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ORIGINAL STUDY

Is the tip of the greater trochanter a reliable reference for the rotation centre of the femoral head in total hip arthroplasty ?

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A variety of techniques have been used to determine intra-operative leg length during total hip arthroplasty. One method often described is using the tip of greater trochanter as the reference for the rotation centre of the femoral head to align the femoral component. There is little in the literature to support this method of leg length restoration.

We analysed standard anterior-posterior pelvic radiographs of 225 patients with osteoarthritis of the hip who were about to undergo total hip arthroplasty. The distance between the tip of the greater trochanter and the rotation centre of the femoral head was measured for the affected hip.

The average location of the tip of greater trochanter is 3.4 mm proximal to the centre of the femoral head, with a range from 20 mm proximal to 10 mm distal to the femoral head centre.

There is considerable variation in the anatomy of the proximal femur ; however, with adequate preoperative templating, the greater trochanter can be a helpful guide to determine the rotation centre of the femoral head of the femoral component and should be used with other conventional techniques to determine leg length intra-operatively.

Keywords : femoral head ; greater trochanter ; hip arthroplasty ; leg length discrepancy.

INTRODUCTION

Restoration of appropriate leg length is an important part of total hip arthroplasty (THA) in patients with osteoarthritis of the hip. Leg length discrepancy (LLD) after THA is a significant source of patient dissatisfaction and a common reason for litigation. Minor LLD can be detected by patients and shoe raises are not always well accepted (*6*). Significant lengthening of the leg can result in nerve palsy, such as the peroneal and sciatic nerve (*16*).

Leg length discrepancy can be minimised by appropriate preoperative templating and intra-operative measurements. Numerous fixed references for determination of intraoperative changes in limb length have been reported. These include use of intraoperative calipers, iliac fixation pins and screws and fixed suture lengths (*2,8,9,11,12*). The tip of the greater trochanter has been used commonly as a guide to the rotation centre of the femoral head (*13*) despite Charnley's observation that these landmarks may not be reliable (*4*). There is a paucity of data in the literature to substantiate this common reference point to guide limb length restoration in THA.

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The aim of this study was to determine if the tip of the greater trochanter (GT) is a reliable reference point for the rotation centre of the femoral head as determined by measurements from standardised pelvic radiographs.

MATERIAL AND METHODS

Two hundred and twenty five consecutive plain radiographs of the pelvis of patients with osteoarthritis about to undergo primary hip arthroplasty were analysed. There were 79 male and 146 female patients with an average age of 67.2 years (range, 29-91 years) all of Caucasian origin.

Standard radiographs were taken of the pelvis in the antero-posterior (AP) projection. A single observer measured the hip that was to undergo surgery.

The anatomical axis of the femur was identified and marked using the centre of the femoral canal and the piriformis fossa as landmarks. Using a concentric ring template, the centre of rotation of the femoral head was identified and a line perpendicular to the anatomical axis was drawn to pass through the centre of rotation. The perpendicular distance from this line to the tip of the trochanter was then measured to the nearest millimetre and recorded, as well as whether the tip of the trochanter was proximal or distal to this line (fig 1).

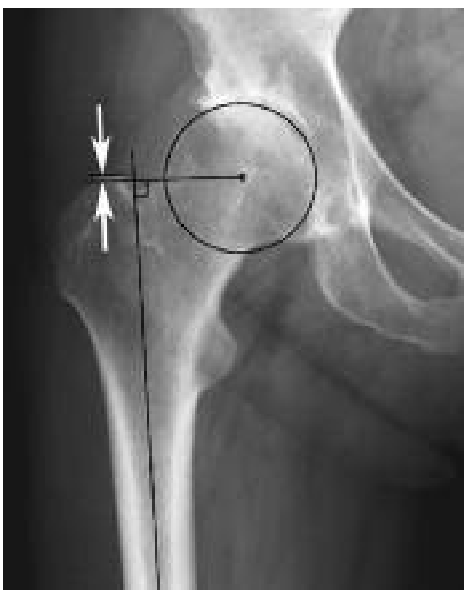

Fig. 1. — The arrows shows the distance measured from the femoral head centre to the tip of the greater trochanter on a line perpendicular to the anatomical axis of the femur.

We excluded patients with developmental dysplasia of the hip and other morphologically abnormal hips on radiographs. Computer software (SPSS 17.0, SPSS Inc, Chicago, Illinois, USA) was used for statistical analysis.

RESULTS

The mean location of the tip of GT was 3.4 mm (95% confidence interval, 2.5 to 4.3) proximal to the centre of the femoral head. Its position ranged from 20 mm proximal to 10 mm distal to the femoral head centre. The median distance of the tip of GT was 3.0 mm (SD 6.6) proximal to the centre of the femoral head. Figure 2 shows the box plot diagram summarising the descriptive data, and figure 3 shows the distribution of the distances from the tip of the GT to the femoral head centre grouped into 5 mm sections.

We found that the GT was at the same level as the centre of the femoral head in 32% (73 hips), proximal to it in 51% (115 hips), and distal to it in 16% (37 hips).

DISCUSSION

Inadvertent limb lengthening after THA has been associated with complications such as nerve palsy, low back pain and abnormal gait (*7,12,15,18,20*). This study suggests that using the tip of the GT as a reference point for the centre of femoral head in positioning the femoral component in THA lengthens the leg on average by 3.4 mm. In a study of 23 patients after THA complicated by nerve palsy, Edwards *et al* noted that an average lengthening of 2.7cm was related to peroneal nerve injury and 4.4cm to sciatic nerve palsy (*5*). In a large series, Williamson and Reckling reported that 27% of patients required heel lifts on the contralateral side after THA to gain a satisfactory gait pattern (*21*). Konyves and Bannister noted in a study of 90 patients undergoing THA that an average limb lengthening of 9 mm was perceived in 43% of patients (*10*). They also noted that correctly positioning the femoral component was the factor most likely to prevent leg length discrepancy.

Several methods of measuring limb length directly or indirectly during THA have been described. As examples of the indirect methods, Charnley

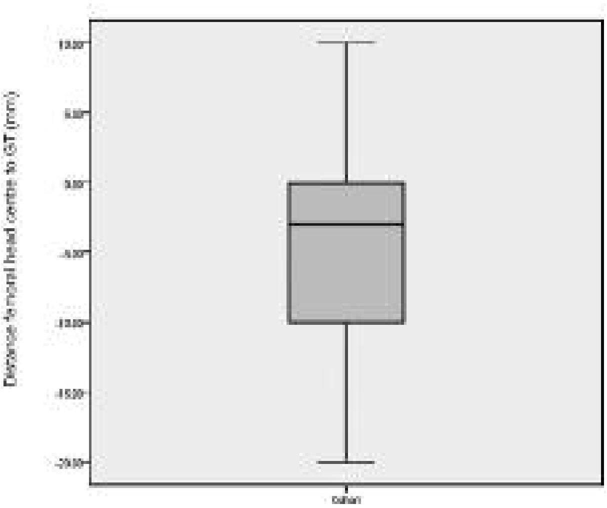

Fig. 2. — Box plot summarizing the patient cohort. Negative values represent the GT being proximal to the femoral head centre and positive values indicate that the GT is distal to the femoral head centre.

reported comparison of the limb length by palpation of the medial malleoli and what is commonly called the "shuck" test of the operated hip (*4*). Measurement of the distance between two reference points on the ilium and the femur has been one of the most commonly employed approaches of the direct methods using measurement callipers and rulers. Methods using the anterior superior iliac spine or iliac wing as a reference point may make it difficult to gain accurate measurements since these landmarks are located away from the centre of rotation of the hip. It should also be noted that changes to the offset and anteversion of the femoral component will also influence these measurements. Sproul *et al* analysed 34 cadaveric proximal femora and noted that the diameter of the femoral head was similar in size to the distance from the top of the lesser trochanter to the centre of the femoral head (*17*). They suggested it may be a useful clinical measurement to assess leg length during hemiarthroplasty of the hip. More recently surgical navigation using pelvic coordinates has been used to determine intraoperatively the position of the femur and therefore determine the correct leg length (*14*).

Whilst this study concentrates on measurements in relation to the femur alone, it should be noted that alterations can be made deliberately or inadvertently when preparing the acetabulum. When dealing with a dysplastic acetabulum or in the presence of gross erosion, seating the inferior margin of the socket at the level of the transverse ligament is essential to restore the biomechanics around the hip. Overreaming of the acetabulum may lead to a

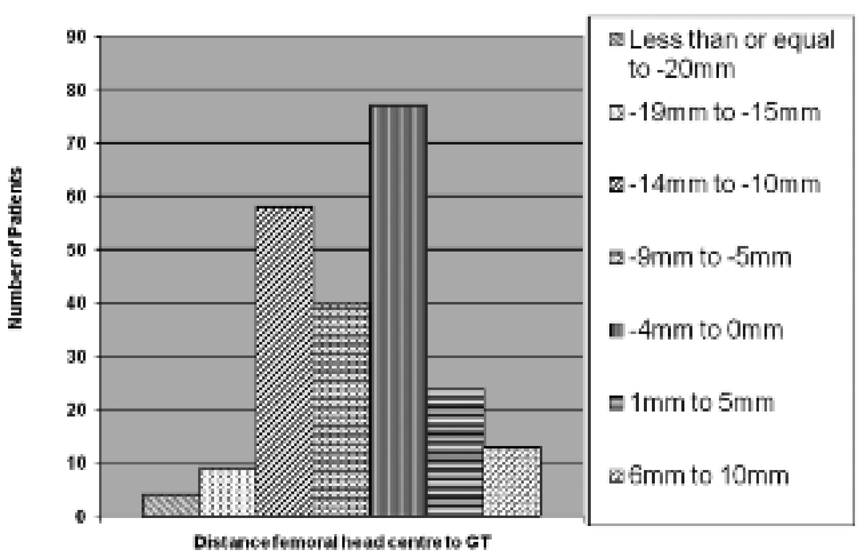

Fig. 3. — Graph showing the distribution of the distances (in 5 mm groups) from the centre of the femoral head to the tip of the greater trochanter (GT).

higher hip centre, therefore shortening the leg, and this may need to be addressed by increasing either the neck length, offset or neck-shaft angulation. In the revision situation it should be noted that if reinforcement rings are used within the acetabulum then this may lower the hip centre and lead to increased leg length. We acknowledge that multiple variables will have an effect on the final position of the femur following total hip replacement and hope to offer further information on the variability of proximal femoral anatomy with this paper.

Our study suggests that in one third of cases the tip of the greater trochanter was within 1 mm of the femoral head centre, and on average 3.4 mm proximal to it. In 32% of cases the tip of the greater trochanter was between 0 and 4 mm proximal to the femoral head centre. The tip of the greater trochanter as an intra-operative guide to restore femoral head centre and thus guide limb length restoration should be used with caution. However, in conjunction with adequate pre-operative templating, it may be useful as an easily palpable and visual intra-operative guide rather than an absolute marker in positioning the femoral component. Other radiological studies have indeed yielded different results : Antapur and Prakash in a series of 150 patients found that the tip of the greater trochanter was on average 9 mm proximal to the femoral head centre, and they discouraged the use of the tip of greater trochanter as a reference point (*1*).

Several studies investigating the migration of the femoral component after THA have used various reference points to accurately determine the amount of migration with time on plain radiographs. Walker *et al* found that the distance from the greater trochanter to the collar of the stem provided the most accurate landmark to determine axial migration of the stem (*19*). They also found that the distance from the greater trochanter to the centre of the femoral head was the least reproducible landmark as there is variation in anteversion angles in successive radiographs and varus-valgus migration may produce vertical movement of the head. Later Biedermann *et al* confirmed the findings of Walker *at al* and showed that the top of the greater trochanter near the shoulder of the femoral component provided the best landmark for measurement of subsidence using EBRA-FCA computer assisted analysis ; the lesser trochanter was the worst reference point (*3*).

Whilst our study only looks at the vertical distance from the tip of the greater trochanter to the femoral head centre, we acknowledge that leg length is dependent on a number of other factors including femoral stem varus-valgus positioning, neck shaft angle, femoral neck offset and acetabular component positioning which were not addressed in our study.

Other limitations include variability in magnification correction errors on radiographs which may lead to small variation in lengths measured. Whilst all radiographs of the pelvis were standardised, small variations in leg adduction/abduction and internal/external rotation may have occurred, leading to altered distances being measured.

Overall we would recommend the use of the GT tip as a helpful clinical guide in determining the femoral head centre and as a guide to leg length restoration in THA. However, there is considerable anatomical variation in the proximal femur and this should be used in combination with other conventional techniques to determine the position of the prosthetic components during total hip arthroplasty.

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