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Restoration of Some Anatomical Dimensions By Spiron Short Stem Hip Replacement Applied To Vietnamese People

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Research article

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Abstract

Background: The process of using proximal bone in hip arthroplasty will allow the remaining bone to be preserved in future surgeries. To take advantage of these advantages, many types of short stem prosthetics have been developed in recent years. The obtained survey parameters combined with the obtained anatomical parameters shown that the Spiron joint is suitable when applied to adult Vietnamese.

Research subjects and methods: The anatomical dimensions of the hip joint related to Spiron joint replacement were analyzed by the authors.

Results: The anatomical results with Spiron showed that the acetabular average diameter and tilt angle were 49.77 mm and 41.55°. The femoral neck-to-body angle, the femoral upper-neck diameter, the distance from the crest to the hard shell along the femoral neck axis was on average 131.52°, 34, 32mm, and 51.39mm, respectively. The offset distance from the center of the crest to the axis of the femur is 38.33mm. These parameters show the working ability as well as stability when replaced by the Spiron joint.

Conclusion: When applied to adult Vietnamese, the femoral neck diameter is consistent with the Spiron diameter. Preoperative planning is needed to check the femoral neck angle and femoral neck length prior to surgery to see if the Spiron joint replacement is eligible. The findings of this study support the assumption that it is feasible to use Spiron prostheses in joint replacement in Vietnamese adults.

Introduction

Hip replacement is often used to treat degenerative joint diseases, aseptic necrosis of the femoral head, and ankylosing spondylitis in ankylosing spondylitis. In Vietnam, hip replacement is most common in Avascular necrosis (AVN) of the femoral head. This disease usually occurs in the 40-60 age group and more and more young patients need joint replacement. The number of young patients with aseptic necrosis of the femoral head in Vietnam is increasing day by day. This patient will have to face the second and the third time joint replacement after the first time joint replacement [1-3].

When having to replace the joint for the second and third time, it will face a more difficult and complicated technique along with a much higher rate of complications and symptoms than the first joint replacement. Since then, a number of short stem joints designed with the aim of preserving the bones of the neck and upper femur were born. Recently, Spiron short stems joints have been used a lot for young patients, however, studies on Spiron hip joints have only been limited to a short follow-up period and a small number of patients. The researchers all agree that the results need to be followed up for a longer time [4, 5]. In general, studies show that the introduction of the short-stem hip joint in general and the Spiron hip, in particular, has overcome difficulties and limit complications when replacing joints [6, 7]. However, it also presents many disadvantages such as more difficulty when reaming and placing the acetabulum due to retention of the femur neck or difficulty in choosing the position when placing the mandrel exactly as desired.

When it comes to total hip arthroplasty (THA), the orthopedic community has seen a growing interest in more conservative surgical techniques for hip arthroplasty [8-10]. Meanwhile, second-generation hip resurfacing and minimally invasive surgery (MIS) have received widespread attention. After a period of application, both of these THA methods encounter worrisome problems. As the number of hip rehabilitation decreases, both patients and surgeons are looking for other potentially successful conservative treatments for THA. Recent studies have focused the surgeon's interest on short-stem replacement designs. Today, there are many types of short stem implants with little clarification on the basis of design, fixation, surgical technique, and clinical outcome [11, 12]. Almost every major implant company now offers short stems and comes in a variety of designs. However, it is important to note that not all short stems achieve initial fixation at the same bone interface region. Furthermore, surgical techniques vary widely, and the postoperative radiological interpretation of the position and fixation of the short stem requires careful consideration [13, 14]. Research by Thielen et al. [15] shows that the advantages of cement-free total hip arthroplasty are immobilization through bone growth and avoidance of problems associated with polymethyl methacrylate (PMMA). However, achieving the perfect position for bone restorations requires precise preparation of the pulp cavity with a variety of shafts of different shapes and sizes. Other problems noted with the use of cementless systems include fractures, bone resorption and excessive movement between the implant and bone. Important technical aspects of cementless total hip arthroplasty involve optimal fit and fill, for the restoration to be stable, bone growth is promoted, and weight-bearing is transferred to the physiologically proximal femur.

In order to contribute to limiting the disadvantages and promoting the advantages of Spiron short joint, it is necessary to improve surgical techniques to restore hip anatomy after replacement. Therefore, it is necessary to study the anatomy of the hip joint to have an orientation to choose the appropriate joint size, position, and angle of the Spiron mandibular joint, thereby restoring the anatomical structure to maximize the function of the joint. Nowadays, there are only a few studies on the size of the femoral head alone, but none have studied the anatomical dimensions of the hip related to Spiron replacement, especially applied to other human races together. Stemming from the above reasons, in order to further improve the effectiveness of treatment, we carried out this work with the goal of determining some dimensions of hip anatomy for adult Vietnamese.

Hip Anatomical Parameters Related To Spiron Joint Replacement For Vietnamese People

The study was conducted on 129 normal hip X-ray films of 83 Vietnamese adults aged 18-50. The study period was conducted from February 2012 to October 2016, at the Institute of Trauma and Orthopedics, 108 Vietnam Central Military Hospital. This process aims to find the average value of the hip anatomical index representing the Vietnamese, the study sample size follows WHO guidelines and is determined by:

$$n = \frac{Z^2_{1-\alpha/2} \times p \times (1 - p)}{d^2} = \frac{1,96^2 \times 0,58 \times (1 - 0,58)}{0,09^2} = 116$$

where: n is the sample size, α is the coefficient of significance, Z is the confidence coefficient (Z = 1.96 with 95% confidence), p = 0.58 is the predicted proportion in the population, d = 0.09 is the absolute error.

2.1. Study dimensions and measurement methods

Figs. 1 a and b show the diameter of the acetabulum (D1.1) and the angle of inclination acetabulum (D1.2). Where D1.1 is the diameter of the circle whose arc fits the acetabulum and D1.2 is the angle made by two straight lines, a straight line passing through the inner lower rib (teardrop) of the acetabulum on both sides and 1 line straight through the superior border of the acetabulum with the medial inferior ridge of the ipsilateral acetabulum.

The femoral neck indexes include the length of the upper border, the lower border, and the distance between the top and bottom of the femoral neck. Line segment XY through the base of the femoral head (Point X is at the upper border of the femoral neck, the Y point is at the lower border of the femoral neck). The base of the femoral head is the junction between the neck and the femoral head (Figs. 2a, b). C is the facial point in the greater trochanter along the superior border (Fig. 2a), D is the superior point of the minor trochanter (Fig. 2b). P is the midpoint of arc XC, Q is the midpoint of arc YD (Fig. 2c). The length of the superior border of the femoral neck: is the distance from point X to point C (Fig. 2a). The length of the lower border of the femoral neck: is the distance from the Y point to the D point (Fig. 2b). The upper and lower distance between the femoral neck (legacy neck): is the distance between the 2 points P and Q (Fig. 2c).

Indicators related to the selection and placement of the Spiron mandibular mandrel include the distance from the base of the femoral head to the medial edge of the lateral femoral wall, the angle of the neck of the femoral body, the distance from the center of the crest to the anatomical axis of the femur (offset). The distance from the base of the femoral head (close to the femoral head) to the medial edge of the lateral femoral wall (along the median axis of the femoral neck) is the distance from point I to point K as shown in Fig. 3a. Where point I is the midpoint of segment XY, and point K is the intersection of the longitudinal axis between the femoral neck and the medial border of the lateral femoral wall. Femoral neck angle: is the angle formed by the axis of the neck (IK Line) and the anatomical axis of the femoral body (Z line) as depicted in Fig. 3b. Distance from the center of the crest to the anatomical axis of the femur (offset): Is the distance from the point O (point O is the center of the head) to the line z.

To determine the size through the X-ray film of the hip, the authors use the standard object as described in Fig. 4a, through the standard size will accurately determine the true size in the X-ray film. The reference object is a ball 28 mm in diameter, mounted on a transparent plastic block through which it is easy to place the reference object in the desired positions. Before imaging, the reference object is placed midway and closest to the groin (so that the reference object is in the same plane as the femoral head, between and closest to the hip joints) as shown in Figs. 4c and d. The patient lies supine with legs extended, heels 20cm apart, feet internally rotated (for consistency and accuracy, all patients with both legs are fixed on a wooden stand (20 cm wide base, the sidewall is tilted 20 degrees, upper is 2 thumbs tied as shown in Fig. 4b), this position allows the foot to rotate between 15º - 20º), balanced hip distance, distance from the ball to the pubic joint is 100cm (Figs. 4c and d). The hip joint measurements are shown in Fig. 5.

Results And Discussion

3.1. Analysis of hip anatomical dimensions

The anatomical dimensions were analyzed by the authors based on 129 X-ray films of the hip joints of 83 patients, with 46 patients being studied on both sides of the hip. The age of the patients ranged from 18-50, the mean age of the group was 37.8 ± 8.7 years old. The group of patients aged 41-50 years old accounted for the most 44.6%, the group of patients 18-30 years old accounted for the least 22.9%. In 129 hip joints, there are 37 female hip joints (accounting for 28.68%) and 92 hip joints of men (accounting for 71.32%), male/female hip ratio is 2.49:1.

The results obtained as described in Table 1-5 show that the average femoral neck-body angle is 131.52° (from 120.91°-140.38°), distributed in the range of 125°-135° up to 73.6%. The lower femoral neck angle is 125° (120.91° – (<125°)) accounted for 5.4%. The average diameter of the upper and lower leg bones of the femoral neck is 34.32 mm (from 27.76 mm to 43.69 mm) on average, scattered distribution more concentrated in the range of 32-36 mm with 48.1%. The average distance from the base of the crest to the hard shell along the femoral neck axis was 51.39 mm (from 39.91 to 64.77 mm). The group with this length from 39.91 to less than 50 mm accounted for 35.6%. The distance from the center of the crest to the axis of the femur (offset) is 38.33mm, distributed non-centrally in the range from 27.05 mm to 51.15 mm. The most concentrated group is the group with lengths from 34-40 mm with 45.7%.

Table 1. Average value of measured dimensions (n=129)

No.	Parameters of hip joint survey	Symbol	The average value
1	Diameter of acetabulum	D 1.1	49.77±1.98 (mm)
2	Acetabulum tilt angle	D 1.2	41.55±3.2º
3	Distance from upper border of femoral neck	D 2.1	17.21±3.56 (mm)
4	Distance of lower border of femoral neck	D 2.2	22.71±3.90 (mm)
5	Upper-lower neck diameter of the femur	D 2.3	34.32±3.23 (mm)
6	Femoral neck angle (straight angle)	D 3.1	131.52±3.88º
7	Distance from base of the crest - shell hard	D 3.2	51.39±4.50 (mm)
8	Distance from the crest center to the femur axis	D 3.3	38.33±4.85 (mm)

Table 2. Angle neck - femoral body

Joint	Angle (degrees)			Total
	120.91 – (<125)	125 - 135	>135- 140.38	
Amount	7	95	27	129
Ratio %	5.4	73.6	20.9	100
□ = 131.52 ; SD = 3.88				

The femoral neck angle of Vietnamese adults is often studied on the dry femur with not many different values. According to research by Siwach R.C. [16], a study on 578 femurs showed that the average Indian femoral neck angle was 126.55 degrees. According to Baharuddin et al. [17] the femoral neck angle in Europeans is 136 degrees/male and 133 degrees/female. The average femoral neck angle in our study was 131.52° (n= 129), ranging from 120.91°-140.38°, distributed quite concentratedly in the upper range of 125°-135° with 73.6%. The results show that the neck angle of the femur is lower in Vietnamese people than in Europeans. Birkenhauer B. [18] in the Spiron study advised against this joint placement in patients with a femoral neck angle below 122°. If the neck angle of the femoral body is too low, the neck can collapse, the handle can penetrate the hard bone wall. Table 2 shows that 5.4% of patients have femoral neck angle 120^{o}-125^{o}. Obviously, these cases should be considered and paid attention to when replacing the Spiron joint.

Table 3. Upper-lower neck diameter of femur

Joint	diameter (mm)			Total
	27.76 – 32 <	32 - 36	>36 – 43.69	
Amount	30	62	37	129
Ratio %	23.3	48.1	28.7	100
□ = 34.32; SD = 3.23				

Table 4. Distance from the base of the crest to the hard shell along the femoral neck axis

Joint	Length (mm)				Total
	39.91-(<45)	45 – (<50)	50 –(<60)	60- 64.77	
Amount	11	35	80	3	129
Ratio %	8.5	27.1	62	2.3	100
	□ = 51.39; SD = 4.50				

Table 5. Distance from the center of the crest to the femoral axis (offset)

Joint	Length (mm)			Total
	27.05- (<34)	34-40	(>40)-51.15	
Amount	26	59	44	129
Ratio %	20.2	45.7	34.1	100
□ = 38.33; SD = 4.85				

In this study, the mean upper and lower femur neck diameter was 34.32 mm (range 27.76 mm-43.69 mm). According to the relationship between the anterior and posterior diameters and the upper and lower diameters of the femoral neck, the average anteroposterior diameter of the femoral neck will be determined, from which the Spiron handles with diameters from 18, 20, 22 mm can be used completely for the Vietnamese. The average distance from the base of the crest to the hard shell along the axis of the femoral neck on both sides is on average 51.39 mm (from 39.91 to 64.77 mm), scattered in the range of 39.91- (<60) mm. Thus, the majority of Spiron shanks that can be replaced are 45, 50 (mm) (because the end of the handle must be 5 mm from the hard shell). According to Table 4, up to 35.6% of the neck bones have the distance from the base of the crest to the hard shell along the axis of the femoral neck from 39.91-(<50) mm. The shortest Spiron handle is 45 cm so these are cases where Spiron joint replacement is not recommended because of insufficient length of the femoral neck. That means that 35.6% of Vietnamese people with femoral neck length are not eligible for Spiron joint replacement. Therefore, preoperative planning (template) is very important when having this hip replacement.

The results in table 8 show that the distance from the center of the crest to the femoral shaft (offset) is 38.33 mm. Thus, the results of our study are equivalent to those of Sanchita R. and Siwach R.C [9]. This is a size that has received little research attention, but it is very important in restoring hip function. Since the beginning of hip replacement surgery in the literature, there has been a lot of debate about whether to reduce or increase offset. 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 expands the free range of motion of the joint. The disadvantage of an increase in offset is an increased load on the distal end of the mandrel.

3.2. Clinical research

Study subjects: Including 72 patients (22 patients with bilateral replacement and 50 patients with unilateral replacement), patients who underwent Spiron short stem total hip replacement surgery from February 2012 to August 2016 at the Institute of Trauma - Orthopedics, 108 Central Military Hospital.

Clinical features: Patient height, pain level, hip range of motion, walking ability, Harris score, complications such as nerve damage, infection, joint dislocation, deep vein thrombosis, etc. After measuring and calculating the necessary parameters for the surgical procedure, the expected mandibular placement according to the index calculated into the femoral neck (Fig. 6a). After selecting a suitable mandrel, re-determine the official femoral neck cut position by measuring the distance from the greater trochanter and the lesser trochanter to the plate (AC, BD lines - Fig. 6b), the AB line is the official femoral neck cut.

The model calculates the dimensions of the acetabulum diameter, the angle of the acetabulum as described in Figs. 7a and b. The angle of the femoral neck: before surgery (Fig. 8a), the angle between the mandibular axis and the anatomical axis of the femur after surgery (Fig. 8b). The distance from the end of the mandrel to the post-operative hard bone wall and the time of final examination: Measured from the center of the plane of the end of the mandrel to the medial edge of the lateral wall of the femur along the mandibular axis (Fig. 8b).

Distance from the medial inferior ridge of the bilateral acetabulum (teardrop) to the line passing through the superior border of the trochanter and the limb deviation (mm) as shown in Fig. 9. Measuring the length of the lower extremities of the patients after surgery if the limb deviation is less than 5 mm, they are classified into the group of results where the legs are of equal length.

Studying a number of hip anatomical indices related to Spiron joint replacement helps to determine the measurement method and the range of this value from which to make a pre-operative plan on the computer (Fig. 6a). Through the analysis to determine the femoral neck cut position (Fig. 6b), the oscillometric distance of the femoral neck angle (concentrated in the range 125° - 135° (73.6 %)), the distance from the center crest to the anatomical axis of the femur (27.1 - 51.2mm), etc., to compare with the values measured during surgery. If the measured value is outside of this range, care should be taken to check that the measurement method is correct, the position of the Spiron mandrel is correct. This is a very important job to help improve the quality of treatment.

In fact, if the exact size of the hip handle cannot be predicted, when reaming the femoral neck or placing the shank larger than the actual size, the risk of femoral neck fracture is very high. With a standard hip shank, the upper femur bone is thick and hard to break, while in Spiron joint replacement, the femoral neck is thin and weak, so it is easier to break. If for fear of breaking the femoral neck, the joint handle is smaller than the actual size, then the joint is not pressed against the hard bone wall, the more spongy bone will quickly cause joint loosening. In short-handle hip replacement in general and Spiron hip replacement in particular, due to the retention of the femoral neck, the observation, reaming, and acetabular placement are often more difficult than in long stem hip replacement, so preoperative planning Using the computer to accurately predict the size of the acetabulum, the joint will help the surgeon to be proactive in this case.

Conclusion

The mean femoral neck-body angle was 131.52°, and the mean femoral upper-neck diameter was 34.32 mm. The average distance from the base of the crest to the hard shell along the femoral neck axis is 51.39 mm. The distance from the center of the crest to the axis of the femur (offset) is 38.33 mm.

The short stem hip replacement in general and Spiron hip replacement in particular, due to retention of the femoral neck, observation, reaming, and acetabular placement is often more difficult than standard hip replacements. So preoperative planning is required. Using the computer to accurately predict the size of the acetabulum, the joint will help the surgeon to be proactive in this case.

The diameter of the adult Vietnamese femoral neck matches the Spiron handle diameter. The femoral neck angle and femoral neck length should be checked before surgery to see if they are eligible for Spiron joint replacement. Computerized preoperative planning is recommended prior to Spiron joint replacement to check for this condition.

This study showed good results on offset reconstruction, femoral neck angle and limb length after Spiron short-handle hip replacement. Restoring the anatomical shape of the hip joint is the basis for restoring hip function after replacement.

Abbreviations

THA: Total hip arthroplasty;

AVN: Avascular necrosis

MIS: Minimally invasive surgery;

PMMA: Polymethyl methacrylate

Declarations

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Authors' contributions

Thuan Mai Duc provided data collection procedures, perform surgical steps, provide analysis steps, and writing the manuscript. Dung Nguyen Quoc analysis and interpretation of the result, performed the analysis and writing the manuscript. The final manuscript was read and reviewed by the authors prior to submission.

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Availability of data and materials

The data in the manuscript was created by the authors

Ethics approval and consent to participate

The study has been approved by the Ethical Committee in Biomedical Research, 108 Military Central Hospital, Hanoi, Vietnam (No. 225/QD-V108). All patients in the study were asked for their consent, and they agreed to participate in the study. They were notified of their complete right to withdraw from the study at any time without threats or disadvantages.

Consent to Participate

Consent to Participate was obtained from all individual participants included in the study.

Consent to Publish

Consent to Publish was obtained from all individual participants included in the study.

Conflict of Interest

The authors declare that they have no conflict of interest.

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Figures

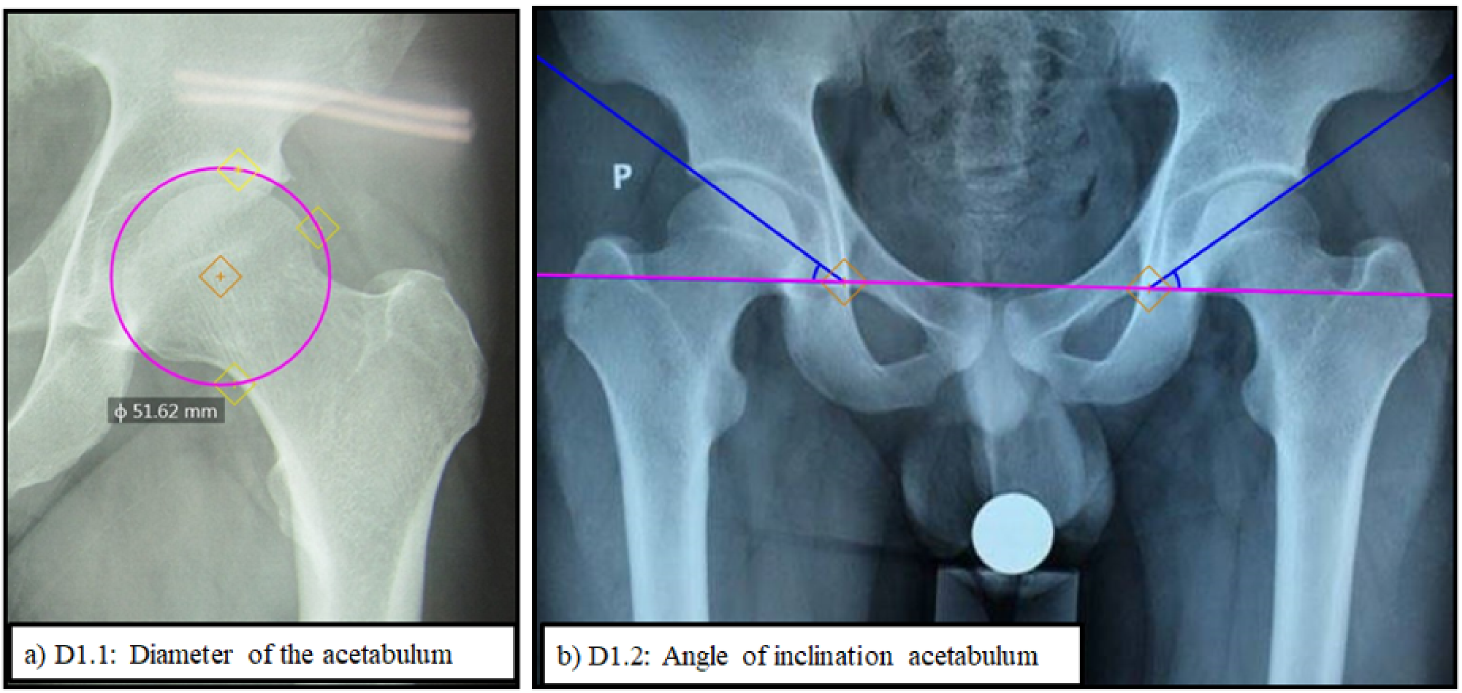
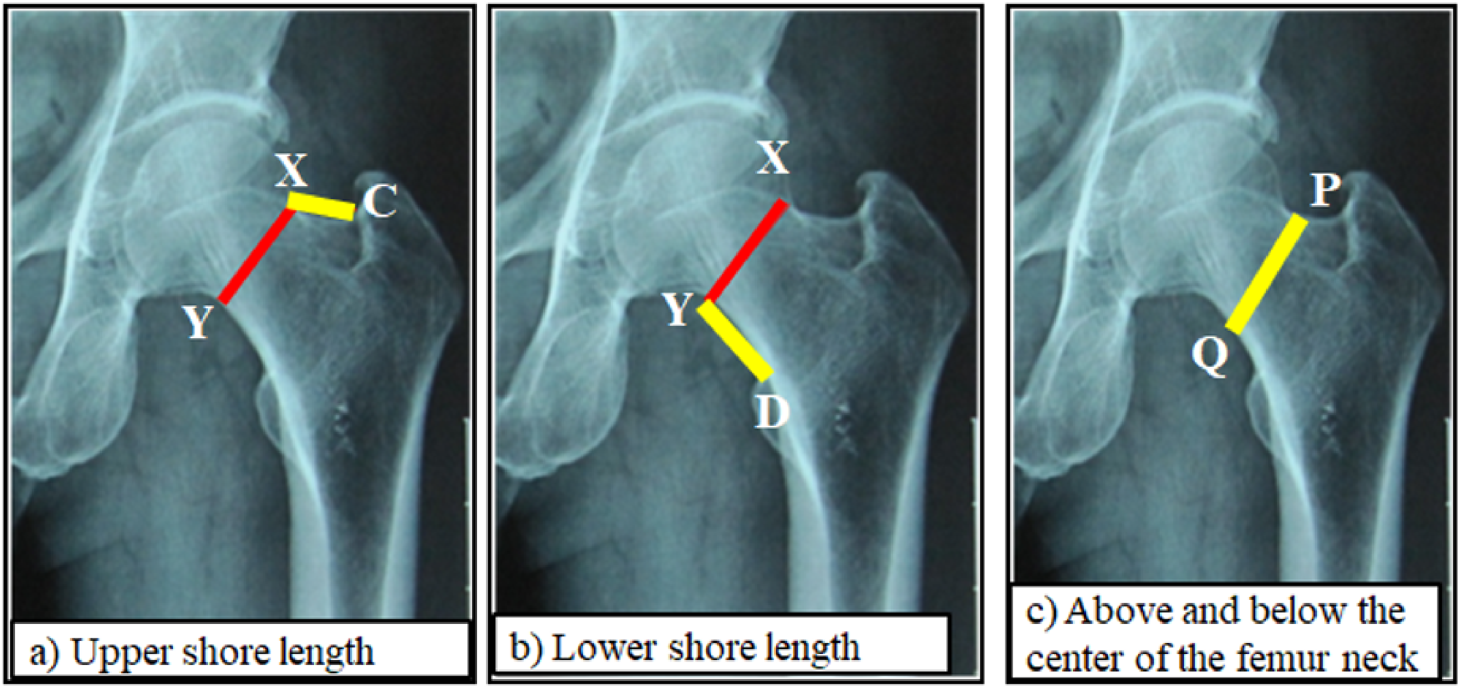


Figure 1

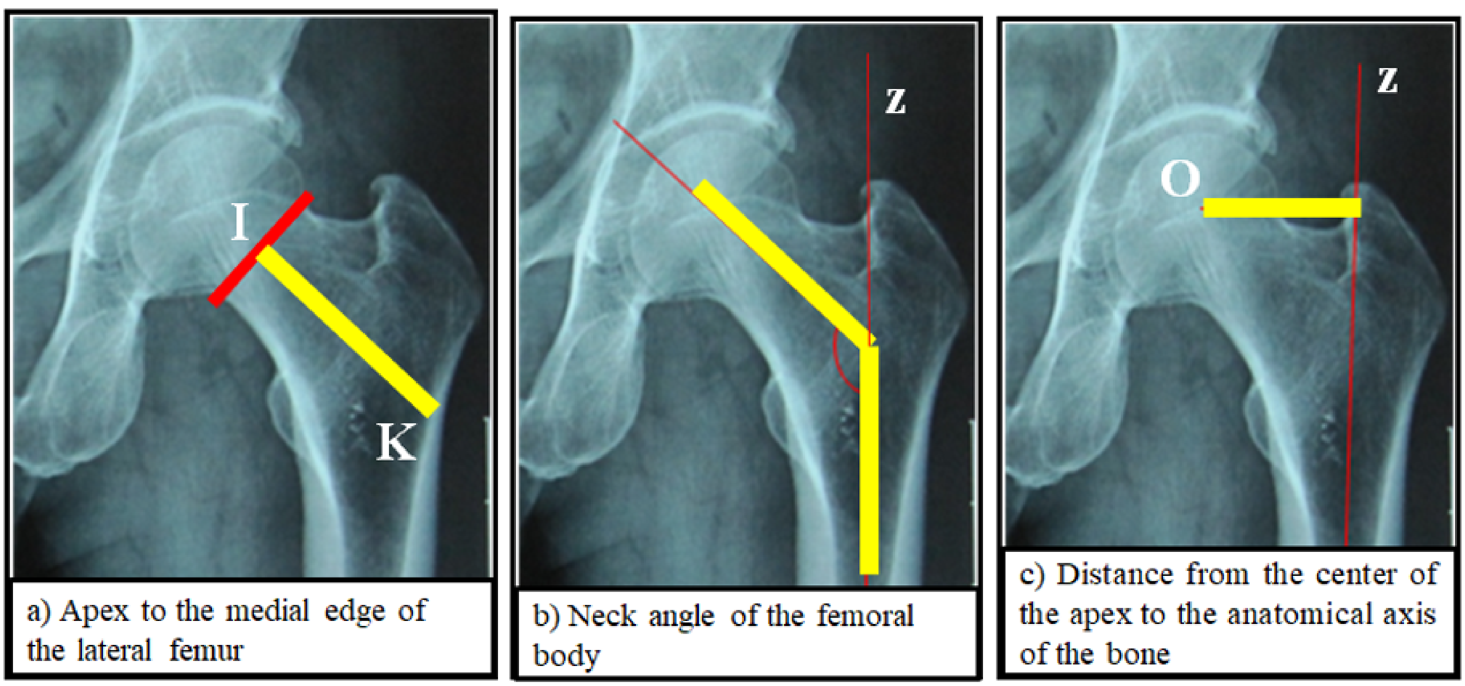
Dimensions of the acetabulum



a) Upper shore length
b) Lower shore length
c) Above and below the center of the femur neck

Figure 2

Femur neck indexes



a) Apex to the medial edge of the lateral femur
b) Neck angle of the femoral body
c) Distance from the center of the apex to the anatomical axis of the bone

Figure 3

Indicators related to the selection and placement of the Spiron

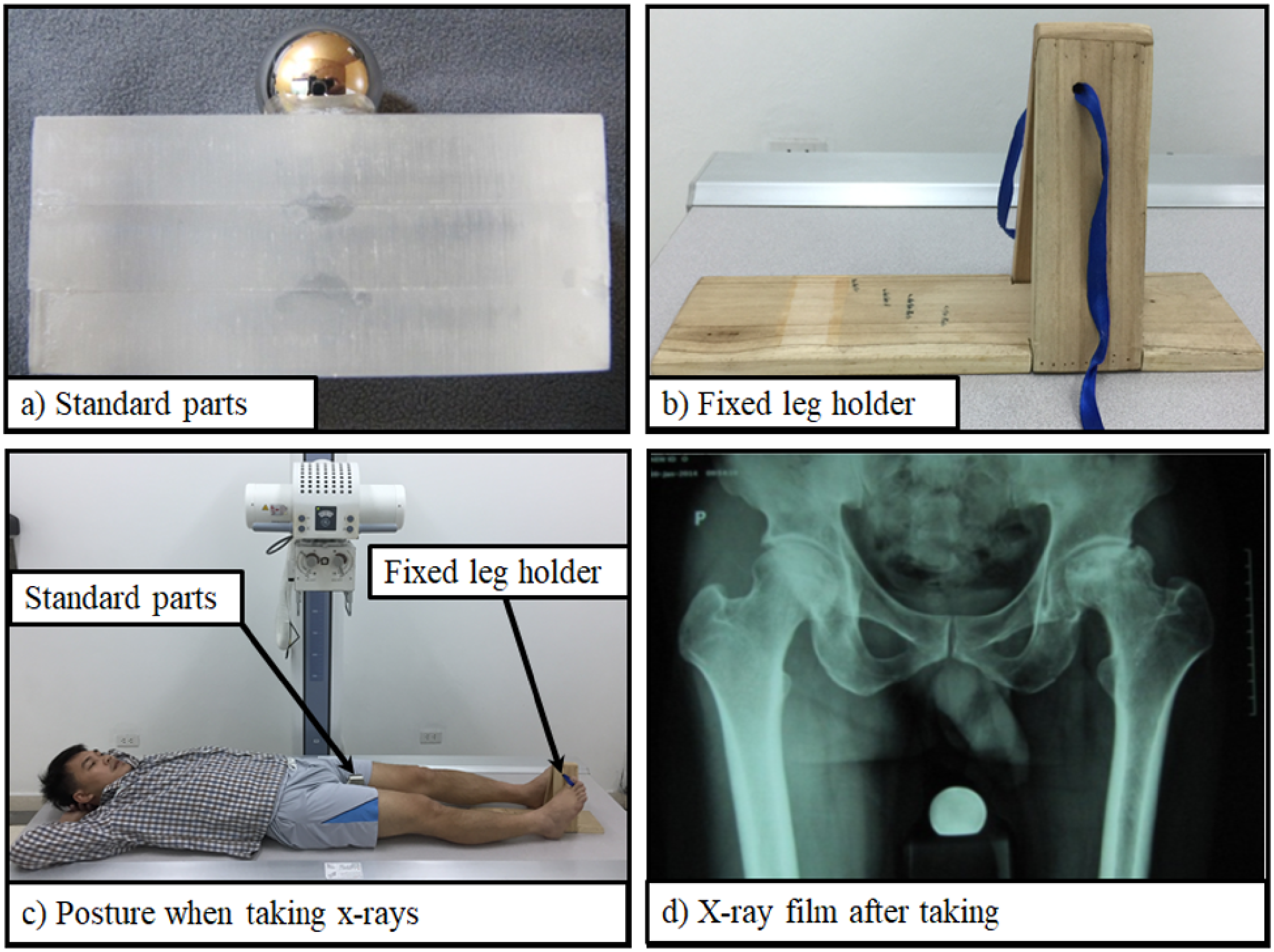


Figure 4

Standard part and X-ray position for the bilateral straight hip

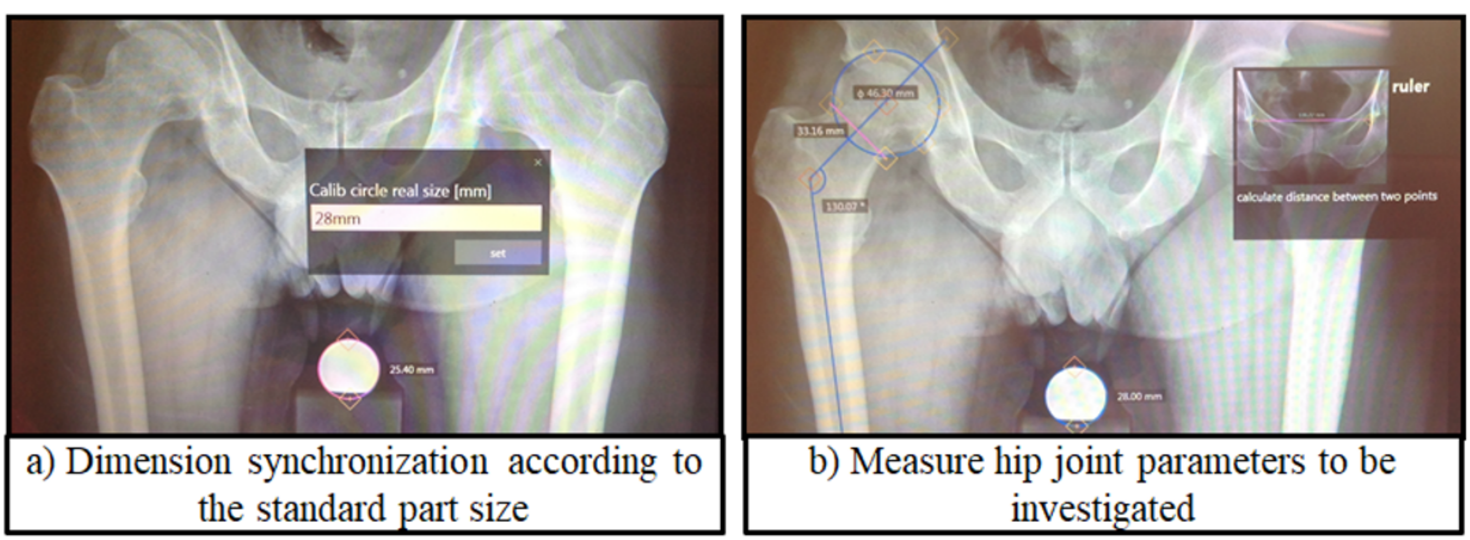


Figure 5

Measurement of hip joint indices on radiographs

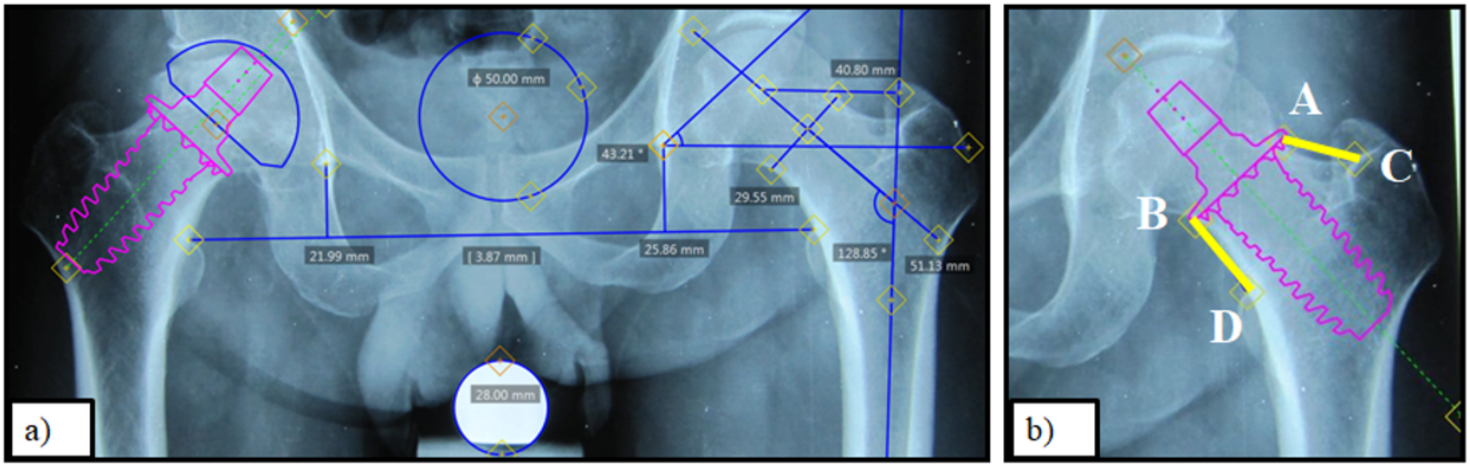


Figure 6

Preoperative planning on radiographs and formal femoral neckline determination

Figure 7

Diameter and angle of inclination of the acetabulum

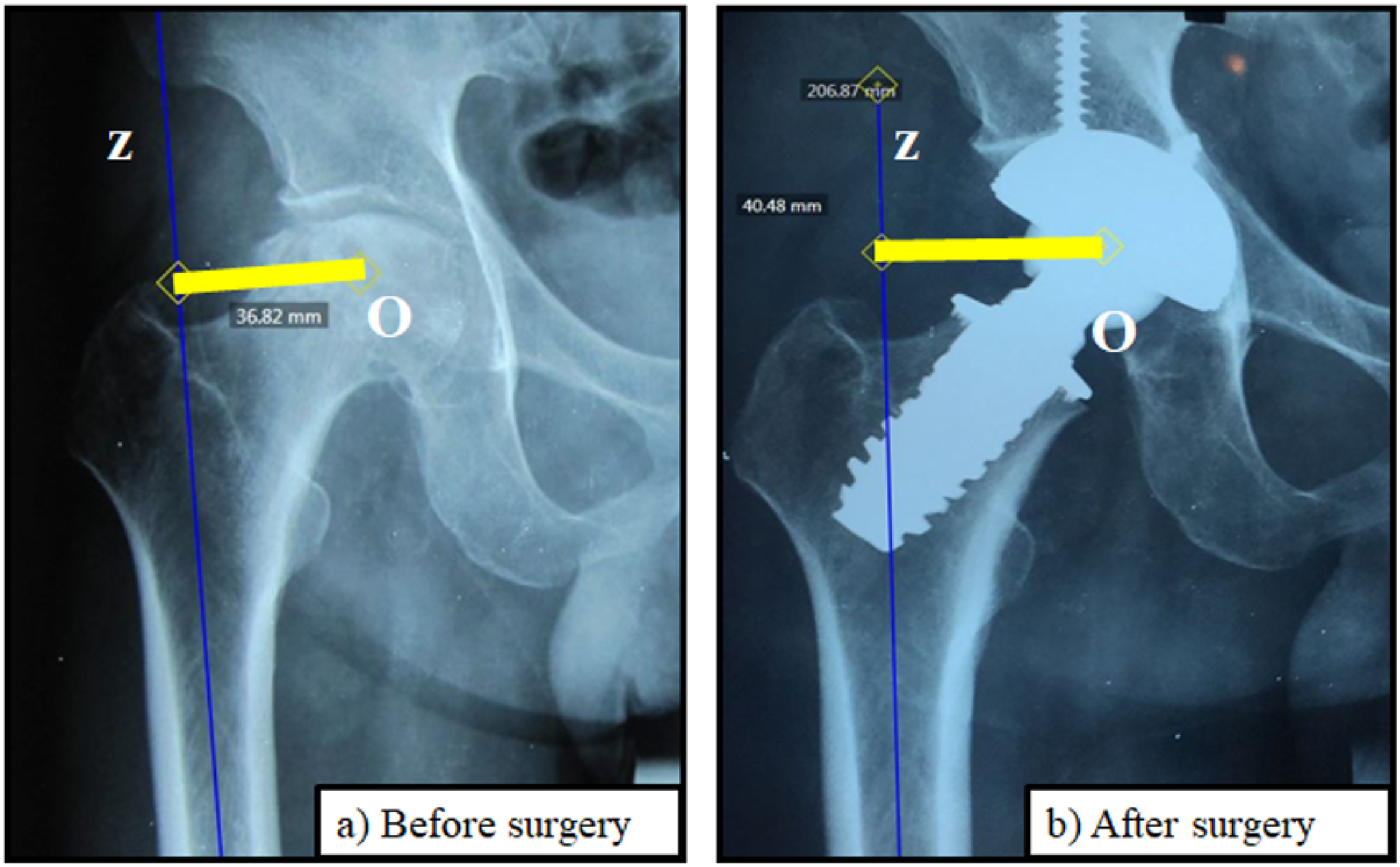


Figure 8

Distance from the center of the crest to the anatomical axis of the femur (offset)

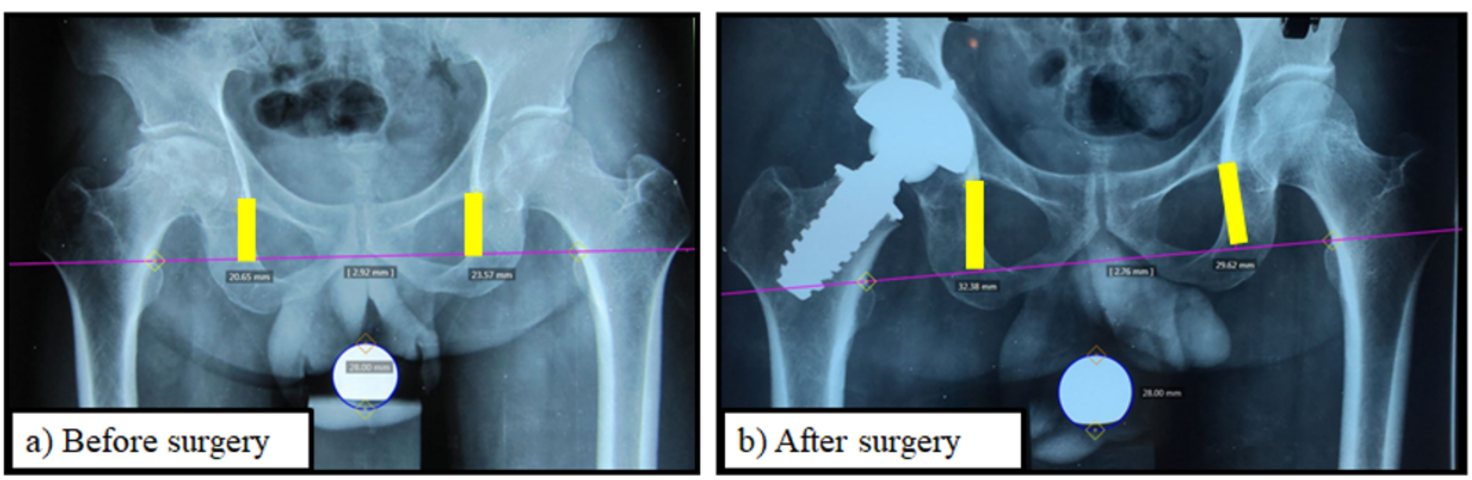


Figure 9

Distance from the inferior ridge in the acetabulum to the line passing through the superior border of the 2 minor trochanters and limb deviation