nFO) as well as the prosthetic stem (pFO, Fig. 1A–C). Baseline characteristics of a Nanos short stem prosthesis are shown in Fig. 2. The prosthetic neck-shaft angle was defined as the size-dependent angle between the long-axis and the neck axis of the component (Angle G, Fig. 2).

Calculation of Hip Rotation

Following Lechler et al [6], the hip rotation can be calculated with the knowledge of the true and the projected NSA (NSA_T, NSA_P) of the implant: Hip rotation (°) = arcos (tan (180 − NSA_P)/tan (180 − NSA_T)). Therefore, the rotation-corrected FO (FO_{RC}) = calibrated FO • (tan (180 − NSA_P)/tan (180 − NSA_T)).

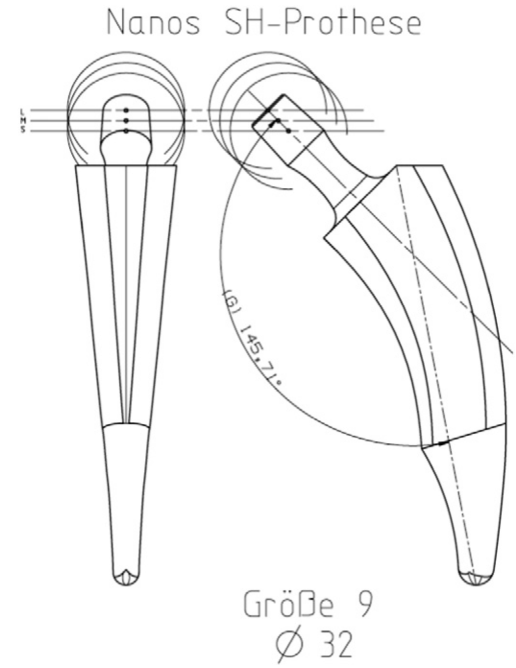

Fig. 2. Technical drawing of a size 9 Nanos short stem femoral component. The prosthetic neck-shaft angle—as measured in this study—is the angle G in the drawing. It is size-dependent. Used with permission from OHST Medizintechnik AG.

Statistical Analysis

For descriptive analysis, absolute mean values and ranges of the measured variables are reported. Intraclass correlation coefficients (ICC) were calculated for repeated measures for intraobserver and interobserver reliability with a two-way mixed model. Variables were tested for normality using the Kolmogorov–Smirnov-test. Because most variables were non-normally distributed, the Mann–Whitney *U*-test was used for comparison. For non-Gaussian variables, the Spearman rank correlation coefficient was used to analyze correlations. The level of significance was set at $P < 0.05$ and confidence intervals were 95%. Results are shown for analysis of the means of repeated measurements. IBM SPSS Statistics 22 (IBM

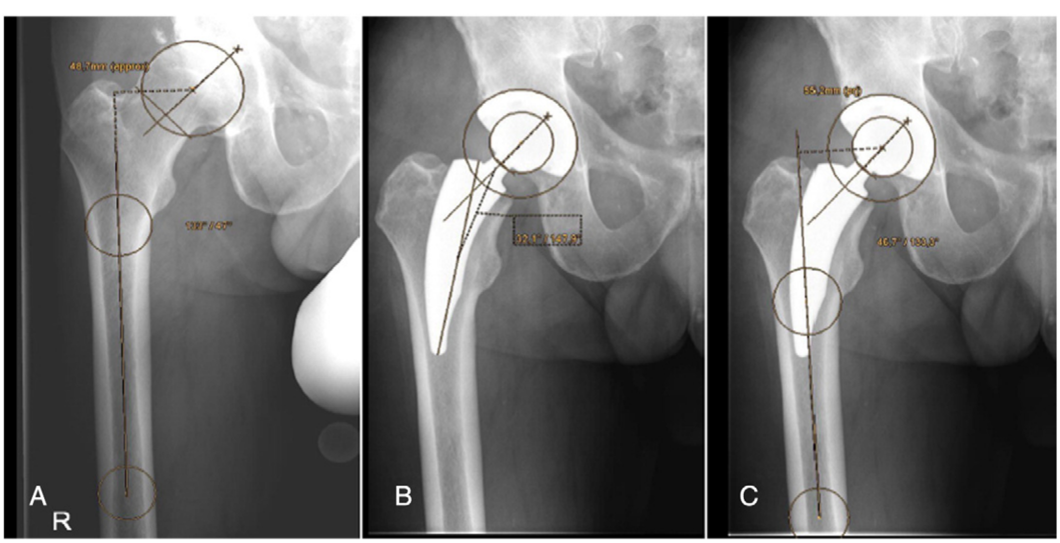

Fig. 1. (A–C) Anteroposterior radiographs (partially shown) of the pelvis before (A) and after short stem THA (B and C). (A) Measurements of the native neck-shaft angle (NSA) and femoral offset (FO) are shown. (B) Measurement of prosthetic NSA. (C) Measurements of the postoperative NSA and FO.