FUNCTIONAL AND RADIOLOGICAL ASSESSMENT OF COMPONENT POSITION IN TOTAL HIP ARTHROPLASTY USING 2D COMPUTED TOMOGRAPHY

Abstract:
Intertrochanteric fracture is one of the most common fractures of the hip especially in the elderly with osteoporotic bones, usually due to low-energy trauma like simple falls. Dynamic Hip Screw (DHS) is still considered the gold standard for treating intertrochanteric fractures by many. Not many studies compare the DHS with Proximal femoral nail (PFN), in type 1 and Type 2 intertrochanteric fractures (Boyd and Griffin classification). This study was done to compare the functional and radiological outcome of PFN with DHS in treatment of type 1 and Type 2 intertrochanteric fractures.

Keywords: Component Position, Total Hip Arthroplasty, 2 - D Computed Tomography
Introduction

Arthritis of the hip is one of the most disabling disorders of old age and the ultimate answer to it is Total hip arthroplasty, which is the most commonly performed adult reconstructive hip procedure. THA not only requires surgical expertise but also other factors like proper selection of patients, choice of implants and choice of the surgical approach. Proper placement of the components is one of the most important factors in determining the outcome and longevity after surgery. Improper placement of the acetabular component may lead to many complications such as increased dislocation rates, altered hip biomechanics, component impingement, bearing surface wear and tear, pelvic osteolysis requiring revisions in the long term. Computer Assisted Surgery (CAS) may provide real time information on component position but it is expensive and also has a relatively steep learning curve. This is a retrospective analysis in the patients who underwent THA in our hospital without CAS - their functional outcome was evaluated to correlate it with the radiological assessment of component positioning using 2D(two dimensional) computed tomographic scans and radiographs.

Materials And Methods

It is a retrospective study done at Government Mohan Kumaramangalam Medical College Hospital between July 2013 and July 2015. Twenty patients who had underwent total hip arthroplasties in our hospital and who were on regular follow up were selected. A proper written informed consent was obtained from all the patients. All the patients were clinically examined and functionally graded according to the Modified Harris Hip Score. All the patients had a minimum follow up of one year. A plain radiograph of the pelvis with both the hip joints was taken with the patient lying supine. Necessary precautions were taken while positioning the patient. The patient was then subjected to a two-dimensional computed tomography of the pelvis starting from the anterior superior iliac spines (ASIS) to the femoral condyles.

The results were then tabulated. The acetabular cup abduction was measured on the plain radiographs by the angle formed between the line joining the inferior and superior margins of the cup and the line joining both the tear drops or the line joining both the lesser trochanter. The acetabular anteversion was measured on the 2D CT by the angle formed between the line joining both the lateral anterior and posterior margins of the acetabular cup and the sagittal plane defined as the perpendicular drawn to the line connecting both the posterior superior iliac spines or any identical points on either side of the pelvis.

The femoral anteversion was measured on the CT by the angle formed between the line connecting the centre of the prosthetic head and the neck and the posterior femoral condylar line. The combined anteversion was then calculated from the individual values of the acetabular anteversion and the femoral anteversion. Patients with bilateral hip arthroplasties, with associated lumbar spine disease and those with associated fixed flexion deformities of the ipsilateral knee and of the contralateral hip were excluded from study. The acetabular cup abduction angles were measured using the TOSHIBA FDP digital roentgenograms. The patients were then subjected to two-dimensional computed tomography with the four slice and one hundred and twenty-eight slice CT. The acetabular anteversion, the femoral stem anteversion and the combined anteversion were then measured using ALEXION software model TSX-033A, software volume(2D260-105EN*B). The results were then tabulated and analysed.

Observations And Results

We included twenty patients in our study who underwent Total Hip Arthroplasties in our hospital and who were on regular follow up. The acetabular cup abduction was measured on the plain roentgenogram of the pelvis and the values of the acetabular anteversion and the femoral component anteversion and hence the combined anteversion that were measured on the two dimensional...
computed tomography were tabulated and the results analysed.

### Table 1: Age Distribution Of THA

<table>
<thead>
<tr>
<th>Age in years</th>
<th>No. of patients</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30-50</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td>51-70</td>
<td>9</td>
<td>45</td>
</tr>
<tr>
<td>71-90</td>
<td>1</td>
<td>05</td>
</tr>
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</table>

**Graph 1: Age Distribution of THA**

### Table 2: Gender Distribution Of THA

<table>
<thead>
<tr>
<th>Gender</th>
<th>No. of patients</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>11</td>
<td>55</td>
</tr>
<tr>
<td>Female</td>
<td>09</td>
<td>45</td>
</tr>
<tr>
<td>Total</td>
<td>20</td>
<td>100</td>
</tr>
</tbody>
</table>

**Graph 2: Gender Distribution of THA**

### Table 3: Laterality Of The Side Operated

<table>
<thead>
<tr>
<th>Side involved</th>
<th>No. of patients</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right</td>
<td>13</td>
<td>65</td>
</tr>
<tr>
<td>Left</td>
<td>07</td>
<td>35</td>
</tr>
<tr>
<td>Total</td>
<td>20</td>
<td>100</td>
</tr>
</tbody>
</table>

**Graph 3: Laterality Of The Side Operated**

### Table 4: Cemented THA VS Uncemented THA

<table>
<thead>
<tr>
<th>Cementation</th>
<th>No. of patients</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cemented</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>Uncemented</td>
<td>16</td>
<td>80</td>
</tr>
<tr>
<td>Total</td>
<td>20</td>
<td>100</td>
</tr>
</tbody>
</table>

**Graph 4: Cemented THA VS Uncemented THA**

### Table 5: Approaches Used In THA

<table>
<thead>
<tr>
<th>Approach</th>
<th>No. of patients</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lateral</td>
<td>06</td>
<td>30</td>
</tr>
<tr>
<td>Posterior</td>
<td>14</td>
<td>70</td>
</tr>
<tr>
<td>Total</td>
<td>20</td>
<td>100</td>
</tr>
</tbody>
</table>

**Graph 5: Approaches Used In THA**

THA was performed on all these patients for various causes, among which, arthritis due various causes was the commonest, followed by non union neck of femur fracture and osteonecrosis of hip. One of our patients had a protrusio acetabuli following a hemiarthroplasty of the hip for whom a total hip arthroplasty was performed.

Acetabular cup anteversion of more than 25° was noticed in 6 patients post operatively, among which 4 patients were operated by posterior approach and 2 by lateral approach.

Femoral component anteversion of less than 15° was seen in 13 of the patients, among which 9 cases had posterior approach and 4 cases had lateral approach.

Combined anteversion of less than 25° was observed in 4 patients and more than 50° was seen in 2 patients. Among these 6 cases, 4 had posterior approach and 2 had lateral approach.

X ray evaluation of cup abduction was done and 3 patients were found to have a degree of abduction less than 30° and 2 patients had a degree of abduction more than 50°. Among the 5 patients, 4 underwent posterior approach and 1 underwent lateral approach.

**Graph 6: Radiological evaluation of component position**

- Post operatively, 5 cases showed features of lengthening, among which were performed by posterior approach and one was performed by lateral approach. The lengthening was 1cm in 2 cases, 1.5 cms in 1 case and 2 cms in 2 cases.
- Three cases showed shortening among which 2 were posterior THA and one was lateral THA. The level of shortening was 2cms in 2 patients and 4cms in 1 patient and it was managed by using a heel raise in these patient’s foot wear.
- Fixed Flexion deformity of 10° was seen in 3 patients who underwent posterior approach THA.
The final outcome of the patient was assessed by Modified Harris Hip Score (functional hip score). Among the 20 patients, 5 had poor outcome, 3 had a fair outcome, 5 had a good outcome and 7 patients had an excellent outcome.

- Among the 7 patients with excellent outcome, 6 underwent posterior THA and one had a lateral approach.
- Among the 5 patients with good outcome, 4 underwent posterior THA and one lateral THA.
- Two among the 3 cases with fair outcome, two underwent posterior THA and one underwent lateral THA.
- Out of the 5 cases which had poor outcome, 3 were operated by lateral approach and two were operated by posterior approach.

Among the 5 patients with poor outcome, two patients showed shortening ≥2 cm, 2 patients showed lengthening, 3 patients were outliers in cup abduction and 3 patients were outliers in combined anteversion.

- Out of the 3 patients who showed fair outcome, one patient had lengthening of 2 cm, one patient showed decreased femoral component anteversion and one patient showed increased acetabular cup anteversion.
- A total of 5 patients showed good outcome, of which one patient showed shortening along with fixed flexion deformity and decreased degree of combined anteversion. All patients showed femoral component anteversion of less than 15°.
- Among the 7 patients with excellent outcome, one patient had fixed flexion deformity and one patient had abnormal degrees of cup abduction.

Among the 14 patients with normal degrees of acetabular cup anteversion, 6 patients showed excellent outcome, 4 patients showed good outcome, 2 had a fair outcome and only 2 patients had poor outcome.

- Out of the seven patients who had normal degree of femoral component anteversion, 3 patients showed an excellent outcome. 2 patients had fair outcome and only 2 patients had poor outcome.
- Among the 14 patients who had normal degrees of combined anteversion, 5 of them displayed excellent outcome. 4 patients had good outcome, 3 had fair outcome and only 2 patients had poor outcome.
- Out of the 20 patients operated, 15 patients X-rays showed normal degrees of acetabular cup abduction. Among these 15 patients, 6 of them showed an excellent outcome, 4 showed a good outcome, 3 showed fair outcome and only 2 patients showed poor outcome.
10 were operated by posterior approach and 4 by lateral approach.

- Among the 15 patients X-rays which showed normal degrees of cup abduction, 10 patients underwent THA by posterior approach and only 5 by lateral approach.

Graph 11: Radiological Outcome Vs Approach

Discussion

Component positioning plays a major role in Total Hip Arthroplasty (THA) and any discrepancy in placing the components in the right position may lead to many unwanted adverse effects such as early wear and tear, dislocations and impingements, thereby untowardly affect the outcome of the patient.

A study conducted by Takaaki Jujishin when grasping the holder of the acetabular component for right THA, the surgeon stretched across the patient to achieve the appropriate anteversion and that this posture could disturb the sense of orientation in right THA.

Six of our patients had an acetabular anteversion that did not confine to the normal range and three of them were right THA and three of them left THA and we did not find any significant difference with laterality and acetabular cup anteversion.

A study by Vikas Bachhal and Masoodh Basha et al postulated that CT was the gold standard for measuring the acetabular anteversion as it may be difficult to measure the acetabular anteversion with plain radiographs.

The study by Vikas Bachhal et al\textsuperscript{14} proposed a new method of measuring acetabular cup anteversion on simulated radiographs and using goniometer to measure it.

In our study we measured acetabular anteversion on 2D CT and with simple software- Alexion which was found to be more easier and less time consuming and less cumbersome.

A study by Y. K. Lee et al\textsuperscript{15}, analysed the femoral stem measuring using the modified Budin method by comparing the femoral component anteversion on plain radiograph and the CT and concluded that CT and plain radiographic measurements did not have any significant difference.

The radiographic method was very cumbersome by making the patient to sit with knees flexed to 90 degree and hip abducted to 30 degree and radiograph taken. This had many shortcomings with obese patients, patients with stiff knee, etc and hence in our study we used CT as the standard method for measuring femoral component anteversion.

In a study by Jeya Palan\textsuperscript{16}, the advantages and disadvantages have been well documented and the choice of the approach is largely dependent on the surgeon.

We had no difference in dislocation rates, although the posterior approach performed better functionally.\textsuperscript{23}

A study by Thomas Kalteis et al\textsuperscript{22} and Douglas M. Hansan et al\textsuperscript{20} stated that inclination of the acetabulum can be easily read from radiographs wherein the calculation of anteversion is troublesome and has technical difficulties and CT based method is fast and accurate for measuring abduction and retroversion of the cup and thus CT based methods are the method of choice.

Hence for our study, we used CT based measurement for acetabular component version.\textsuperscript{24}

A study by Eric. A. Bogner and Bernard Ghelmann\textsuperscript{18} concluded that CT had advantage over plain radiograph in determining component alignment due to its tomographic nature and its ability to visualise structures about a prosthesis in multiple orthogonal planes.

A study by L. Fabeck et al\textsuperscript{21} used two radiographs to measure the acetabular cup anteversion and measuring angles with a goniometer but intra observer variability may be a confounding factor with this method and it is very cumbersome.

For our study, only the acetabular cup abduction was measured on the plain radiograph and anteversions of both femoral stem and acetabular cup were measured on 2D CT.

A study by J. H. Nho\textsuperscript{19} stated that anteversion and retroversion cannot be examined on AP radiographs and CT is preferred over radiograph for measuring the same.

Acetabular Cup Abduction

In our study there was only one patient who had an acetabular cup abduction of 63.75° (normal 30° to 50°) and this patient also had a poor functional outcome clinically based on the Modified Harris Hip Score(score-67.7). This patient had a Total Hip Arthroplasty through the lateral approach.

Acetabular Cup Anteversion

Six of our patients had an acetabular cup anteversion of >25° (normal 5° to 25°) and among whom four of them had undergone Total Hip Arthroplasties through the posterior
approach and two of them through the lateral approach. The more number of outliers in the posterior approach could be attributed to the surgical difficulties faced due to inadequate exposure of the acetabulum in the posterior approach and thereby difficulty in the orientation for placement of the acetabular cup. Patients operated through the posterior approach (Modified Harris Hip Score-89.45) did functionally better and had a good outcome when compared to the patients operated through the lateral approach (Modified Harris Hip Score-44.5) as suggested by the Modified Harris Hip Score.

Among the 14 patients with normal degrees of acetabular cup anteversion, 2 patients had a poor outcome which could be explained by the following factors, one patient had heterotopic ossification (Brooker type IV, ankylosis) and in the other case even though the acetabular cup anteversion was within the normal limit, the combined anteversion and the cup abduction were on the higher end.

Among the six patients with abnormal degrees of cup anteversion, three patients had a poor outcome and the remaining three patients each had a fair, good and excellent outcome. The better results could be explained by the fact that even though there was an abnormal degree of acetabular cup anteversion, these patients did better because the combined anteversion of these patients was within the normal limit.

**Combined Anteversion**

The normal range for the combined anteversion is between $25^\circ$ to $50^\circ$. Four of our patients had a combined anteversion below $25^\circ$ and among whom three were operated by the posterior approach and one patient by the lateral approach. The patients who underwent Total Hip Arthroplasties through the posterior approach (Modified Harris Hip Score) (93.66) had a clinically and functionally better outcome whereas the patient operated through the lateral approach had a poor outcome (Modified Harris Hip Score 67.7) as suggested by the Modified Harris Hip Score.

Two of our patients had a combined anteversion of more than $50^\circ$, and one each was operated by the lateral and the posterior approaches. Both the patients had a poor functional outcome as suggested by the Modified Harris Hip Score.

In a study conducted by Jeya Palan et al, found no differences in the complication rates between the two approaches to the hip- the lateral and the posterior. They reported no clinical difference between the two groups.

In our study we see that the patients operated through the posterior approach did functionally better as compared to the patients operated through the lateral approach, this could be attributed to the increased trochanteric pain and increased gait abnormalities in the lateral approach group. There were no difference in the complication rates between both the groups and this very well correlated to the study results by Jeya Palan et al.

Contrary to the traditional Orthopaedic teaching associating the posterior approach with an increased risk of dislocation, we found no difference in the dislocation rates between the two groups.

This very well coincided with the study conducted by Hedlundh et al and the meta analysis by Jolles and Bogoch et al who also reported that the dislocation rates were not influenced by the surgical approach. They also stated that the dislocation rates could be related to the size of the femoral head than the type of surgical approach.

Jeya Palan et al concluded that the posterior approach group, though initially had a better outcome in terms of pain and function, in the long term, there was no difference between the two groups in terms of dislocation and revision rates at 5 years and that the success of primary Total Hip Arthroplasty is independent of the surgical approach and this very well correlated to our study.

In a retrospective CT - controlled study, Saxler et al showed that only 27 out of 150 cups (26%) were placed within the safe zone of Lewinnek and another study by DiGioa et al by CAS only 22% of the cups were within the safe zone.

In our study out of 20 cups, only 6 cups were outliers, whereas 14 cups (70%) of the cups were within the safe zone dictated by Lewinnek.

On the other hand, Lewinnek et al also reported a higher incidence of anterior dislocations in THA more than $25^\circ$ of acetabular component anteversion but in our study we did not have any such complications.

However, the risk factors that predispose to dislocation are multivariate and include patient-related, operative and implant design variable. In addition surgical approach and endogenous factors such as morbidity and muscular status may contribute to the fate of the hip joint.

**Conclusion**

Computed tomography (CT) is the imaging modality of choice for measuring anteversion of the components after Total Hip Arthroplasty as it gives accurate measurement of the anteversion of the components.
Component positioning adversely affects the outcome of the patients after THA.

Combined anteversion as an individual factor is the most important parameter in determining the outcome of patients after THA.

Approach may have an effect on the version and thereby the outcome of the patient.

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