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ORIGINAL STUDY

Proximal femoral anatomy in total hip arthroplasty
A tri-planar computed tomographic assessment

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The relationship between the tip of the Greater Trochanter (GT) and the centre of the Femoral Head (FH) is commonly used as reference point to align the femoral component during hip arthroplasty. We performed tri-planar computed tomography analysis of the proximal femoral anatomy in a series of 150 patients (n = 150) to accurately delineate this relationship. The mean location for the centre of the FH was 8.64mm (95% confidence interval, 9.44-7.83) distal to the tip of the GT. The centre of the FH was found to be distal to the tip of the GT in 90.6% of cases. Hence we would suggest caution in using the tip of the GT as a reference point during total hip arthroplasty as it could be associated with an inadvertent intraoperative leg lengthening.

Keywords : hip arthroplasty ; leg length discrepancy ; femoral head centre ; tip of trochanter.

INTRODUCTION

Limb length discrepancy is one of the most common surgical complications following THA. Not only is it associated with patient dissatisfaction, but it is also a potential reason for litigation. Patients appreciate even minor changes and use of a shoe raise to address this problem is frequently unacceptable to patients (*6*).

There have been a variety of approaches to address this problem. The most common ones include use of fixed reference points like the relationship of the tip of the greater trochanter (GT) to the centre of the femoral head rotation, lesser trochanter, intra-operative calipers and pins placed in the ilium (*2,7,8,10*). Many surgeons rely on soft tissue tension and hip stability. Excessive leg lengthening is associated with a number of nerve palsies, such as sciatic nerve and peroneal nerve (*12*). Improved preoperative templating and intraoperative measurements could potentially address this issue.

Prior studies using non-standardised plain radiographs have suggested that considerable variation exists in the relationship between the tip of the GT to the centre of the femoral head rotation (*1,13*). Our study attempted to accurately address this issue and is the first study to use tri-planar computed tomography to accurately delineate the relationship

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between the tip of the greater trochanter to the centre of the femoral head.

METHODS

This was a cross sectional study to analyse the proximal femoral anatomy using a consecutive series of one hundred and fifty lower limb CT angiograms (n = 150) performed on a 64 slice CT scanner.

Amongst the selected patients, 31 were females and 123 were males. Their mean age was 71 years (range : 42-93). They underwent full-length lower limb CT angiograms for peripheral vascular disease. The CT lower limb angiograms provided full-length views for accurate measurement of centre of the femoral canal and femoral head.

Images utilized for analysis were standardised full-length femoral views. The centre of the femoral canal was identified using orthogonal tri-planar imaging in coronal, sagittal and axial views. A perpendicular was then drawn to the centre of the canal intersecting the inter cortical point at three points along the canal. After having identified the centre of the femoral head in the axial, coronal and sagittal planes, a line was drawn across the long axis of the femoral head. Subsequently this line was divided to mark the centre of the head. Finally the distance was measured from the point of the centre of the head to the line intersecting the tip of the greater trochanter (Fig. 1-3).

Exclusion criteria for this study included hips with prior childhood or adult pathology. The neck shaft angle and the femoral offset were not taken into consideration.

All data analysis was performed using SPSS 17.0 (SPSS Inc, Chicago, Illinois, USA) and figures generated using Analyse-it softwear in conjunction with Microsoft Excel.

RESULTS

The mean location for the centre of the femoral head was 8.64 mm (95% confidence interval : 9.44-7.83) distal to tip of the greater trochanter. The median location for the centre of the femoral head was 8.4 mm (standard deviation 4.97) below the tip of the greater trochanter.

The centre of the femoral head was found to be at the same level as the tip of the greater trochanter in 6% (9/150) of cases. It was distal to the tip of the GT in 90.6% (136/150) of cases and was proximal to it in 3.3% (5/150) of cases.

Fig. 1. — The true midpoint of the femoral canal was identified in coronal, sagittal and axial planes using the intercondylar point inferiorly and the midpoint of intercortical lines placed along the shaft of the femur.

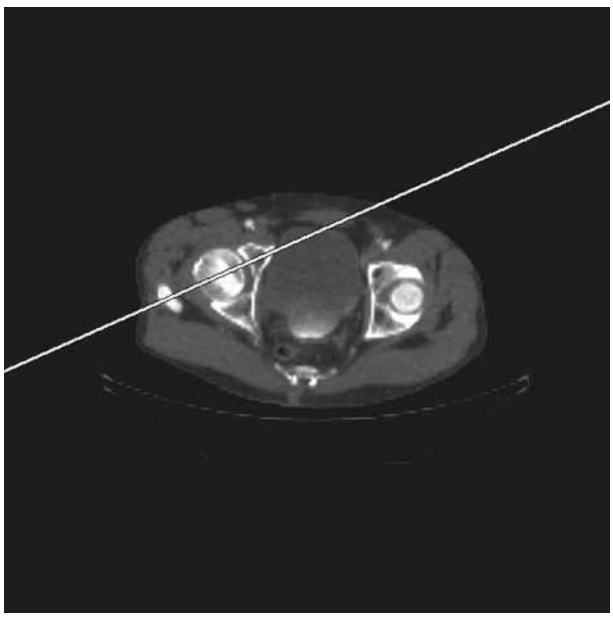

Fig. 2. — While maintaining the true long axis of the femur, the true plane for measuring the centre of the femoral head was identified in the coronal and axial planes.

The distribution of distances from the centre of the femoral head to the tip of the greater trochanter was demonstrated in a box plot (Fig. 4). The

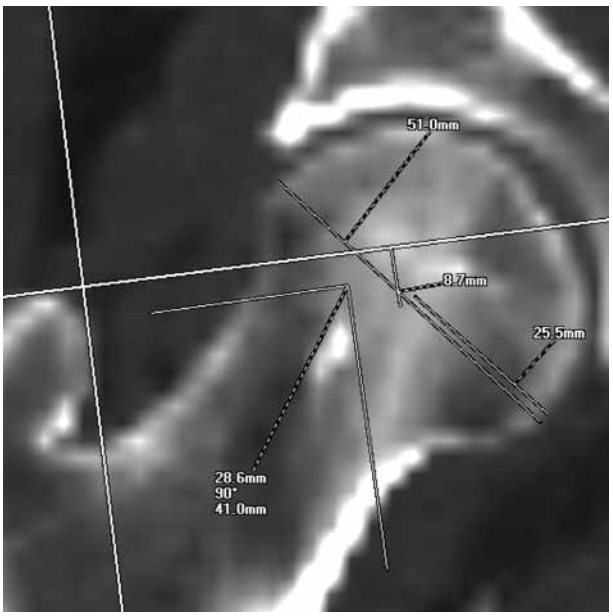

Fig. 3. — In the coronal plane along both the true long axis of the femur and the true femoral head, the midpoint of the femoral head was determined by finding the midpoint of a line from the outer margins of the femoral head. The distance from the tip of the GT to the femoral head centre was then measured using fixed a angle guide.

distribution of the distances from the centre of the femoral head to the tip of the greater trochanter grouped into 2.5 mm sections was also determined (Fig. 5).

In order to assess a normal distribution of the data set, we displayed the distances measured in a normal Q-Q plot (Skewness 0.16, Kurtosis 0.25, p = 0.2331) (Fig. 6).

DISCUSSION

Limb length discrepancy is a commonly associated problem following THA. Limb lengthening of 16 mm was reported in a series of 144 patents (*14*). Twenty seven percent of patients in this series were symptomatic and were treated with a shoe raise on the contralateral side. In a subsequent series of 391 patients, 3% of patients had limb lengthening of more than 10 mm (*15*).

In a series of 90 patients undergoing primary total hip arthroplasty, 62% of limbs were lengthened by an average of 9 mm and this was symptomatic in 43% of patients after three months and 33% after 12 months (*9*). A further study of 68 patients having undergone total hip arthroplasty attempted to determine the clinical consequences (patient satisfaction, shoe lift use, gait abnormalities, etc) of leg-length inequality (*4*). The average inequality in this series was 9.7 mm, with 32% of patients being symptomatic. More than half of these patients were disturbed by this limb length discrepancy.

Increasing patient expectations following total hip arthroplasty have lead to limb length discrepancy being the leading source of patient dissatisfaction especially in the younger age group. It is associated with biomechanical problems such as gait disturbances, in addition to sciatic and peroneal nerve palsies and persistent pain. Konyes and Bannister had observed that the Oxford hip score following total hip arthroplasty in patients with true leg lengthening was 27% worse at three months and 18% worse at 12 months when compared to

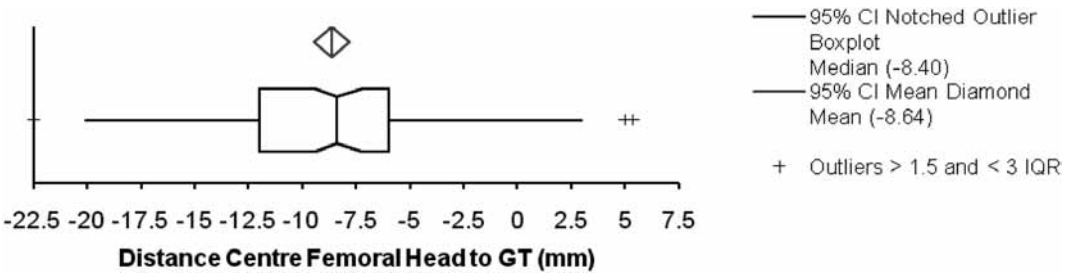

Fig. 4. — The distribution of distances from the centre of the femoral head to the tip of the greater trochanter was demonstrated in a box plot.

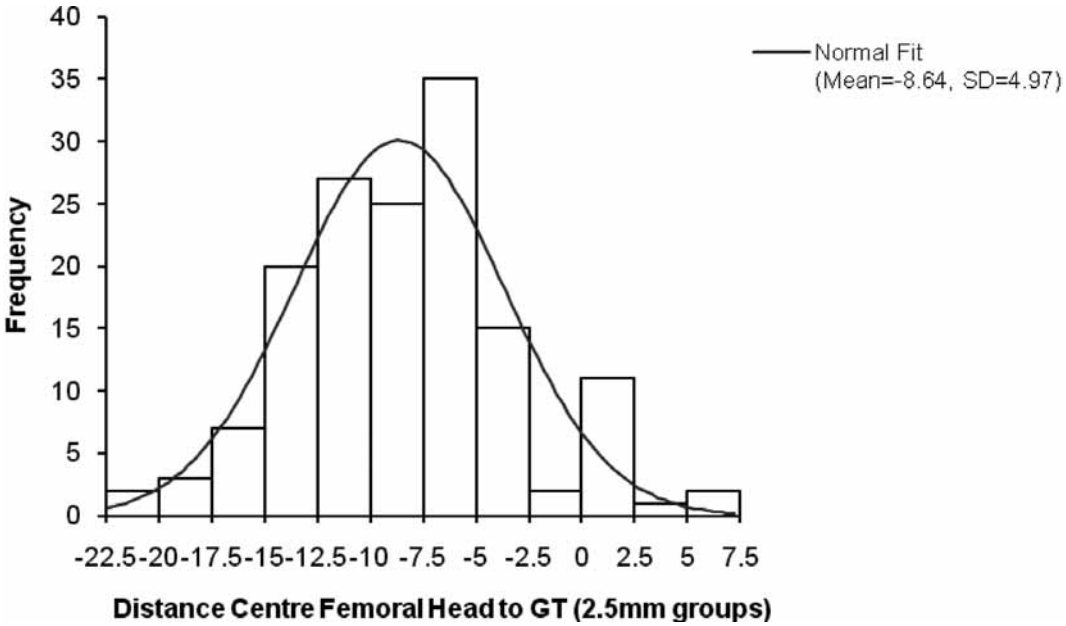

Fig. 5. — The distribution of the distances from the centre of the femoral head to the tip of the greater trochanter grouped into 2.5 mm sections was also determined.

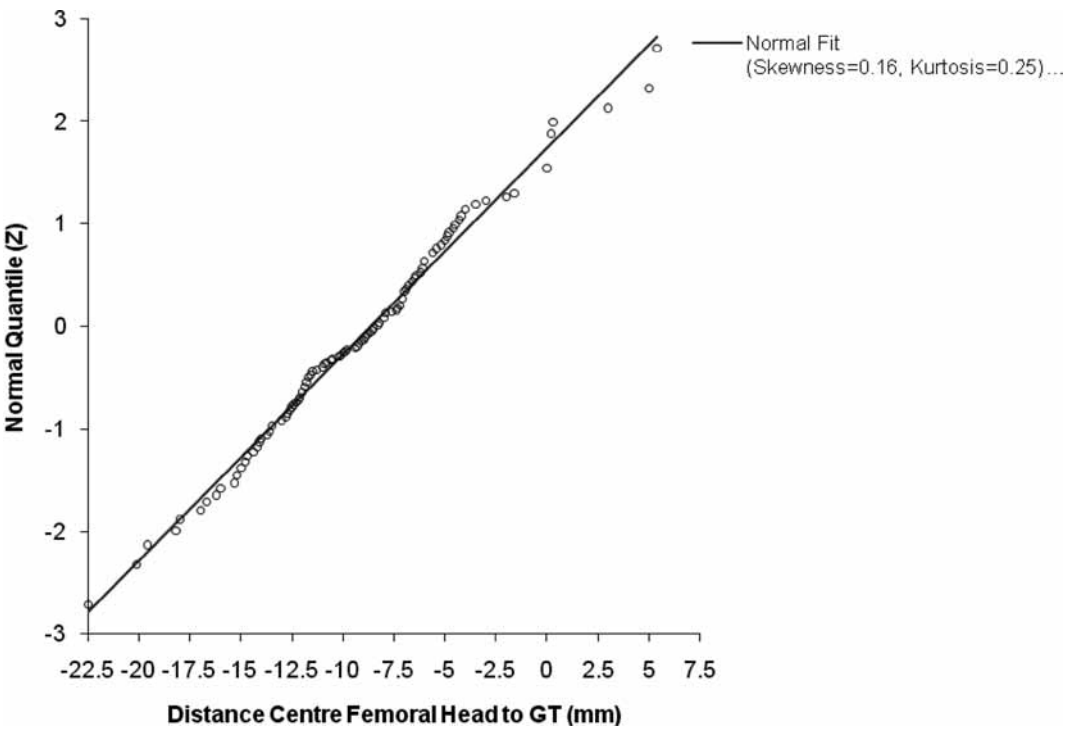

Fig. 6. — In order to assess a normal distribution of the data set, we displayed the distances measured in a normal Q-Q plot (Skewness 0.16, Kurtosis 0.25, p = 0.2331).

patients with no leg length discrepancy (*9*). A study of 23 patients with peroneal and sciatic nerve palsies, demonstrated that an average limb lengthening of 2.7 cm was associated with a peroneal nerve injury while 4.4 cm lengthening was associated with a sciatic nerve injury (*5*).

Several methods of direct and indirect measuring of limb length have been described. One method described by Charnley is to measure the limb length by palpating the medial malleoli, which is otherwise commonly known as 'shuck' test of the operated leg (*3*). Another commonly employed direct method is to measure the distance between two reference points from the ilium to the femur using calipers and rulers. Various factors that influence the measurements with calipers and rulers are femoral offset and version of the femoral component. A study analyzing 34 cadaveric femora showed that the diameter of the femoral head was equal to the distance from the tip of the lesser trochanter to the centre of the femoral head. More recently the computer assisted navigation system has been used to identify the femoral anatomy intraoperatively and hence determine the correct leg length (*11*).

Leg length following THA is also affected by the preparation of the acetabulum. If the acatabulum is over reamed, then the centre of the hip is shifted proximally whereas if reinforcement rings are used as in revision surgery, then the centre of the hip may be displaced distally. The issue of over reaming then may be addressed by increasing the neck shaft angle, offset or the neck length.

While the author notes that the actual post op limb length is dependent on various factors, including acetabular component positioning, femoral offset, neck shaft angle and femoral component varus/valgus positioning, our study would suggest that if the distance from the tip of the GT to the centre of the femoral head is the only point referenced during THA, then it may result in the limb lengthening of 8.6 mm.

Previous studies analysing plain radiographs have demonstrated similar results (*1,13*). The limitations of these studies have been the use of the plain AP radiographs. We are aware that even a slight change in the projection of the Xray beam can alter the measurements significantly. We addressed this issue in our study by using the computed tomography images. The measurements were done in three dimensions of axial, coronal and sagittal plane.

Based on our study we would suggest caution in using the tip of the greater trochanter as a reference point during THA. Whilst it may be a good anatomical landmark due to its easy palpability and access, its use as a sole point of reference may result in inadvertent lengthening of the operated leg. Our study highlights that the tip of the greater trochanter lies proximal to the centre of the femoral head in a vast majority of the population and thus its use as a reference point in THA may be associated with inadvertent leg length discrepancy.

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