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ORIGINAL STUDY

Achieving the required medial offset and limb length in total hip arthroplasty

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The magnitude of the medial offset and limb length discrepancy after a total hip arthroplasty (THA) significantly affects the biomechanics of the hip. If both of these components are not properly restored, the rate of dislocation may increase. In addition limb length inequality can be a cause for legal problems. We have used a method of intraoperative assessment to restore both the length and the medial offset, and assessed this by comparing the medial offset and leg length in the pre- and post-operative radiographs in 39 consecutive THAs. The median medial offset was 93.9% (range : 85 to 100) preoperatively and 94.2% (range : 85 to 110) postoperatively, compared with the unaffected contralateral side. The median limb length discrepancy was improved from a preoperative –4.84 mm (range : 0 to –30) to a postoperative –0.06 mm (range : -9 to +16). In conclusion, this technique is a simple, accurate and reliable way of restoring the medial femoral offset and correcting the limb length inequality.

Keywords : femoral offset ; limb length inequality ; total hip arthroplasty.

INTRODUCTION

Restoration of anatomic geometry of the hip is critical for the overall success in primary total hip arthroplasty (THA). The main parameters that are important to be considered are the restoration of medial femoral offset and the limb length. Their inappropriate correction may result in significant alteration of the biomechanics of the hip leading to dislocation, abnormal joint reaction forces with increased polyethylene wear, early aseptic loosening, nerve stretching and decreased range of motion. Furthermore, limb length inequality (LLI) may lead to serious legal issues (*2*).

There are several methods described in the literature to correct LLI, with only a few addressing the issue of restoring the medial femoral offset (*1,4,5,11*). Most authors utilise preoperative templating to achieve the correct medial offset preoperatively (*9*). However, this method has pitfalls, in that intraoperatively, even a minor malpositioning of the femoral implant within the femoral canal in any plane can result in an alteration of the true medial femoral offset.

Many authors have utilised fixed points on the pelvis and the femur to achieve correction or restoration of limb length (*1,3-5,7*). However it has been shown that utilising such points may lead to

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significant errors in limb length with small errors in repositioning of the femur in abduction, flexion and rotation (*7,8*). This problem may be overcome by choosing a point close to the centre of the hip joint like the infracotyloid groove as described by Ranawat *et al* (*7*).

We describe a new technique to accurately restore the medial femoral offset and correct LLI by selecting the points of reference within the femur so as to negate the variations in measurements with different limb positions during surgery. To evaluate the efficacy and accuracy of this method we performed a prospective study and compared the preoperative and postoperative radiographs to assess the restoration of medial femoral offset and correction of LLI.

Fig. 1. — Measurement of medial offset and limb length inequality in preoperative radiographs.

Fig. 2. — Intraoperative measurement of medial offset before performing the neck cut using the prominent tubercle just below the greater trochanter and the center of rotation of the femoral head. In this case it measures 47 mm.

MATERIAL AND METHODS

Thirty-nine primary THAs in 37 patients were prospectively evaluated in this study. The diagnosis was primary osteoarthritis in all the cases. Preoperatively the patients had radiographs of the pelvis with both hips. The medial femoral offset was measured from the centre of the femoral head to a line through the axis of the femoral shaft. To avoid the magnification error while comparing radiographs, the medial femoral offset of the other side was also measured. The value of the affected side was then expressed as a percentage (medial offset on affected side $\times$ 100/offset on contralateral side).

The LLI was measured utilising the technique described by Ranawat *et al* (*7*). The difference in the perpendicular distance between the most prominent part of the lesser trochanter to the trans-teardrop line on both sides indicated the preoperative LLI (fig 1). This measurement was made on a 10% magnified radiograph. Preoperatively all the patients had no other pathology involving the same limb to account for LLI. All the preoperative radiographs were templated specifically for the implants used, to provisionally determine the level of the neck cut and the size and position of the prosthesis to be used.

During surgery, all the patients were positioned laterally on the operating table, a posterior approach was used to expose the hip and the hip was dislocated posteriorly. To measure the offset, the prominent tubercle just below the tip of the greater trochanter was used as one reference point (fig 2) and the centre of rotation of the femoral head was used as the second reference point. The distance between these two points was noted as the medial femoral offset. A ruler was then taken from the level of the lesser trochanter perpendicular to the axis of the femoral shaft proximally up to the proximal tubercle in the greater trochanter, then the vertical distance between the ruler and the centre of rotation of the femoral head was measured (using another ruler) and noted as positive or negative depending on whether the centre of the head lies above or below the level of the ruler as in valgus or varus neck respectively.

Fig. 3. — Intraoperative restoration of the medial offset to 47 mm and leg length, and confirming by measuring as preoperatively.

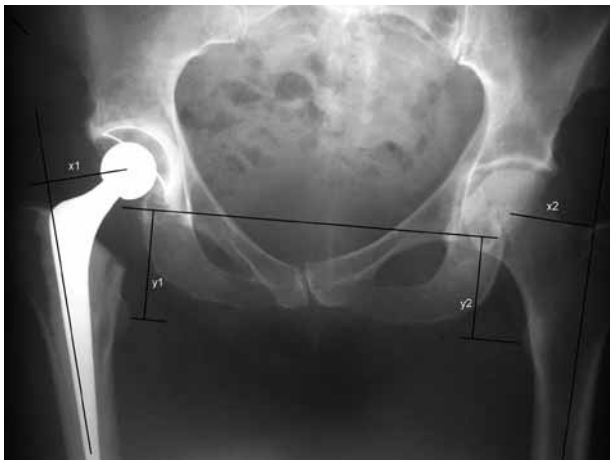

Fig. 4. — Postoperative radiographs showing the measurements (medial offset and LLI).

The neck cut was performed as determined preoperatively. The cup was aimed to be placed in its correct anatomic location in the acetabulum in all the cases. After initial femoral canal preparation, the trial femoral components were placed and the measurements repeated. The femoral components were altered in such a way as to simultaneously achieve restoration of medial offset (from the prominent tubercle on the greater trochanter) and the required limb length. This was achieved by altering the size of the femoral head or choosing a different neck length/offset or both (fig 3). The stability of the reduction along with the soft tissue tension was then assessed. The femoral component positioning was then marked on the proximal femur both in relation to the varus/valgus angulation as well as the version in respect to the femoral canal with the help of an electrocautery. The trial components were removed and the appropriate femoral prosthesis seated with correct inclination in the femoral canal utilising the marks.

The measurements were repeated to confirm the correct positioning of the final prosthesis. The surgery was then completed as per routine after assessing the stability of the reduction.

The postoperative radiograph of the pelvis with both hips was taken (10% magnification) within the first three days of the surgery and the medial femoral offset and the limb length measurements were done as for the preoperative radiographs (fig 4). The actual size of the femoral head prosthesis was used to ascertain the exact amount of magnification to calculate the LLI.

The statistical analysis for comparison was performed using SPSS software version 11.5 for Windows. The correlation between individual values was performed using Pearson's correlation coefficient.

RESULTS

There were 20 men and 17 women with an average age of 66.7 years (range : 54 to 78). Twenty-one hips were on the right and 18 on the left side. Preoperatively the median medial offset on the affected side was 93.9% (range : 85 to 100) of that on the opposite side. Thirty-six cases had short limbs preoperatively and two cases did not demonstrate LLI. The median LLI preoperatively was -4.84 mm (range : +3 to -30).

Postoperatively the median medial offset was 94.2% (range : 85 to 110) on the operated side as compared to the opposite side. The correlation between the individual values was significant ($r = 0.59$, $p = 0.002$). After the THR 14 limbs were short, 8 limbs were equal and 17 limbs were long. The median LLI postoperatively was –0.06 mm (range : -9 to +16) ; none of the limbs were shorter than they were preoperatively. The range of LLI was –4 mm to +6 mm in 35 cases with four outliers, viz, -9 mm, +7 mm, +9 mm and +16 mm. The corrected median LLI postoperatively was

-0.045 mm (range : -7.3 to +12.8). Only in one case was the difference more than 10 mm.

DISCUSSION

Several authors have described various methods to obtain correction of LLI (*1,3-5,7,11*) and restore medial offset (*6*) with a view to restore the normal geometry of the hip. However most articles involve various methods aimed only at achieving correction of LLI.

Preoperative templating may be a way of restoring the required medial offset and correcting the LLI. However, component malpositioning in any one plane during surgery may significantly alter the results achieved postoperatively. Hence, placement of the femoral stem in the canal in the varus-valgus plane along with controlling the version of the prosthesis and simultaneously achieving the required medial femoral offset and limb length becomes more challenging in each case.

Many authors chose fixed reference points on the pelvis and the operated limb to achieve correction of the parameters. Bose (*1*) used a carpenter's level to achieve correct limb positioning before hip dislocation and after trial reduction to achieve correction. Eighty-four percent of patients who had the device used intraoperatively had limb length discrepancy < 6 mm as compared to 30% in the group in which the device was not used.

Woolson *et al* (*11*) used preoperative templating, an arithmetic formula and a caliper for intraoperative correction. Eighty-six percent of patients in their series had a discrepancy of less than 6 mm. Here they attributed their results to measuring from the top of the head instead of the lesser trochanter, as they argue that it is better visualised intraoperatively. Jasty *et al* (*4*) have used a limb length measuring caliper in association with preoperative templating and found that 16% of the patients had post operative LLI ; of these, 13% were lengthened 5 to 10 mm. McGee and Scott (*5*) have used a bent guide wire to achieve equal limb lengths though no data is available for comparison.

However, these techniques have not produced reliable and reproducible results (*4,7,10*), as they rely on accurate repositioning of the operated limb in abduction, flexion and rotation. Sarin *et al* (*8*) described the importance of accurate limb positioning for intraoperative assessment of limb length inequality. Using a calibrated test bench they found that 5° of abduction/adduction malpositioning of femoral position caused 8 mm error in leg length measurement and 10° of abduction/adduction malpositioning resulted in 14-17 mm error. The rotational malalignment between pelvis and femur accentuates the effects of this, as the measurements are made away from the rotational centre of the joint.

Ranawat *et al* (*7*) used a pin in the infracotyloid groove posteriorly to measure limb length inequality ; 87% of their patients had postoperative LLI of ≤ 6 mm. They argue that placement of the pin close to the centre of rotation of the head reduces errors in measurement of distances intraoperatively.

Our technique describes fixed reference points only on the femur and this logically neutralises the effect of positioning errors between the femur and the pelvis while measuring the different parameters. Further, this technique is simple to use and easily reproducible, demanding no extra technique or operative procedures. In our series, 35 out of 39 cases (89.7%) had LLI of less than 6 mm. Furthermore it also reproduced the medial offset effectively. Only in one case was the LLI more than a centimetre. The prominent tubercle is a standard anatomical point present just below the tip of the greater trochanter posteriorly in all the cases.

This technique reliably reproduces the medial femoral offset and the leg length simultaneously. In addition, this technique allows to change the offset and limb length as required for each case, and does not depend on the positioning of the limb. Appropriate component selection is thus facilitated and additionally requires only positioning of the prosthesis in the same manner as the trial implants. This positioning is facilitated by intra-operative marking of the proximal femur in relation to a known point on the trial implant in both varus-valgus plane and to maintain the version of the prosthesis.

To the best of our knowledge this is the first study evaluating the results of a technique that

intraoperatively reproduces the medial femoral offset and corrects LLI simultaneously. In conclusion, the technique described has achieved the required medial offset and limb length in THA reliably and effectively with little variations. The errors encountered by other techniques have been logically negated in our technique. Further this technique does not require a learning curve.

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