Clinical Biomechanics 27 (2012) 165–169

Contents lists available at SciVerse ScienceDirect

Clinical Biomechanics

journal homepage: www.elsevier.com/locate/clinbiomech

Femoral head to neck offset after hip resurfacing is critical for range of motion☆,☆☆,★

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ARTICLE INFO

Article history:
Received 16 June 2011
Accepted 25 August 2011

Keywords:
Hip resurfacing
Flexion
Range of motion
Head to neck ratio

ABSTRACT

Background: Range of motion after hip arthroplasty may be limited by soft tissues around the hip, extra-articular contact and femoral stem-neck contact with the acetabular articular surface. Femoral head–neck diameter ratio is recognized as a major factor influencing hip range of motion. In hip resurfacing, range of motion is constrained by "cup component to femoral neck" contact. To avoid cup-to-bone contact or to increase the degree of flexion at which it occurs, anterior translation of the femoral component relative to the central femoral neck axis may improve anterior head–neck offset and hip flexion. We questioned whether low or high anterior femoral head to neck offset, cup inclination, stem anteversion, and component size influenced postoperative range of motion and hip flexion in patients who had undergone hip resurfacing.
Methods: We prospectively followed 66 patients (68 hips) who underwent hip resurfacing at a mean age at operation of 46.4 years (range, 19–60 years). Mean follow-up was 37.5 months (range, 33–41 months). No patient was lost to follow-up. All patients were evaluated clinically and range of motion was precised. Radiological measurement evaluated the anterior femoral head–neck offset.
Findings: Mean anterior neck–head offset was 7.5 mm (range, 5–12 mm). We found significant linear regression correlation between anterior offset and flexion (R = 0.66) and between anterior offset and global range of motion (R = 0.51). One millimeter of anterior offset increased hip range of motion by 5° in flexion. No significant correlations were found between global range of motion or flexion arc of motion and component size, stem anteversion, cup inclination, gender ratio, preoperative arc of flexion or global range of motion.
Interpretation: Restoring or improving deficient anterior femoral head–neck offset appears important for restoring postoperative range of motion and specifically hip flexion.

1. Introduction

The main objective of total hip arthroplasty (THA) is to restore painless, normal hip function. Better hip function is correlated with greater range of motion (RoM) (Davis et al., 2007; Malik et al., 2007). Among all arcs of motion, hip flexion appears to be the main factor for high-level activity and better sports performance (Davis et al., 2007; McGrory et al., 1996).

Femoral head–neck diameter ratio is recognized as a major factor influencing hip RoM. After conventional THA, RoM is mainly limited by "prosthesis to prosthesis" contact, soft tissues around the hip and extra-articular contact. After hip resurfacing, RoM is limited by "cup component to femoral neck bone" contact (Lavigne et al., 2008). For example, to avoid cup-to- anterior neck bone contact, anterior translation of the femoral component relative to the central femoral neck axis may improve anterior head–neck offset and hip flexion. The morphology of the native femoral neck is a non circular shape and lead to inconstant head–neck offset around the head/neck junction circumference. According to Clarke, the larger neck diameter is oriented from 2 o'clock to 7 o'clock (Clarke, 1982). In contrast, the morphology of the THA femoral component neck is cylindrically homogeneous (Lavigne et al., 2011). So the relative low ratio in size between the resurfaced femoral head and the relatively thick femoral neck raises the question of whether the hip range of motion is sufficient (especially with young patients). The design and orientation of hip resurfacing components may have a strong influence on RoM owing to the thickness of the femoral component, cup opening angle and cup or stem anteversion (Amstutz et al., 1975).

Metal-on-metal hip resurfacing provides a "bone-preserving arthroplasty option" for young, active patients with end-stage hip

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☆☆ Each author certifies that his or her institution approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research.
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doi:10.1016/j.clinbiomech.2011.08.013

osteoarthritis (Markolf and Amstutz, 1980; Vendittoli et al., 2006a, 2006b; Wagner, 1978). Hip resurfacing designs include large femoral head sizes that are reportedly important for improving hip stability (Malik et al., 2007). On the other hand, low head to neck diameter offset may be detrimental to attaining better range of flexion (Amstutz et al., 1975; Beaule et al., 2007).

We questioned whether anterior femoral head–neck offset, implant position, and component size correlated with postoperative RoM.

2. Methods

Between September 2007 and March 2008, we prospectively followed 66 patients who underwent 68 hip resurfacing. Twenty-six were women and 40 men, with 23 right-handed and 45 left-handed. The initial diagnosis was primary idiopathic osteoarthritis in 23 cases and secondary osteoarthritis in the others: femoro-acetabular impingement (19), hip dysplasia (12), slipped capital femoral epiphysis (1), Legg-Calvé-Perthes disease (2), post-trauma (4), hip chondrolysis secondary to slipped capital femoral epiphysis (2), osteochondromatosis (2), coxa profunda (1), and late sequelae of staphylococcus-related hip arthritis (2). Our study received prior ethics committee approval. All subjects who participated in the study gave their written informed consent.

All operations were performed by a single trained surgeon (JG). The Durom® resurfacing system (Zimmer, Inc., Warsaw, IN) was used for hip resurfacing. The Durom femoral component wall is 4 mm thick and the estimated cement mantle is 1 mm (reducing the risk of fatigue failure of the bone cement), giving an offset of 5 mm compared to the opening of the component. The Durom cup was less than a hemisphere (1.5–2.7 mm according to the size) and subtended a constant angle of 165° (which is similar to the natural acetabulum) which could minimize the acetabular bone loss and improve the RoM. All hip resurfacings were installed through a posterolateral approach. In all cases, we measured the neck size after osteophytes removal at the head–neck junction. The femoral head was then dislocated anteriorly and the acetabulum reamed sequentially until the corresponding neck size. Peripheral acetabular osteophytes were excised to prevent a cam effect. The femoral head was prepared with Zimmer Durom® instrumentation to align and position the guide rod. Maximal anterior head to neck offset was systematically searched with the femoral component implanted flush with the posterior cortex of the femoral head–neck junction. We assessed the bone support and the cylindrical femoral fit should be completed. Then, the cup was impacted and the head was reamed and fixed with high-viscosity cement.

Immediate full weight-bearing was allowed with 2 crutches during the first week. No restriction was applied to hip mobility, and rehabilitation was supervised by a physiotherapist 3 times per week (hip exercise to improve joint mobility, muscles strengthening and stretching exercises to regain balance and fine muscle control).

For all the patients, clinical and radiographical evaluation was obtained for all patients post-operatively and at the last follow-up. Hip function was assessed by Merle d'Aubigné score (Merle D'Aubigne, 1970), the Harris hip score (Harris, 1969), and WOMAC (Bellamy et al., 1988), and activity level by the classification of Devane et al. (Devane et al., 1997). All patients were examined by one observer (NK) who did not participate in the surgery. All pre- and postoperative arcs of movements were measured with the patient in the supine position, using a goniometer according to American Academy of Orthopedic Surgeons (AAOS) guidelines (Greene WB, 1994). Each individual arc of motion (flexion, extension, abduction, adduction, internal and external rotation) was calculated, and total arc of hip RoM was estimated by adding each individual motion.

AP and lateral radiographs were taken postoperatively, annually, and at last follow-up. AP radiographs of the pelvis were taken with the legs positioned in 15° of internal rotation.

Three of us (NK, DB, JG) analyzed all pre- and postoperative radiographs. The radiographs were rejected if the coccyx was not centered on the pubic symphysis and was not 2 to 4 cm proximal to it. This ensured proper positioning of the pelvis in both the frontal and sagittal planes (Tannast et al., 2005). Cup inclination was measured according to the teardrop line. Variation of more than 5 mm between follow-up radiographs was considered as migration (Massin et al., 1989). Preoperative cervical–diaphyseal angle and stem–shaft angle were considered (Beaule et al., 2004); the latter is defined as the angle between the stem and the anatomical axis of the femoral shaft. Anterior femoral head–neck offset was evaluated, as outlined by Beaulé et al. (Beaule et al., 2007) (Fig. 1). On cross-table lateral radiographs, a line was drawn along the longitudinal axis of the femoral neck, followed by a second line parallel to it but along a tangent to the anterior border of the neck. A third line was then drawn parallel to the first two but tangential to the femoral head. The perpendicular distance between the second and third lines was measured. On cross-table incidence, the femoral component version was defined by the angle between the stem and the femoral shaft. Measurements were standardized according to the well-known diameter of the implants. We considered the averages of all measurements by the three observers. We ascertained the reliability of our method for measuring femoral component offset. Interrater reliability was evaluated by analysis of variance (ANOVA). Measurement precision was calculated as the mean ± SD of the standard error of the mean of 3 measures in each case. ANOVA demonstrated that there was no significant difference between the three raters. The precision of femoral component offset measurement was 0.38 mm (± 0.02 mm).

Student's *t* test was used to compare pre-operative and last follow-up clinical scores as well as radiographic measurements. Associations between variables were tested by Pearson's correlation coefficients after normal distribution was confirmed. Comparability between groups was assessed by Levene's test for equality of variance. Simple linear regression analysis was conducted to determine any association between anterior offset and all arcs of motion and on all continuous

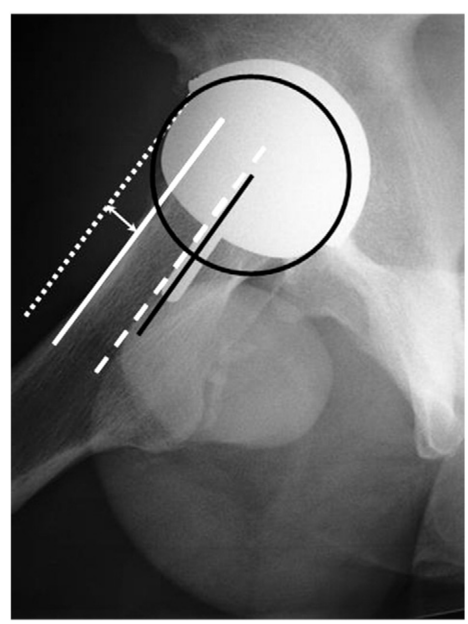

Fig. 1. Radiograph showing the biomechanical parameters measured. A line was drawn along the longitudinal axis of the femoral neck, followed by a second line parallel to it but along a tangent to the anterior border of the neck. A third line was then drawn parallel to the first 2 but tangential to the femoral head. The perpendicular distance between the second and third lines was measured. Femoral component version was defined by the angle between the stem and the femoral shaft. For this 34-year-old man, the femoral component implanted was a 50-mm diameter head, anterior head to neck offset was 10 mm, and stem version was + 3°.