Original article

Difference in trochanteric thickness between well-aligned and malaligned polished collarless stem

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ABSTRACT

Background: Surgical techniques and instruments are continuously evolving to improve placement of components in ideal position. We investigated if there is difference in greater trochanter thickness between the stems in satisfactory position and stems in malposition and to assess the ideal thickness of trochanter for femoral stem placement in neutral position as under reaming of trochanter can result in stem malposition.

Methods: Measurement of greater trochanteric thickness in 95 hip replacements (posterior approach) was performed by a junior doctor and two hip fellows using the trauma CAD/PACS software. The stem was considered neutral if the central axis of femur passes through the distal tip of stem in AP and in varus if the tip of stem was lateral to the femoral shaft axis.

Results: 79 patients had stem in satisfactory position and 16 patients in varus malposition. Mean trochanteric thickness was 12.6 mm (+/−0.56 mm 95%CI, Median 12.5 mm, SD 2.5 mm) in neutral stems while mean thickness in the varus stem was 18.4 mm (+/−1.01 mm 95%CI, Median 17.8 mm, SD 2 mm). There was statistical significant difference between both groups with $p < 0.0001$ with intra-observer correlation at 99% between the senior personal while correlation was at 80% between the senior personnel and junior doctor. No statistically significant difference was noted in measurements between the senior personal.

Conclusions: The study confirms the significant difference in greater trochanteric thickness between the well aligned and misaligned femoral components. The study raises the possibility that trochanteric thickness can be used as an accessory surgical aid to check if sufficient broaching has been done laterally to allow the stem to be seated in neutral position with an ideal remnant thickness of 12.5 mm. A surgical instrument can be developed to measure the intraoperative thickness of the trochanter which can be a useful tool for young hip surgeons for better placement of components.

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1. Introduction

Annually around 7–8% increase has been noted in the number of hip replacements being performed as per the ¹ NJR England report 2015. Surgeon related factors which include component malpositioning can be devastating in terms of outcome. All surgeons have a learning curve during the early training phase. Intraoperative tips and techniques have been developed and published in various literatures and journals and multiple instruments have been developed in aiding the surgeon to place the components in ideal position to improve the clinical outcome.

Femoral component malpositioning can have adverse clinical outcome. Varus malpositioning is most commonly caused by non

ideal entry point for the femoral stem. Though senior consultants and surgeons of many years of experience are able to identify the ideal entry point for the femoral broaches and the stem, it is difficult for young surgeons in their early years to identify the anatomical variations and ideal entry point. Satisfactory entry point of the femoral component has to be as lateral as possible in the coronal plane and posteriorly in the sagittal plane to negotiate the femoral anterior bowing which results in the stem in the centre of the femur without abutting or breaching the lateral or posterior cortex. ^{2,3} Anterior entry point might have adverse effect of breaching the posterior cortex with catastrophic outcome of intraoperative periprosthetic fracture. With increasing number of hip replacements annually, risk of periprosthetic fracture has increased with a ³ report of 3% associated with uncemented stem and 0.23% with cemented stem and an overall incidence of 1.7%. ² The risk of intraoperative fracture is higher with direct anterior approach in patients with higher BMI and in females. Medial entry

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point can cause the stem to be placed in a varus position. Varus malposition can have non-ideal outcome due to abnormal force distribution in weight bearing and joint mechanics. The varus position can cause significant stress at the tip of the stem against the lateral cortex of the femur and if the stem is in significant varus can cause breach in the lateral cortex and can be a cause for ⁴ late insufficiency fracture. Since the stem is in varus, this may also cause abnormal load bearing at the femoral head acetabular articulation surfaces with higher shear forces at the bearing surface resulting in higher wear and may also be a cause of instability.⁵ Femoral stem in varus position though has shown 96% survival at 10 years.^{6–8} Femoral stem malpositioning can also be a cause of hip instability and dislocation.

Modern day training in orthopaedics have been focussing in improving surgical skills with various methods relying on intraoperative anatomical landmarks as well as developing various instruments to aid the surgeon. Though it has been advised to broach the femoral canal as lateral and as posterior as possible, it can be difficult for a training surgeon to ensure if he/she has reached lateral enough to allow the stem to be seated centrally in the femoral canal and to avoid varus malposition of the femoral canal in coronal plane.

Intraoperative anatomical landmarks provide valuable guide for an operating surgeon for multiple reasons. The greater trochanter can be useful anatomical guide as this is visualised during the hip replacement irrespective of the difference in surgical approaches. The greater trochanter is visualised in its entirety during the surgical approach.

We investigated the difference in trochanteric thickness between well aligned and maligned femoral stems. We felt that if there is significant difference, the remnant greater trochanteric thickness following the broaching of the femoral canal can act as a possible accessory guide for satisfactory lateral entry for the femoral component.

2. Materials and methods

The study was performed with objective of whether there is difference in the trochanteric thickness between the stem in ideal or neutral position and stem in varus malposition as well as to identify ideal thickness of trochanter when the femoral stem in ideal position. The study measured the trochanteric thickness from the postoperative radiographs in the patients with femoral stem in non ideal position and when stem is in satisfactory position. The thickness was measured in the postoperative pelvis AP views as this reflects the lateral thickness of the trochanter following the broaching intraoperatively. All patients had cemented collarless polished C-stem femoral components [Depuy, Warsaw, USA] through posterior approach. All patients had at least 1 year follow up.

The varus malposition was defined as when distal tip of the femoral stem and the central axis of the stem are lateral to centre axis of shaft of femur in the AP view of the pelvis. The stem was considered to be in neutral or satisfactory alignment when both the lines were aligned. The trochanteric thickness was measured from the most prominent lateral part of the trochanter to the lateral most point in the corresponding cement mantle in the AP pelvis view. This reflects the remnant lateral trochanteric thickness intraoperatively following broaching of the femoral canal before cementation.

The study was approved by the local research committee. Hip replacements done for primary osteoarthritis in 2014 under single surgeon were identified from NJR providing at least 1 year follow up when the study was commenced. Patients with Hip replacement for primary OA alone were included as authors felt that hip replacements for other indication has a possibility of altered

anatomy which might be a confounding factor for the study. Inclusion criteria for the study were the presence of adequate follow up records with availability of the satisfactory radiographs, hip replacement with collarless, polished tapered C-stem. In 2014, 85 hip replacements were identified to be eligible for the study but 79 patients had neutral alignment of the stem and only 6 were in varus malposition. The groups were considered not matched. From an existing database, further 10 hip replacements during the same period with known varus malalignment were identified fulfilling the eligibility criteria and were included in the study. This allowed matching the groups with approximately 1 varus malpositioned stem for every 5 neutrally aligned stem.

In total, 95 hip replacements were selected for the study. 79 patients had stem in neutral satisfactory alignment and 16 patients had stem in varus malposition. The trochanteric thickness was measured with the trauma CAD software of the centricity PACS system by the first author (Hip fellow 1 or HF1) [Fig. 1].

To reduce the observer related bias and for assessment of the consistency in measurements, the measurements were done by a senior house officer (SHO) with no major previous orthopaedic experience and an orthopaedic surgeon (post CCT) on a hip fellowship (Hip fellow 2 or HF2) before a consultant post. The senior fellow also confirmed the position of the femoral stems in both groups whether they were in varus or neutral position.

The mean average trochanteric thickness, median value, standard deviation, confidence interval, inter observer variability by correlation were calculated with Microsoft Excel 2007 and the two groups were compared by student *t*-test for assessing if significant difference existed between the groups with $p < 0.001$ being considered as significant. The ideal trochanteric thickness corresponding to neutral alignment of the stem was calculated from the median value.

3. Results

The mean trochanteric thickness in the patients with femoral stem in neutral alignment was 12.6 mm (± 0.56 mm at 95% CI, SD 2.57) with median value of 12.5 mm while the mean trochanteric thickness in the patients with femoral stem in varus misalignment was 18.4 mm (± 1.01 mm at 95% CI, SD 2.07) with median value of 17.8 mm [Fig. 2]. Statistical analysis with student *t*-test showed the difference was significant with $p < 0.00001$.

The inter observer variability was measured by measuring correlation between the measurements of the junior trainee and the senior personnel. The correlation between the measurements between the first author (Hip fellow 1 or HF1) and senior fellow

Fig. 1. Figure showing increased trochanteric remnant thickness on the left side when the stem is in varus compared to the right side when the stem is in neutral.

Fig. 2. Graph depicting the median values of the trochanteric thickness in well aligned and malaligned stems as measured by the Senior house officer (SHO), Hip fellows (HF1 & 2). The Y-axis is in millimetres (mm).

(Hip fellow 2 or HF2) was at 99% while the correlation was consistently approximately at 80% between the junior trainee (SHO) and the senior fellows (HF1&2) [Fig. 3]. There was consistently statistically significant difference noted between the groups when measured by all three personnel with $p < 0.00001$. Fig. 4 shows the scatter diagram with linear regression of the data as measured by the senior house officer and the fellows.

The statistical difference is significant in trochanteric thickness between the femoral stem in neutral and varus alignment. The median value of trochanteric thickness with the stem in neutral alignment was $12.5 \text{ mm} \pm 0.56 \text{ mm}$ at 95% CI.

4. Discussion

The study has shown that there is difference in the remnant trochanteric thickness when the femoral stem is in varus or when in neutral position. This is possibly due to under reaming of the trochanter or non ideal entry point of the reamers. Further the study shows the median value of $12.5 \text{ mm} (\pm 0.5 \text{ mm at } 95\% \text{ CI})$ for the remnant trochanteric thickness when the stem is in neutral position as well as a median value of $17.8 \text{ mm} (\pm 1 \text{ mm at } 95\% \text{ CI})$ which can be guidance for the young surgeons when they are able to place the stem in confidence as well as to identify the under reamed trochanter with a potential for stem malposition.

The correlations of the measurements between the senior hip fellows is at 99% when the stem is in neutral and 98.7% when is at misalignment. This suggests that there is consistency in

Fig. 3. Graph depicting the correlation (interobserver variability) between the investigators. A factor of 1 gives the highest correlation of 100% between the investigators.

Fig. 4. Scatter diagram with linear regression of the data as measured by the investigators. The X-axis is the number of patients (n) and the Y-axis is the thickness of the greater trochanter in millimetres (mm).

measurements between the young surgeons and, therefore, the trochanteric thickness measurement is reproducible.

The study can be of help in development of a surgical tool to measure the trochanteric thickness which might be a valuable tool for the young surgeons to guide better placement of the femoral stem avoiding complications and to improve clinical survival. Intraoperatively, measurement of the remnant thickness of the trochanter following broaching can be a crude but valuable guide for better placement of the femoral stem by the young surgeons.

Though the importance of the entry point as lateral and posterior in the neck/trochanter region has been emphasised, there is no study to quantify as far as we are aware of. The study is not without limitations. The study is based on the radiological measurement of the trochanteric thickness in the postoperative radiographs. The study needs to be validated and to assess whether the results are replicable independently by intraoperative measurements or cadaveric or bone saw models. The study is based on the polished collarless stem of a particular brand (C—Stem, Depuy, Warsaw, USA). There are other causes like under sizing the component, inappropriate use of centraliser which might influence misplacement of femoral components when cemented polished collarless stems are used and trochanteric thickness alone cannot act as a sole guide to prevent stem malpositioning. The impact of the femoral stem design (other manufacturers, uncemented stems, collared matt stems) on the trochanteric thickness following broaching is unknown though it can be logically thought of minimal. The study can be of use when uncemented components are used though this needs to be investigated. Further studies on different stems are required to validate the findings. It is also to be noted that the trochanteric thickness may not be of value when altered anatomy of the proximal femur is present.

The authors are aware of the restriction of the studies. The study provides an insight for development of a surgical instrument which can be an accessory tool for the better placement of stems as well as to identify the potency for the varus malposition as intraoperative trochanteric thickness has not been explored as guide for femoral component placement. Further validation studies with a development of surgical instrument can be a valuable accessory guide for the surgeons.

Conflict of interest

The authors have none to declare.

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