

Radiographic Measurement to Restore Femoral Head Center in Hip Arthroplasty

Phonthakorn Panichkul MD*,
Piya Pinsornsak MD*

* Department of Orthopaedic Surgery, Faculty of Medicine, Thammasat University, Pathumthani, Thailand

Objective: The purpose of the present study was to find the anatomical landmarks used as a reference for restoration of the femoral head center in hip arthroplasty patients.

Material and Method: One hundred anterior-posterior digital radiographs of the hip with no magnification were analyzed to measure the correlation between the distance from the center of the femoral head to the most prominent part of lesser trochanter and the femoral head diameter, and the relationship between the level of tip of the greater trochanter and the level of femoral head center.

Results: The authors found the linear correlation between the distance from the femoral head center to the lesser trochanter and the femoral head diameter (Pearson's correlation coefficient = 0.95) with the average ratio of 1.023. The level of tip of the greater trochanter was found 75% higher than the femoral head center, 15% below the femoral head center, and 10% at the same level. The average level of the tip of greater trochanter was 8 mm above the femoral head center.

Conclusion: The distance from the center of the femoral head to the most prominent part of the lesser trochanter is approximately equal to the diameter of the femoral head. The use of the level of the tip of greater trochanter as a reference point for the level of the femoral head center should be carefully evaluated because of the variability of anatomy.

Keywords: Radiographic measurement, Femoral head diameter, Lesser trochanter, Tip of greater trochanter, Hip arthroplasty, Limb length discrepancy

J Med Assoc Thai 2012; 95 (Suppl. 10): S32-S36

Full text. e-Journal: <http://jmat.mat.or.th>

Limb length discrepancy (LLD) is one of the most concern problems observed in patients following hip arthroplasty. Some patients feel uncomfortable with the result, even with a small leg length difference⁽¹⁾. Importantly, this disappointment, despite otherwise satisfactory operation, is a potential reason for litigation^(2,3). Failure to restore limb length has a potential risk of hip instability, dislocation and abnormal gait pattern. The compromised hip biomechanics caused by LLD worsen patients' functional outcomes and long-term clinical results^(1,4).

There were many techniques for minimizing LLD after hip arthroplasty, including preoperative templates, intraoperative measurement devices, intraoperative palpation of bony landmarks with soft tissue tension and computer navigation^(3,5,6). However, these techniques are of limited value when working within the distorted hip anatomy, such as femoral neck fracture.

The present study objective was to find the anatomical landmark that can use as a reference to identify the original location of femoral head center in hip arthroplasty patients. Based on a literature review, the distance from center of the femoral head to lesser trochanter was nearly equal to diameter of the femoral head⁽⁷⁾. This finding would be one of helpful tools for identifying the original location of the femoral head even with distorted hip anatomy in femoral neck fracture. The primary objective of the present study was to find a correlation between the distance from the center of femoral head to the lesser trochanter and the femoral head diameter (FHD) in the preoperative anterior-posterior (AP) radiograph. The secondary objective was to identify the relationship between the levels of the tip of greater trochanter and femoral head center. If the correlations between these landmarks are consistent, they will be one of the helpful tools to identify the original location of the femoral head.

Correspondence to:

Panichkul P, Department of Orthopaedics, Faculty of Medicine, Thammasat University, Pathumthani 12120, Thailand.
Phone: 0-2926-9775, Fax: 0-2926-9793
E-mail: dr.panichkul@gmail.com

Material and Method

A total of 100 AP digital radiographs of the hip with no magnification were analyzed to measure the correlation between the distance from the center of

femoral head to the most prominent part of lesser trochanter and FHD. Additionally, the level of the tip of the greater trochanter was compared with the level of the femoral head center.

Hips with pathologic deformities of the proximal femur, a deformed femoral head (such as by avascular necrosis or slipped capital femoral epiphysis), or inflammatory arthritis were excluded from the present study.

The present study subjects comprised 52 female and 48 male patients with an average age of 67.3 years (range, 45-94 years). The center of femoral head was identified using the perfect circle generated by computer around femoral head. The center of the circle was identified as the center of femoral head. The distance between the center of femoral head and the most prominent part of lesser trochanter was measured. This line was compared to the measured FHD (Fig. 1).

Femoral shaft axis was made by plotting center of the canal in three points level. These points were joined to produce the anatomical axis of femur. The perpendicular line to the anatomical axis was drawn at the level of the tip of greater trochanter to behave as the level of greater trochanter. The vertical distance between this line and the femoral head center was measured (Fig. 2).

Statistical analysis of results was performed using SPSS statistical software system. Pearson's correlations were calculated between the distance from the lesser trochanter to femoral head center and the femoral head diameter.

Results

From the present study, we found the average distance from the center of femoral head to the lesser trochanter was 51.85 ± 4.58 mm (54.69 ± 3.61 mm in male and 49.21 ± 3.75 mm in female). The average FHD was 50.66 ± 4.26 mm (53.39 ± 3.33 mm in male and 48.15 ± 3.39 mm in female). The ratio between the distance from the center of femoral head to the lesser trochanter and the FHD was 1.023 (1.024 in male and 1.022 in female). The correlation coefficient between these two values was 0.95 (Fig. 3).

The level of tip of greater trochanter located from 14 mm above to 5 mm below the level of femoral head center. The average level of tip of greater trochanter was 8 mm higher than femoral head center (8.79 mm higher in male and 7.21 mm higher in female). In 75% of cases, the level of the tip of greater trochanter laid above the femoral head center, 15%, below the femoral head center and only 10%, at the same level.

Discussion

The LLD is one of the most concerns problems in patients after hip arthroplasty operation. This problem caused patient dissatisfaction, mechanical problems, pain and neurological deficit⁽⁸⁾. Several techniques have been advocated to minimize LLD problems after hip arthroplasty, including preoperative and intraoperative measurements.

Preoperative measurement by the templating technique is one of the most popular methods to identify the femoral head center and neck resection level. The intraoperative techniques could be performed by direct leg length comparison of the operative limb with the contralateral limb, distance from the bony landmark at the pelvis to the greater trochanter and the level of the tip of the greater trochanter. However, the clinical success of these techniques is varied and depends on many factors, such as patient positioning, type of anesthesia and muscle relaxation and soft tissue contracture⁽⁸⁾. Some of these techniques cannot be used as a reference in a patient with distorted hip anatomy, such as femoral neck fracture.

The ratio between the distance from the center of femoral head to the lesser trochanter and the FHD is not disturbed by the distorted hip anatomy in the case of fracture neck femur. This measurement was easy to measure both preoperative and intraoperative period. In cadaveric study, the length of FHD is nearly equal to the distance from the center of femoral head to the lesser trochanter⁽⁷⁾. From the radiographic finding of this study we proved that this ratio was linear correlated and consistent (1.023). This ratio could be one of the helpful tools in locating the true position of the femoral head center, and assessing the limb length.

Several orthopedic surgeons believed that the center of the femoral head is at the same level as the tip of the greater trochanter. In the literature review, one study reported the level of the tip of the greater trochanter to lie above the femoral head center in 82% of cases, lie below in 14% and lie at the same level in only 4%⁽¹¹⁾. Another recently study showed the greater trochanter to lie at the same level as the femoral head center in 32% of cases, above the femoral head in 51% and below the femoral head in 16%⁽¹²⁾. The present study found that the level of the tip of the greater trochanter lies above the femoral head center in 75% of cases, below in 15%, and at the same level in only 10%. Because of the variability of this anatomical landmark, using the tip of the greater trochanter as a reference point for the femoral head center should be carefully evaluated. Surgeons should consider using combi-

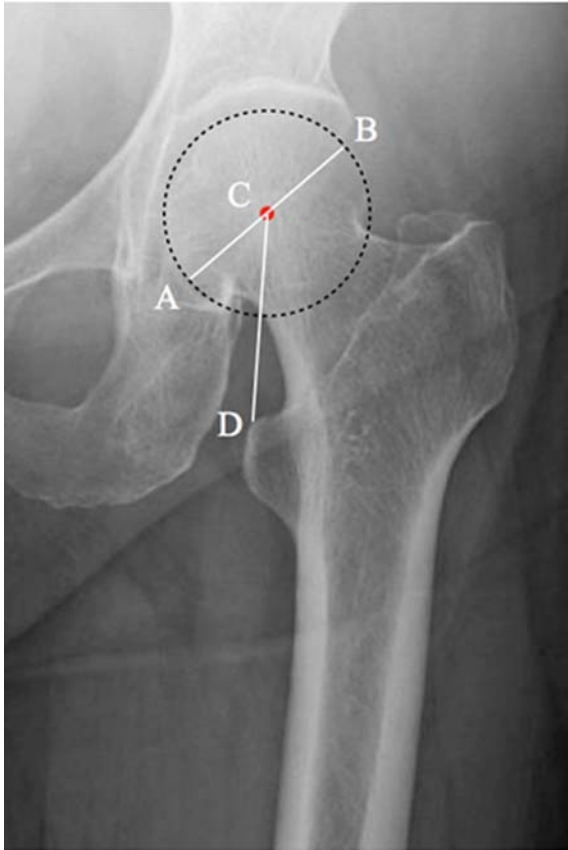


Fig. 1 The AP radiograph of the hip showed femoral head diameter (AB) and femoral head center (C) which was determined by the spherical templates. D was the most prominent part of lesser trochanter. CD was the distance between the center of femoral head to the most prominent part of lesser trochanter

nations of techniques to identify the correct level of the femoral head center in hip arthroplasty.

The present study had a number of limitations. A single author obtained the measurements, which leaves open the possibility of inter-observer variation. The measurement of the FHD on AP radiographs could not represent the thickness of cartilage, it could underestimate the head diameter. But the technique that using the digital template circle was simple and accuracy method to identify the femoral head center. The prominent part of lesser trochanter was easier to identify when compared with the cadaveric model. The distance would be more accurate than manual method.

Conclusion

Based on the present study, the distance from

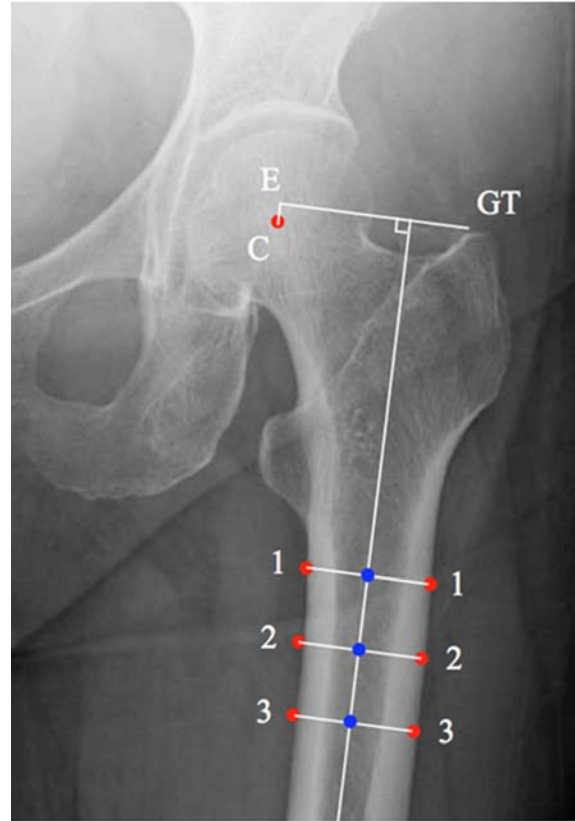


Fig. 2 The AP radiograph of the hip showed the distance from the femoral head center (C) to the level of the tip of greater trochanter (E). The anatomical axis of femur was drawn from 3 center points of the canal. The perpendicular line from the anatomical axis was determined as a level of tip of greater trochanter (GT-E). CE was the vertical distance from the femoral head center to the level of the tip of greater trochanter

the center of the femoral head to the most prominent part of lesser trochanter is approximately equal to the diameter of the femoral head. Assessing the femoral head center by this technique is a helpful measurement in relocating the center of the femoral head during hip arthroplasty. The use of the level of the tip of greater trochanter as a reference point for the level of the femoral head center should be carefully evaluated because of the variability of anatomy.

Potential conflicts of interest

None.

References

1. Maloney WJ, Keeney JA. Leg length discrepancy

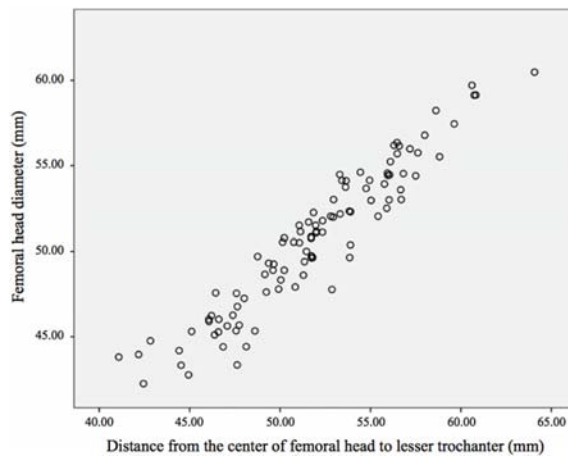


Fig. 3 Correlation between the distance from the center of femoral head to the lesser trochanter and the femoral head diameter (Pearson's correlation coefficient 0.95)

- after total hip arthroplasty. *J Arthroplasty* 2004; 19: 108-10.
2. Mancuso CA, Jout J, Salvati EA, Sculco TP. Fulfillment of patients' expectations for total hip arthroplasty. *J Bone Joint Surg Am* 2009; 91: 2073-8.
 3. Hofmann AA, Skrzynski MC. Leg-length inequality and nerve palsy in total hip arthroplasty: a lawyer awaits! *Orthopedics* 2000; 23: 943-4.
 4. Sakalkale DP, Sharkey PF, Eng K, Hozack WJ, Rothman RH. Effect of femoral component offset on polyethylene wear in total hip arthroplasty. *Clin Orthop Relat Res* 2001; 125-34.
 5. Kurtz WB. In situ leg length measurement technique in hip arthroplasty. *J Arthroplasty* 2012; 27: 66-73.
 6. Franco-Ferrando N, Malik A, Gonzalez-Della Valle A, Salvati EA. Preoperative planning of prosthetic replacement in hip fractures in the elderly. Published in *Rev Ortp Traumatol* 2010; 54: 136-45.
 7. Sproul RC, Reynolds HM, Lotz JC, Ries MD. Relationship between femoral head size and distance to lesser trochanter. *Clin Orthop Relat Res* 2007; 461: 122-4.
 8. McWilliams A, Stewart TD, Grainger AJ, O'Connor PJ, White D, Redmond A, et al. Leg length inequality following total hip replacement. *Ortop Traumatol* 2011; 25: 37-42.
 9. Williamson JA, Reckling FW. Limb length discrepancy and related problems following total hip joint replacement. *Clin Orthop Relat Res* 1978; 135-8.
 10. Woolson ST, Hartford JM, Sawyer A. Results of a method of leg-length equalization for patients undergoing primary total hip replacement. *J Arthroplasty* 1999; 14: 159-64.
 11. Antapur P, Prakash D. Proximal femoral geometry: a radiological assessment. *J Arthroplasty* 2006; 21: 897-8.
 12. Theivendran K, Hart WJ. Is the tip of the greater trochanter a reliable reference for the rotation centre of the femoral head in total hip arthroplasty? *Acta Orthop Belg* 2009; 75: 472-6.

การวัดภาพถ่ายรังสีเพื่อหาจุดศูนย์กลางของหัวกระดูกต้นขาในการผ่าตัดเปลี่ยนข้อสะโพกเทียม

พนธกร พานิชกุล, ปิยะ ปิ่นศรีศักดิ์

วัตถุประสงค์: จุดประสงค์ของการศึกษานี้ คือ การหาจุดทางกายวิภาคเพื่อใช้ในการอ้างอิงในการหาจุดศูนย์กลางของหัวกระดูกต้นขา ในผู้ป่วยที่ได้รับการผ่าตัดเปลี่ยนข้อสะโพกเทียม

วัสดุและวิธีการ: ทำการศึกษาภาพถ่ายทางรังสีดิจิทัลหน้าหลังของข้อสะโพกจำนวน 100 ภาพ เพื่อหาความสัมพันธ์ระหว่างระยะทางจากจุดศูนย์กลางของหัวกระดูกต้นขาไปยังจุดที่นูนที่สุดของปุ่มกระดูกเลสเซอร์โทรแคนเตอร์กับระยะความกว้างของหัวกระดูกต้นขา และหาความสัมพันธ์ระหว่างระดับยอดของปุ่มกระดูกเกรทเตอร์โทรแคนเตอร์กับระดับของจุดศูนย์กลางหัวกระดูกต้นขา

ผลการศึกษา: พบว่ามีความสัมพันธ์แบบเส้นตรงระหว่างระยะทางจากจุดศูนย์กลางของหัวกระดูกต้นขาไปยังจุดที่นูนที่สุดของปุ่มกระดูกเลสเซอร์โทรแคนเตอร์ กับระยะความกว้างของหัวกระดูกต้นขา (Pearson's correlation coefficient = 0.95) โดยมีอัตราส่วนเป็น 1.023 และร้อยละ 75 ของกลุ่มตัวอย่างมีระดับยอดของปุ่มกระดูกเกรทเตอร์โทรแคนเตอร์อยู่สูงกว่าระดับของจุดศูนย์กลางหัวกระดูกต้นขา, ร้อยละ 15 อยู่ต่ำกว่า และมีเพียงร้อยละ 10 ที่อยู่ระดับเดียวกัน โดยระยะห่างเฉลี่ยของระดับยอดของปุ่มกระดูกเกรทเตอร์โทรแคนเตอร์จะสูงกว่าระดับของจุดศูนย์กลางหัวกระดูกต้นขาประมาณ 8 มิลลิเมตร

สรุป: ระยะทางจากจุดศูนย์กลางของหัวกระดูกต้นขาไปยังจุดที่นูนที่สุดของปุ่มกระดูกเลสเซอร์โทรแคนเตอร์มีระยะที่ใกล้เคียงกับระยะความกว้างของหัวกระดูกต้นขา และการใช้ระดับยอดของปุ่มกระดูกเกรทเตอร์โทรแคนเตอร์เพื่อเป็นจุดอ้างอิงในการหาระดับของจุดศูนย์กลางหัวกระดูกต้นขานั้น ควรใช้ด้วยความระมัดระวัง เนื่องจากมีความแตกต่างกันของลักษณะทางกายวิภาคในแต่ละราย
