Initial results in restoration of some anatomical dimensions in standard cementless total hip replacement

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Summary

Objective: To give initial results in the restoration of some important anatomical parameters (femoral neck angle, distance from the center of the crest to the femoral axis (offset), and limb deviation) in the standard cementless total hip replacement in the treatment of aseptic necrosis of the femoral head. *Subject and method:* In studies in the period from 2/2021 to 6/2021, the authors used the Medi-CAD software integrated on the computer to determine the femoral neck angle, the distance from the center of the crest to the femoral axis (offset), the limb deviation of 24 hip joints was surveyed on 20 patients at the time preoperative and postoperative with standard Zimmer hip joints. The method used in this study is a cross-sectional, prospective study. *Result:* The results show that the mean postoperative femoral neck angle was 131.1 ± 3.2° while the preoperative size was 129.8 ± 3.4°. The average postoperative offset size was 35.6 ± 4.8mm and higher than before surgery was 32.5 ± 5.4mm. Postoperative limb deviation was 3.2 ± 2.7mm and lower than preoperative was 12.3 ± 4.5mm, the difference was insignificant statistically. *Conclusion:* Research results show that the closer the femoral neck angle and the offset is to the original value, the better the limb balance.

Keywords: Standard hip replacement, limb deviation, femoral neck angle, offset.

1. Background

Currently, cementless total hip replacement has become quite popular surgery in the world and no one can deny its great effectiveness. However, with the "hot" development of this technique, the rate of complications is also increasing. In particular, one of the important reasons that need to be mentioned is that the patient preparation and pre-operative planning for hip replacement surgery have not been given due attention. To overcome this phenomenon at the Institute of Trauma and Orthopedic - 108 Military Central Hospital, the authors applied Medi-CAD (medical Computer-aided design) software to measure the anatomical dimensions of the hip on X-ray film, after Then plan preoperatively (template) and assess the degree of recovery of some important anatomical dimensions of the hip after surgery based on computer analysis. The restoration of the anatomical dimensions of the hip is the maximum restoration of the function of the joint after replacement, this process is to further improve the quality of treatment. With these survey anatomical parameters, if the recovery is not satisfactory, it will lead to postoperative pain, fast wear of joints, severe dislocation can affect gait and possibly damage the sciatic nerve. These dimensions were restored to be as close to healthy lateral indices or to normal anatomical dimensions as possible. Based on the above characteristics, the aim of this work is to give initial results restoration of some important anatomical dimensions (femoral neck angle, distance from the center of the crest to

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the femoral axis (offset), and limb deviation) in standard cementless total hip replacement in the treatment of aseptic necrosis of the femoral head.

2. Subject and method

2.1. Subject

The study subjects in this work included 24 hip joints of 20 patients (in which 4 patients had a bilateral hip replacement) with aseptic necrosis of the femoral head stage IV, V, VI (according to the classification of Steinberg) underwent standard total hip replacement surgery (Zimmer's hip replacement) at the Institute of Trauma and Orthopedics, 108 Military Central Hospital from February 2021 to June 2021.

2.2. Method

The studied dimensions include femoral neck angle, distance from the center of the crest to the femoral axis (offset), limb deviation on X-ray film at the time before and immediately after surgery.

The preoperative femoral neck angle is the angle between the femoral neck and the anatomical axis of the femoral body as described in Figure 1. Meanwhile, the postoperative femoral neck angle is the angle of the hip stem replacement neck with the anatomical axis of the femur as shown in Figure 2. The anatomical axis of the femur is the straight line connecting the two midpoints of the diameter of the canal at the transverse border below the lesser trochanter and the proximal third of the femur.

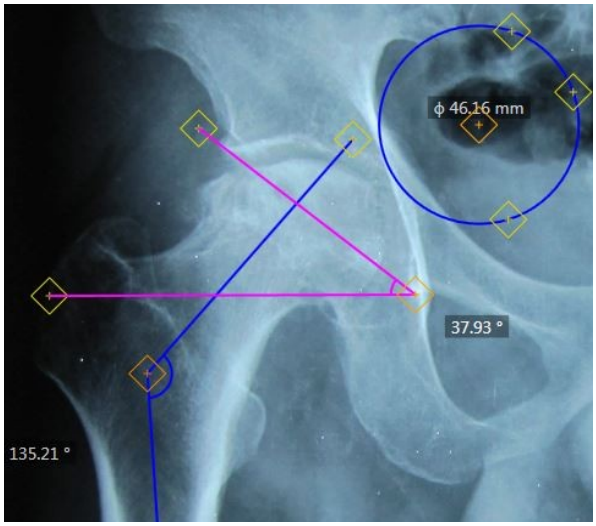


Figure 1. The acetabulum diameter, the inclination angle of the acetabulum, and the femoral neck angle before surgery

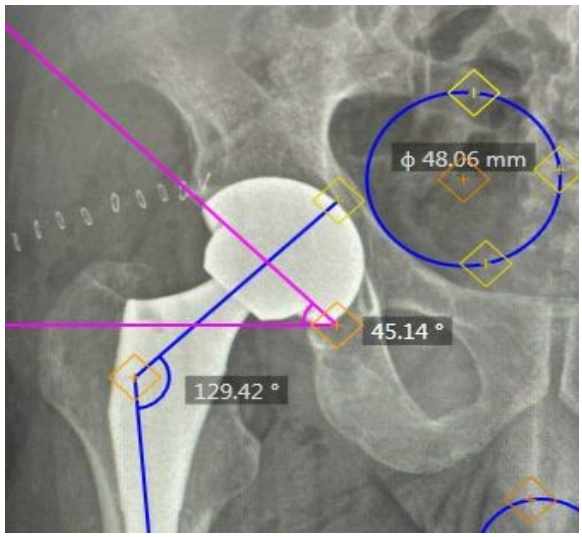
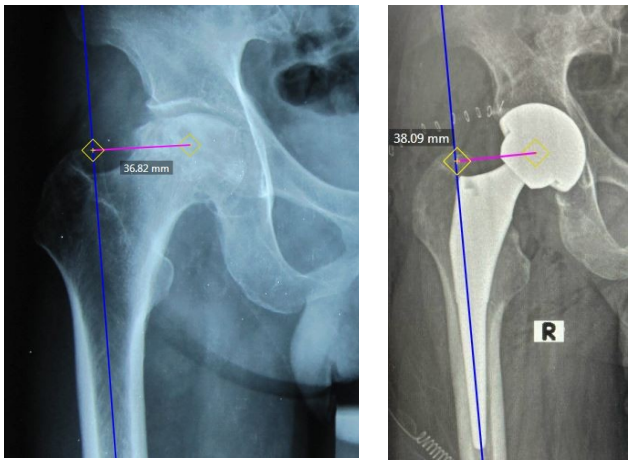


Figure 2. The acetabulum diameter, the inclination angle of the acetabulum, and the femoral neck angle after joint replacement

Offset is the distance from the center of the head (before surgery) or the center of the artificial joint head (after surgery) to the femoral axis (offset) as depicted in Figure 3.

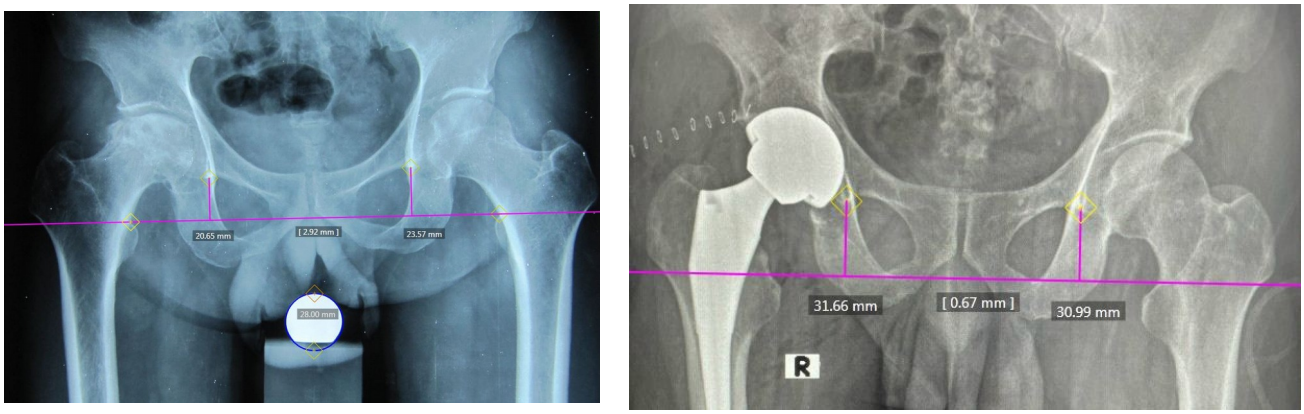


a b

Figure 3. Distance from the center of the head to the anatomical axis of the femur (offset)
a) Before surgery, b) After surgery

Distance from the bilateral teardrop to the horizontal line across the superior border of the minor trochanter and limb deviation. The limb deviation is the difference between the distances

from the left and right teardrops to the line crossing the shore on the two minor trochanter as shown in Figure 4.



a) Before surgery b) After surgery

Figure 4. Distance from the inferior bone ridge in the acetabulum to the line passing through the superior border of the two the minor trochanter and limb deviation

The anatomical dimensions were determined through the software medi-CAD (medical Computer-aided design) with the steps described as follows:

Step 1. To take X-ray film of both hips.

Step 2. Using the reference object as shown in Figure 5b a spherical ball with a diameter of 28mm, as the basis for determining the actual dimensions on the X-ray film. Position of the reference object in the middle of the groin and closest to the inguinal as shown in Figures 5b and c.

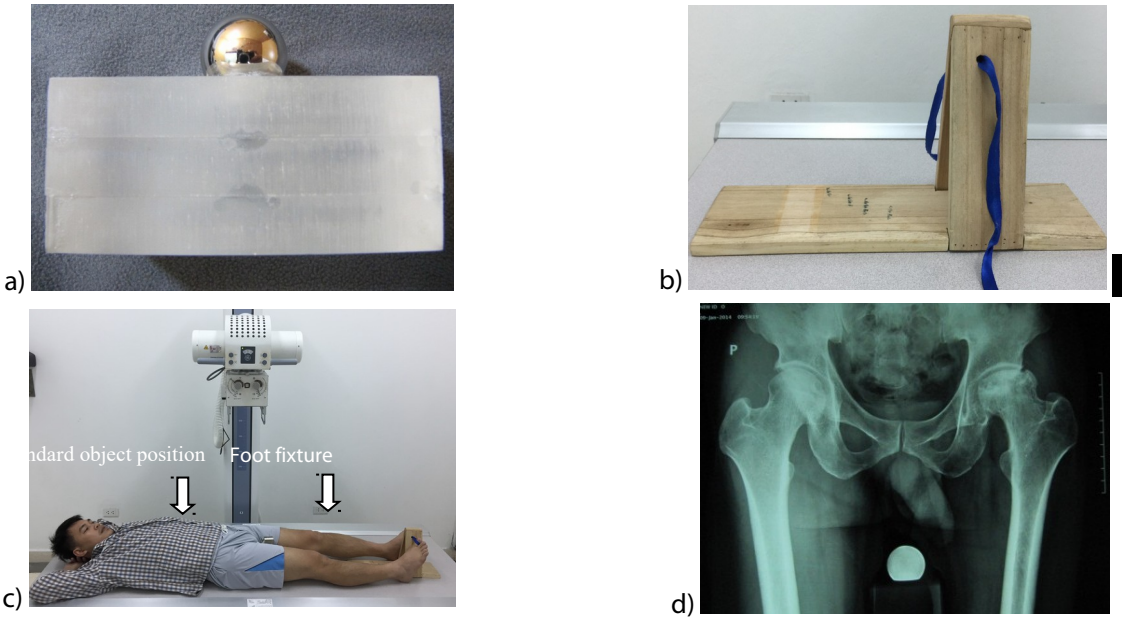


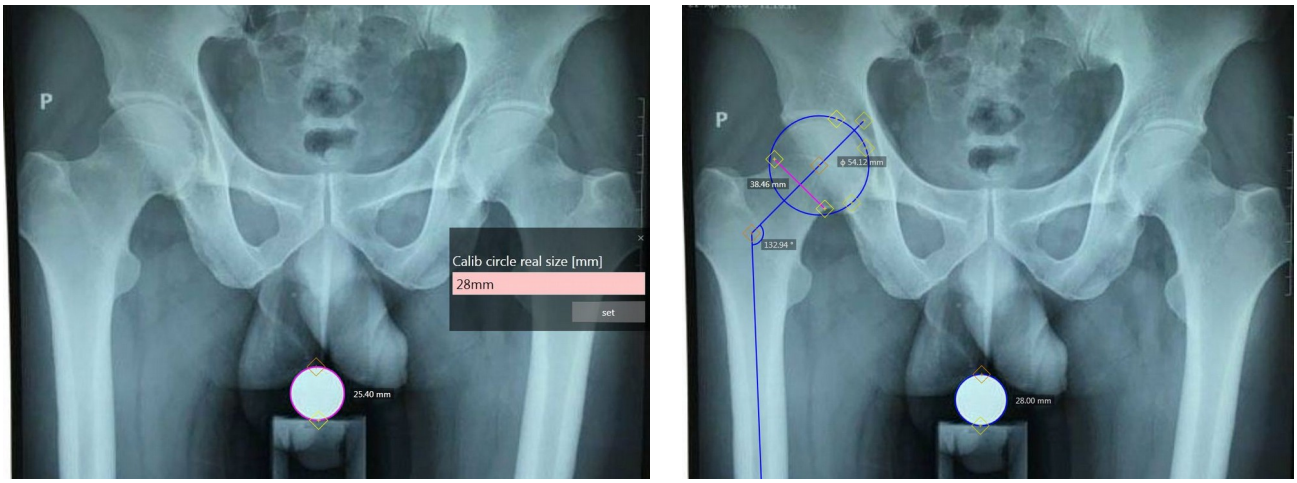
Figure 5. Standard object and radiographic position for bilateral straight hip
a) Standard, b) Footrest, C) Posture, d) X-ray film

Step 3. Take hip joint X-ray film on Dix-Ray Stardard digital X-ray machine as shown in Figure 5B, and C with standard KV 22, mAs 25.

Step 4. Copy picture file of hip joint from X-ray digital machine and send to professional software in computer.

Step 5. Determine the dimension of the X-ray film based on the size of the spherical ball with a diameter of 28mm as shown in Figure 5a.

Step 6. The dimensions to be studied are determined precisely and easily through the toolbars as shown in Figure 6b. Measurements on the machine are accurate to 0.01mm and 0.01°.



a) Standardize the size according to the sphere ball b) Measure research indicators

Figure 6. Measurement of research indicators based on X-ray film

Step 7. The data were analyzed by SPSS 15.0 program with the mean (X), standard deviation (SD), and p-value was calculated.

3. Result

3.1. General data used in the study

The studies on 24 hip joints of patients with age ranged from 48 - 76, the average age was 64.7, the group from 60 - 70 years old accounted for the most with 55.0%. On the 20 patients, there were 17 male patients, accounting for 85.0%, only 3 female patients accounting for 15%, the male: female ratio was 5.7:1.

3.2. Femoral neck angle

Table 1. Comparing femoral neck angle (n = 24)

Femoral neck angle	Pre operative	Post operative
$\bar{X}$ ± SD	129.8 ± 3.4 (126.5 - 133.6)	131.1 ± 3.2 (128.3 - 135.1)
p	p<0.05	p

The femoral neck angle of post-operative was higher than that of preoperative, the difference was statistically significant with p<0.05.

3.3. Distance from central of head to femoral bone axis (offset)

Table 2. Comparing the distance from central of head to femoral bone axis (offset) (n = 24)

Offset	Pre-operative	Post-operative
$\bar{X}$ ± SD	32.5 ± 5.4 (27.3 - 38.4)	35.6 ± 4.8 (29.8 - 40.4)
p	p<0.01	

Comment: The size of offset after surgery was higher than that before surgery. This difference was statistically significant with p<0.01.

3.4. The leg length discrepancy

Table 3. Comparing the distance from teardrop-horizontal line of lesser trochanter (n = 24)

Teardrop-horizontal line of lesser trochanter	Pre-operative	Post-operative
$\bar{X}$ ± SD	23.7 ± 4.6 (19.8 - 28.1)	26.8 ± 5.2 (21.3 - 32.4)
p	p<0.01	

Comment: The distance from teardrop to horizontal line of lesser trochanter post-operative was higher than pre-operative. This difference was statistically significant with p<0.01.

Table 4. Leg length discrepancy (n = 20)

Deviation (mm) Number	0 - 5	> 5 - 16.8	Total
Pre-operative	3	17	20 (100%)
Post-operative	12	8	20 (100%)

Comment: The leg length discrepancy between preoperative and postoperative was not much different, the group accounting for the largest proportion was the difference from 0 - 5mm.

Table 5. Comparing the leg length discrepancy pre and post operative (n = 20)

Period	Pre-operative	Post operative
$\bar{X} \pm$ SD	12.3 ± 4.5 (8.1 - 16.9)	3.2 ± 2.7 (1.2 - 6.1)
p	p<0.01	

Comment: The leg length discrepancy post operative higher than pre operative have statistically significant. We had 4 patients with both side hip surgery, the average deviation of extremities in this group was 4.7mm, the highest number in this group was 5mm.

4. Discussion

4.1. Femoral neck angle

Pouget G. [7] studied 150 hip joints before surgery, ranging from 118° - 140°. After total hip replacement surgery, there were 24 joints with coxa vara (16%) with 125° femoral neck angle. However, in these 24 joints, the distance from the center of the crest to the femoral axis (offset) before surgery was 44.5mm, after surgery was 42.2mm, the average femur displacement was 2.3mm plus the displacement of the femur center of rotation, the results show that this displacement was quite large.

The cervical-axial preoperative angles (CCDpre) determined in this study were comparable with those from studies [3], [7], [8]. According Schidlo et al. [8] reported a mean neck-axis angle of 128° (SD 8.9), and Maruyama et al [5] found a mean of 125° (SD 4.8). The postoperative cervical-axial angle (CCDpost) was significantly increased, due to the fixed prosthetic neck-axis angle of 131°. Overall, only six patients accounted for 13% of CCDpost close to a preoperative angle of ±2°, and with 21 patients accounting for 48%, CCDpost was within ±5°, respectively.

Our study found no evidence of an association between the change in the anterior to postoperative cervical angle and the clinical outcome. Neither pain, satisfaction, nor HHS was associated with the change in cervical-axial angle. There was also no effect on the change in leg length.

Muller M. et al [6] studied the radiographic changes of 44 total hip joints cementless and found that the femoral neck angle increased by an average of 2.8° (from 128° before surgery to 131° after surgery with p=0.009), along with the assessment of offset change and the HHS scale, the author concluded that the change did not affect pain severity, hip function and clinical outcome.

4.2. Distance from central of head to femoral bone axis (offset) and the leg length discrepancy

Lecerf G. et al [4] define that: "The offset of the femoral head is the distance from the center of the crest to the anatomical axis of the femur". This size is very important in restoring hip function [4], [10]. The mean postoperative offset in our study was 41mm. Whereas previous studies have measured similar mean postoperative offset distances of 41mm, 39mm, and 42mm. In 66.7% (corresponding to n = 16 joints), the postoperative disparity increased to about 4.1mm. This is similar to the study by Lecerf et al [4] who found a mean postoperative offset increased of 4.8mm in 84% (n = 64 patients). Research by Muller [6] and colleagues, the offset increased 4.5mm with over 70% (n = 31 patients). Meanwhile, Study by Schmidutz et al [9] measured a postoperative compensatory gain of only 2.0mm in 54% (n = 27 patients) after hip replacement.

Until now, in fact, there is still a lot of debate about whether to reduce or increase offset in total hip replacement surgery. In terms of biomechanics, there are both advantages and disadvantages when the offset changes. The advantage of increasing offset is that the extension of the swingarm reduces the load on the joints, reduces the risk of collision, and extends the free range of motion of the joint [4], [10]. The disadvantage of an increased offset is an increased load on the distal end of the mandrel [10]. The location of the acetabulum and the mandibular joint will affect the offset increase and decrease, this process closely affects limb balance [4]. However, there are no studies that have evaluated the patient's tolerance threshold for changes in offset increase or decrease after hip replacement surgery. Ideally, restore the offset as close to its true value as possible. Usually, in total hip replacement surgery, the femoral head is flattened, deformed, the right limb is shortened, so before surgery, the patient's offset is always lower than normal, so when surgery it is necessary to restore the parameters initial offset.

The leg length discrepancy is the most common problem that patients complain about after hip replacement. In case of having hip replacement in both side, surgeons not only need to balance the length of two limbs but also need to return the original size to the limbs.

The study of Muller et al [6] reported that almost all patients had a difference in limb length < 10mm. Only 2.3% (n = 1 patient) had a difference in limb length > 10mm, the author concluded that the limb balance was good after surgery. Our postoperative limb difference on average was 3.3mm, our results are similar to the results of Schmidutz et al [9], the mean postoperative limb length difference was 1.3mm (SD 3.4.

According to Jerosch et al [3] with adequate preoperative planning and when surgery is performed according to this plan, limb deviations, as well as basic anatomical dimensions, will be well reproduced. Thus, preoperative measurement and planning on a computer (template) are very important in restoring anatomical dimensions after hip replacement surgery.

Our study shows that the line from teardrop to the two minor trochanter cross line after surgery was higher than before surgery, this difference was statistically significant with $p<0.001$. Postoperative limb deviation was lower than preoperative the difference was statistically significant. Thus, after standard hip replacement surgery, we have returned the balance to the patient.

Some authors believe that the difference between the two limbs by 10mm or more after surgery will affect the gait, in the long term, the patient will have pain in the hip joint and the acetabular lining will be quickly worn away, so it is necessary to let the patient walk orthopedic footwear [2], [3]. The study of Edwards et al [2] showed that there was a correlation between the length of the limb after surgery and the sciatic nerve injury. A limb length of about 19 - 37mm will cause paralysis of the external popliteal sciatic nerve. And great sciatic nerve palsy occurs when the limb was 40 - 51mm long [2]. We had no cases of lateral popliteal nerve damage. This is due to the preparation, careful surgical planning, anticipating difficulties, better limb balance, and partly due to the small number of patients so we did not encounter any cases. major sciatic nerve damage.

5. Conclusion

Through studying some important anatomical dimensions after 24 standard hip replacements, the main conclusions of the study are described as follows:

The postoperative angles of the femoral neck were $131.1^o \pm 3.2^o$ is higher preoperative, the postoperative offset sizes were 35.6 ± 4.8mm is higher preoperative postoperative limb deviation 3.2 ± 2.7mm lower than preoperative. The difference is insignificant statistically. Initially, we found that the closer the anatomical parameters were to the initial values, the better the ability to maintain limb balance.

This study initially shows that the application of Medi-CAD software in the preoperative planning process on the computer will give good results in terms of offset reconstruction, restoration of femoral neck angle and length. Posterior limb of standard Zimmer hip replacement. Restoring the anatomical shape of the hip joint is the basis for the restoration

of hip function after replacement. Further studies with a larger number of patients are needed to achieve higher reliability.

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