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Femoral offset in total hip replacement: A study of anatomical offset in the Northern Ireland population

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Abstract Femoral offset is defined as the perpendicular distance between the long axis of the femur and the centre of rotation of the femoral head. The variability of proximal femoral geometry in terms of offset is consistent with the theory that the geometry of the femur is determined by a large number of genetic and environmental factors. These influences appear to lead to unique endosteal geometry's, as characteristic of each individual as any other feature of human anatomy. Traditionally commercially available and widely used hip prostheses offered a limited range of offset sizes. The older Charnley hips offered a choice of 35, 40 and 45 mm offsets. These sizes were provided to match the mean population offset which has been reported as 43.0 mm. This study investigates offset in a sample (n = 477) of the Northern Ireland population having customised total hip replacement. The mean femoral offset for this group was 43.4 mm (range 28—72 mm). A modern femoral implant should construct a biomechanically favourable offset without unduly lengthening the leg. It is evident, therefore, that modern currently available stems require a large range of offsets to adequately cover the NI population variation in terms of anatomical offset.

Introduction

The aims of hip joint replacements are to provide the patient with a painfree mobile hip joint with restoration of lost function. This depends on sound component fixation, sometimes by the use of cement, and accurate component placement. Careful attention to detail, allied with the use of third generation cementing techniques should ensure optimal component fixation in cemented arthroplasty.

Correct orientation of the components is important to minimise the risk of joint dislocation but little specific attention is paid to the combined effect implant 'position' and shape has on the replaced hip geometry. The Charnley low friction arthroplasty is still widely recognised as being the *Gold Standard* in hip arthroplasty. Factors such as

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alignment, offset of the femoral component (Noble et al., 1988; Davies et al., 2007; Lecerf et al., 2009; Daluga, 2009; Ganapathi et al., 2009), thickness of the cement mantle, and the use of a distal bone block to improve cement pressure have been shown to influence the outcome of Charnley hip arthroplasties.

The concept of the Belfast custom X-press hip replacement (Beverland, 1994; O'Brien et al., 2004, 2005, 2007; Archbold et al., 2006) is to achieve a femoral stem that would reconstitute the natural biomechanics in a primary cemented arthroplasty, with improved alignment, an even cement mantle and improved cement pressurisation at insertion.

To evaluate the effect that implant 'position' has on the replaced hip geometry, we need to study how accurately the custom X-press hip reconstructs the natural centre of rotation of the femur. We therefore must study this in three dimensions, namely femoral offset, vertical height of the component in the proximal femur, and component anteversion. This study aimed to assess the accuracy of the Belfast custom X-press custom hip replacement, in achieving one biomechanical parameter, the patients anatomical offset.

Why orthopaedic nurses need to be aware of offset in THA and how it will benefit their care of hip arthroplasty patients

Optimising femoral offset through preoperative templating is critically important in total hip arthroplasty so that limb length and femoroacetabular relationships are maintained as close to normal as possible. Modular prostheses and similar implants can be used to optimise THR. It is essential to understand the starting point so that offset and leg length are not compromised during the surgical procedure. One of the goals in THA is to restore normal joint mechanics by recreating normal force balance about the hip. In a joint with osteoarthritis, determination of joint normal physiologic location and femoral head centre are not always possible due to loss of articular cartilage and bony deformity. In a patient with unilateral osteoarthritis, preoperative planning involves using the unaffected side, a measure not possible with bilateral involvement. Nurses need to be aware that in the osteoarthritic patient the femoral head position tends to be in external rotation. Traditional radiographs taken with the foot perpendicular to the cassette underestimate offset due to the position of the femoral head with respect to the image beam. Data from this study clearly supports this often held opinion. An underestimation of femoral offset in preoperative THA templating of radiographs can occur, especially in patients whose arthritis fixes the femur in external rotation.

Various outcome criteria have been used making comparison of results difficult and prompting the formulation of an international 'standard system for reporting results' — C.A.R.T, (Johnson et al., 1990). In order to evaluate the evolution of the custom stem design and make comparisons with other implants, the data recorded on each patient is standardised using C.A.R.T. As an experienced Outcome Assessment Unit Manager, the author was involved in the development of a computerised documentation system as recommended by Johnston et al. (1990). The author is responsible for recording the clinical, physical and radiographic evaluation at each stage of the patients progress from preoperative assessment to 1 year review and beyond. The author is also a member of the Belfast Joint Group, a 'team' of research staff co-ordinated by a consultant surgeon.

Perceived benefits of customisation in hip replacement

The Belfast custom X-press hip system comprises a modular customised titanium stem together with cobalt chrome or ceramic heads, used in conjunction with a cemented Charnley type socket. The custom X-press stem was first introduced in Belfast (1990), and a limited number of implants were used. It has now evolved and developed, and has been used routinely since 1992, and in that time over 4000 prostheses have been implanted and documented, (Wallace et al., 1992; Engela et al., 1993; O'Brien et al., 1994; Nixon et al., 1994; Beverland, 1994; James et al., 1995; O'Brien et al., 2004, 2005, 2007; Archbold et al., 2006). The custom manufacturing facility closed on the 31st March 2005. The C-Stem and the Corail® Total Hip System (DePuy International Ltd., Leeds, UK) now achieve the design aims of the custom stem and are now our implants of choice.

The custom cemented stem was introduced in order to achieve specific aims, as follows:

(1) Improved stem alignment.
(2) Even stem cement mantle.
(3) Increased cement pressure at insertion.
(4) Reconstruction of the natural centre of rotation of the femur in 3 dimensions: *offset, vertical height and anteversion.*