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The Proximal Femur in Egyptian (Morphometric and Radiological Study)

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Abstract

Introduction: Knowledge about the different diameters of the head and neck of femur is essential in orthopedic surgery for prosthesis and nail application. The aim of this study was to evaluate the average FNA in the young Egyptians and the effect of age on it. Also, matching sex and side differences of the angle were done by using CT. In addition, the different growth parameters of the proximal femur were measured by using plain X-ray. Side, sex differences and correlation analysis between these parameters were also done.

Material and methods: Two hundred cases subjected to the plain X-ray from both sexes (110 males and 90 females) with age above 25 years old were used in the present study. The following measurements were taken the vertical diameter of neck (VDN), vertical diameter of head (VDH), transverse diameter of neck (TDN) and transverse diameter of head (TDH). Computerized tomography (CT) pelvis for the FNA was done in fifty cases. The study was limited to children aged from 6-11years. The children were of both sexes.

Results: In the present work, there was a significant difference of the VDH in the female cases regarding side. It was 6% and 8% lower in females compared to that of males on the left and right sides respectively. Also, there was a significant difference of the TDH in both sexes regarding side in the present study. The TDH was 5% lower in females as compared to that of males on the both left and right sides.

Conclusion: The mean values of the main measurements of the proximal femur of Egyptians differed from the values found in other populations. There was a significant difference between the males and females. Strong correlation between the different diameters on both sides was found.

Keywords: Proximal femur; Egyptian

Introduction

Knowledge about the different diameters of the head and neck of femur is essential in orthopedic surgery for prosthesis and nail application. These normative values are essential for plastic and reconstructive surgeons in their reconstruction and medical rehabilitation. Also, these diameters are used in radiological practice to identify pathology of bone and for determination of age. Finally, morphometric data of femur help doctors and nutritionists to calculate body energy need for normal individuals, sex identification and in forensic medicine [1]. Femoral neck anteversion (FNA) is defined as the angle of torsion formed by the femoral condyles plane and plane passing through the center of the neck and femoral head[2]. It ranges from 15°-45° [3]. The FNA has to be taken into consideration when reduction and fixation is selected as a method of treatment[4]. Abnormal FNA sometimes can be associated with many clinical problems ranging from harmless intoeing gait in the early childhood to osteoarthritis of the hip and knee in adult [4]. Researchers worldwide have used various methods to measure the angle. The angle is measured mechanically on cadaveric bones as well as in patients by using roentgenography, ultrasound, CT and MRI [5]. The aim of this study was to evaluate the average FNA in the young Egyptians and the effect of age on it. Also, matching sex and side differences of the angle were done by using CT. In addition, the different growth parameters of the proximal femur were measured by using plain X-ray. Side sex differences and correlation analysis between these parameters were also done.

Material and Methods

Two hundred cases subjected to the plain X-ray anteroposterior view from both sexes (110 males and 90 females) with age above 25 years old as the ossification of the femur is completed by this age [6]. Computerized tomography (CT) pelvis for the FNA was done in fifty cases. The study was limited to children aged from 6-11years. The children were of both sexes.

The scans and X-rays were obtained from Alfa Scan Radiology Center, Al-Ahram Scan Radiology Center and Cairo Scan Radiology Center in the period from February 2015 to December 2015. The patients were referred from the orthopedic, musculoskeletal and physiotherapy clinics. Consents were taken from the patients to use their plain X-rays and from the parents of children to use their CT images in this study. The patients who had previous operative or non-operative treatment for hip joint were excluded as the treatment might alter the femoral neck anatomy. Also, the patients with neuromuscular diseases or teratologic dislocations (arthrogryposis or genetic syndromes) were excluded from this study.

The measurements of the study were done as the followings

1-Pelvic Axial Toshiba Asteion CT Scanner was used to measure the FNA angle CT was done as it is the most accurate method to measure

the FNA angle[7]. First, a line was drawn through the center of the femoral neck on the oblique axial images Figure 1A, next a line parallel to the posterior femoral condyles was drawn Figure 1B. These images and lines were then superimposed over one another. The angle between the drawn lines (Red arrow) was reported as the anteversion measurement and was recorded in degrees Figure 2. CT imaging was obtained with 4 different scanners GE VCT 64, GE Light Speed 16, GE Bright Speed 16, and GE plus 8 (GE Healthcare Technologies, Waukesha, WI) [7].

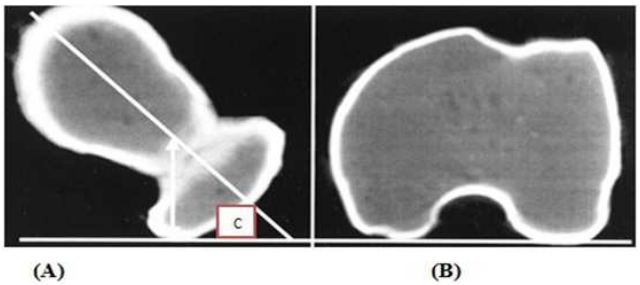

Figure 1 CT figures showing the centre of femoral head neck axis A, transcondylar axis B and note the angle of anteversion c.

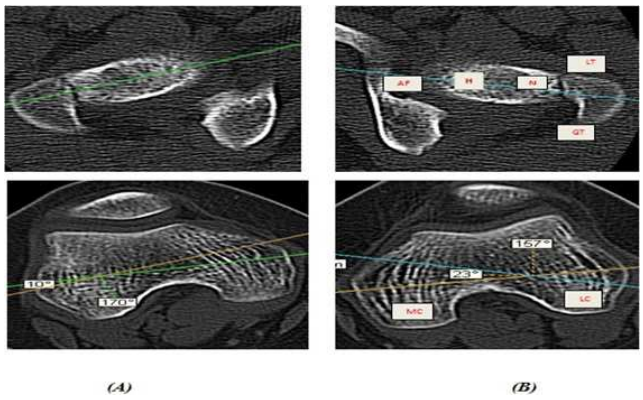

Figure 2 CT figures showing the way of measurement of FNA angle. The angle of anteversion in the right side is 10 degrees A. The angle of anteversion in the left side is 23 degrees B. Note: H: head, N: neck, LT: lesser trochanter, GT: greater trochanter, MC: medial condyle, LC: lateral condyle and AF: acetabular fossa.

2-X-ray pelvis AP view by Philips X-ray tube. The films were taken at a routine object film distance of 5 cm and focal-film distance of 92 cm in the antero posterior view and with the big toes touching on their medial aspects. A magnification correction factor of 2.86% was applied to set the following measurements Figure 3.

1-Vertical diameter of neck (VDN) is the minimum diameter of femoral neck in a plane perpendicular to the head neck midline [8]. 2-Vertical diameter of head (VDH) is the straight distance between the most superior to the most inferior point at the femoral head at right angle to the long axis of the neck of femur [9]. 3-Transverse diameter of neck (TDN) is the maximum distance of the long axis of neck both anteriorly and posteriorly [9]. 4-Transverse diameter of head (TDH) It was measured from the centre of the line of junction between head and neck of femur to the point of maximum curvature of the head, following the long axis of the neck of femur [9].

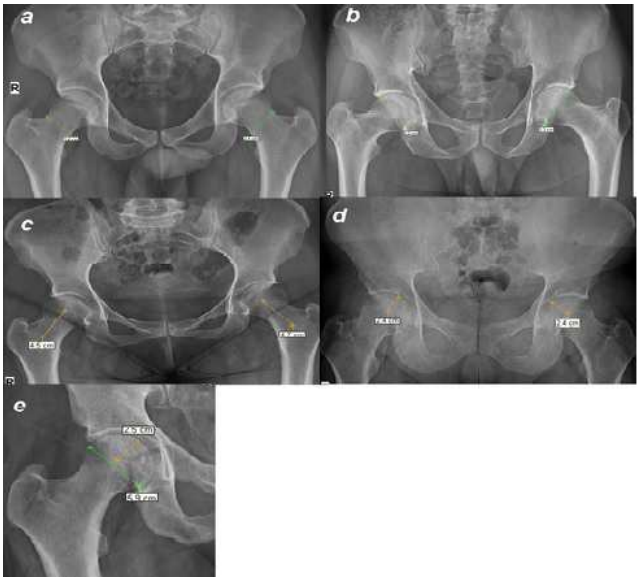

Figure 3 A plain X-ray pelvis, antero-posterior view, showing the way of measurement of the: VDN (a), VDH (b), TDN (c) and TDH (d). Note the TDH is perpendicular to the VDH (e).

Statistical Methods

The data were collected and studied using SPSS 20 statistical program. The mean and standard deviation (SD) were calculated for all variables. The quantitative data were examined by Kolmogrov Smirnov test for normality. The paired t test was performed to compare between the different parameters regarding side and sex. Level of significance was considered at P-value<0.05.

Pearson correlation was done to correlate between the following parameters

The VDH and the VDN

The VDN and the TDN

The VDH and the TDN

The VDN and the TDH

The VDN and TDN

The TDH and the TDN

All these correlations were done on both sides. Level of significance was considered at P-value<0.05. Finally the simple linear regression analysis was done to study the effect of age on the FNA.

Results

Two hundred plain x-rays anteroposterior view have been studied in the present work. The age of the individuals from whom x-rays were obtained ranged from 25 to 75 years. They were distributed into 110 (55%) males (42.66 ± 13.97 years) and 90(45%) females (46.53 ± 15.69) Figure 4.

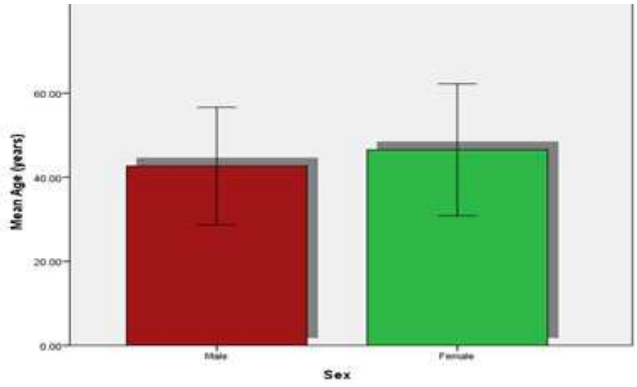

Figure 4 Bar chart showing distribution of sex and mean ± SD of the age of the studied population.

Vertical diameter of head of femur

The VDH ranges 4.2-6 cm on both sides of female with mean values of 4.86 cm, 4.87 cm in the right and left side respectively. It ranges 4.6-6.4 cm on both sides of male with mean values of 5.30 cm, 5.29 cm in the right and left side respectively. There was a significant side difference in female (p=0.05) however, no side difference observed in male Table 1.

Transverse diameter of head femur

The TDH ranges 1.3-2.8 cm on both sides of female with the mean values of 2.29 cm, 2.33 cm in the right and left side respectively. It ranges 1.7-2.9 cm on both sides in males with mean values of 2.43 cm, 2.46 cm in the right and left side respectively. There was a significant difference between the TDH in both male and female concerning the side (p=0.000) Table 1.

Sex			Paired Differences					t Value	Significance
			Mean	SD	SE	95% Confidence Interval of the Difference			
						Lower	Upper		
Male	Pair 1	Right vertical diameter of head - Left vertical diameter of head	0.01	0.19	0.02	-.02-	0.05	0.66	0.51
	Pair 2	Right vertical diameter of neck - Left vertical diameter of neck	-.02-	0.08	0.01	-.04-	-.01-	-3.19-	.00*
	Pair 3	Right transverse diameter of head - Left transverse diameter of head	-.03-	0.07	0.01	-.05-	-.02-	-4.93-	.00*
	Pair 4	Right transverse diameter of neck - Left transverse diameter of neck	-.03-	0.07	0.01	-.04-	-.02-	-4.46-	.00*
Female	Pair 1	Right vertical diameter of head - Left vertical diameter of head	-.02-	0.09	0.01	-.04-	0	-1.97-	.05*
	Pair 2	Right vertical diameter of neck - Left vertical diameter of neck	-.02-	0.09	0.01	-.04-	0	-2.05-	.04*
	Pair 3	Right transverse diameter of head - Left transverse diameter of head	-.04-	0.08	0.01	-.05-	-.02-	-4.43-	.00*
	Pair 4	Right transverse diameter of neck - Left transverse diameter of neck	-.02-	0.08	0.01	-.03-	0	-2.10-	.04*

Table 1 Mean differences between the different studied variables based on sex

Vertical diameter of neck femur

The VDN ranges 2.8 cm to 4.5 cm on both sides in female with the mean values of 3.46 cm, 3.48 cm in the right and left side respectively. It ranges 3.3-5.4 cm on both sides in male with mean values of 3.87 cm, 3.89 cm in the right and left side respectively. There was a significant side difference in both male and female (P<0.05) Table 1.

Transverse diameter of neck femur

The TDN ranges 3.3-6.7 cm on both sides in female with mean values of 5 cm, 5.02 cm in the right and left side respectively. It ranges 3.5-7 cm on both sides of male with mean values of 5.43 cm, 5.46 cm in the right and left sides respectively. There was a significant side difference in both male and female (P<0.05) Table 1.

The values of the all studied parameters were higher in males as compared to their similarities in females Table 1.

Correlation among the different diameters of femur on the right side

There were positive correlations among the different diameters of femur in the right side between the right VDH and the right VDN (r=311, p<0.000), between the right VDH and the right TDH (r=0.424, p<0.000) , between the right VDH and the right TDN (r=0.501, p<0.000), between the right VDN and the right TDN (r=0.210, p<0.003) and finally between the right TDH and the right TDN (r=354, p<003). Contrary, there was a strong negative significant correlation between the right VDN and the right TDH (r=0.482, p<0.000) Figure 5.

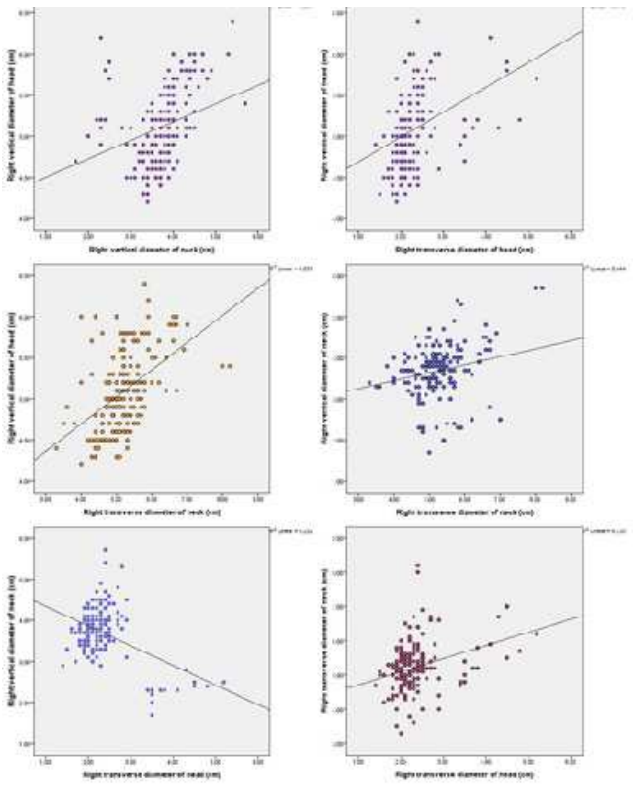

Figure 5 Scatterplot showing the correlation among the different diameters of femur on the right side.

Correlation among the different diameters of femur on the left side

There were positive correlations among the different diameters of femur in the left side between the left VDH and the left VDN (r=287, p<000), left TDH (r=0.395, p<0.000), left TDN (r=0.510, p<0.000) , between the left VDN and the left TDH (r=-0.478, p<0.000), between the left VDN and the left TDN (r=0.210, p<0.003) and finally between the left TDH and the left TDN (r=0.352, p<0.003) Figure 6.

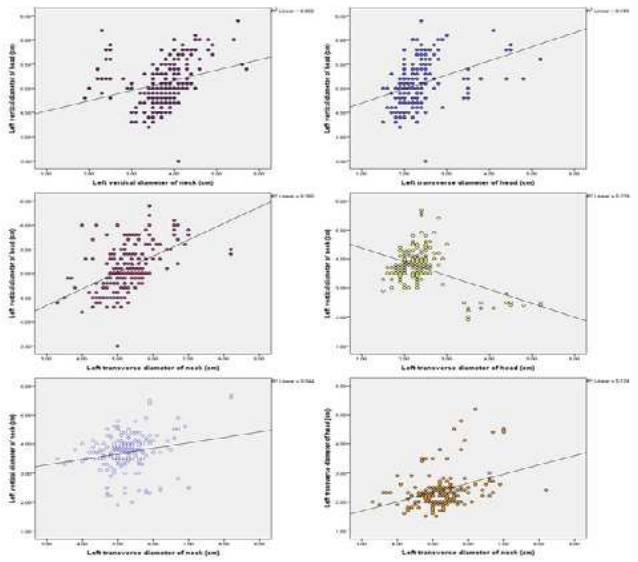

Figure 6 scatterplot showing the correlation among the different diameters of femur on the left side

Femoral neck anteversion angle

The age of the individuals from whom CT scan were obtained ranged from 6 to 11 years. They were distributed into 25 males and 25 females with the mean age of 8.36 ± 2.12 years Table 2. *= Statistically significant

Sex		Age	Right FNA	Left FNA
Male	N	25	25	25
	Mean ± SD	8.36 ± 2.12	22.44 ± 5.14	23.42 ± 7.14
Female	N	25	25	25
	Mean ± SD	8.36 ± 2.12	22.22 ± 5.12	23.60 ± 7.22

Table 2 Mean SD and SEM of the FNA angle in degrees based on sex.

In the present study there was no incidence of retroversion in any of the studied population. All children showed anteversion. The mean (± SD) values of FNA were 22.44 ± 5.14 and 23.42 ± 7.14 degrees on the right and left sides respectively in male. They were 22.22 ± 5.12 and 23.60 ± 7.22on the right and left sides respectively in female Table 2. Statistical analysis revealed significant (p<0.01) greater average anteversion in the left side as compared to that in the right side Table 3.

The linear regression analysis was done and showed significant negative linear effect of the age on the FNA (R=0.56, P=0.000). 31% of the FNA was explained on base of age (R2=0.314). The degree of the FNA can be calculated according to the next equation Table 4. FNA=33.685-1.358 x age years.

		Mean	SD	SE	Significance
Pair 1	Right femoral neck anteversion	22.33	5.08	0.72	0.001*
	Left femoral neck anteversion	23.51	7.11	1.01	

Table 3 Comparison between the right and left FNA

	R	R2	Std error of the estimate	P	Coefficients β	Slope of the age group
				Value		
Age versus femoral neck anteversion	0.56	0.314	4.25	0.000*	33.685	-1.358-
R=simple correlation, R2=R square, Std. error=standard error, *=statistically significant						

Table 4 Regression analysis of the age versus the FNA angle

Discussion

Analysis of the dimensions from the local population is essential as it provides crucial information required to design a more suitable size and shape of implant. This information is important especially when dealing with femoral neck fracture where the use of larger diameter screw may eventually cause avascular necrosis of the femoral head [10].

In the present work, there was a significant difference of the VDH in the female cases regarding side. However, Non-significant difference was observed in the VDH in the male cases regarding side. It was 6% and 8% lower in females compared to that of males on the left and right sides respectively. Also, there was a significant difference of the TDH in both sexes regarding side in the present study. The TDH was 5% lower in females as compared to that of males on the both left and right sides. Many authors documented the difference between the previously mentioned parameters regarding the sex and side in different groups of populations such as China, Thailand, Central India, Gujarat and North India [1,11,12].

The VDH and TDH in adult American male and female were higher [11] than these of the present study. Implants for the replacement of diseased hip joint are mostly developed by European and American manufacturers, presumably using the dimensions of their respective population. These implants come in different sizes to suit the various sizes of their population. However due to the relatively small built size of Egyptians, local surgeons have a fewer choice of size available to them. The search for a perfect match seemed to be more challenging and may require some ingenuity from the surgeon [13].

On the opposite side, the VDH and TDH in adult male and female Caucasians and Mongoloid [14], South Indians [15] and Brazilians [16] were lower than these of the present study. The South Indian populations are vegetarians, so they lack the protein in their food habit and this may be the reason for their low dimensions [8]. In addition, the TDH in the current work was smaller than that of the Nigerians [17]. Nigerians are taller than average Egyptians and so their femoral heads are bigger than that of Egyptians and Indians. This observation also indicates its value in regional differentiation [17].

The variations of the value of the VDH and TDH among different populations may be attributed to races, heredity, climate and other geographical factors. So, every population has their own metric standards [18].

Concerning the sex difference of the VDH and TDH in the present study, as stated before, the VDH and TDH were lower in females as compared to these of males. Many researchers reported similar findings in different group populations such as Malaysians and Nigerians populations [17]. The mean head diameter of male femur was significantly greater than the mean head diameter of female femur; because male individuals had greater mechanical stress than females [19]. The presence of sexual differences in the measured parameters is of great applied and practical value in the medico legal field [8].

Also, in the present work, there were significant differences of the VDN and TDN a regarding sex and side. Both of them were significantly higher in males as compared to their similarities in females. The VDN was 10% lower in females as compared to that of males on the both left and right sides. The TDN was 7% and 8% lower in females as compared to theses of males on the right and left sides respectively. In support of the current work, many authors reported similar side differences of theses parameters among populations from India and Brazil [1,15,16]. The mean of all these studies, were lower than theses of the present study. The difference among different populations might be attributed to genetic factors, environment, physical activity and socioeconomic status of different populations [8].

Concerning the sexual difference of the VDN and TDN in the current study, both parameters were lower in females as compared to these of males. Many researchers reported similar findings in different group populations [16].

In our study, all males and females children showed anteversion. On the contrary, some FNA retroversion was found in Caucasians and Mongoloid population [14]. Abnormal FNA sometimes can be associated with many clinical problems [2], so it is important to conduct preoperative investigations of the FNA for patients who will undergo operations on their femoral heads and necks. The FNA is important in reconstructive surgery such as total hip arthroplasty, and many researches have been undertaken in order to develop the optimal orientation of the hip prosthesis. Some studies found that anteversion of the prosthesis of 10-15° in achieve optimal hip stability together with optimal range of motion [20].

The mean value of the FNA in the current study was similar to the findings among the Indian populations [14,21]. These similarities may be attributed to the similarity of the environment and social way of life of the Indian and Egyptian populations as the latter author stated.

The FNA varies through a wide range, thus making it extremely difficult to determine normal range for a society [21].They added that it is multi-factorial as a result of evolution, heredity, fetal development, intrauterine position and mechanical forces. Overall the mean value of FNA of the present study was not only different from that of the Western society [22] but also different and lower as compared to that of the African and other Asian populations [23]. Muller et al. 2015 measured FNA angle of three different races, namely European, African and two Asian groups using same method and same setting. This study showed gross differences between the mean FNA values of different races. Their mean values were 15.7° for African, 11.1° for

European, 23.0° for Asian and 33.4° for the Inuit group which was a subpopulation of Asian group. This study sounds as the bias of different technique of measurement was eliminated [23].

In the present study, the left FNA was 5% greater than that of the right side (P=0.001). Right to left side differences in the FNA have been documented in several studies including Western, African and Indian ones [14]. Some studies have found significantly higher values of FNA value for left side such as in Iraq male children and in some Indian population [21]. Other studies reported in other Indian population higher FNA value for in the right side [14].

The angle difference between the sides is also a matter of debate. In the current study, the angle side difference was 1.18°. In Indian studies, the angle side differences were 0.9° [21], 2.8° [14], 6.4°, 0.2° and 0.6° [24]. The angle side differences were 4° in Iraq, 0.8° in Pakistani and 0.7°in Thailand [24]. The important reason for the great disparity between different studies of the same populations may also be due to different methods, different axes at proximal and distal end of femur to define the FNA [22,25].

The unique in our current work was that we design a new equation for the calculation of the FNA which is applicable to the Egyptian population. This equation based on the effect of the age on the FNA. 31% of the value of the FNA can be explained on basis of age. Still 69% of the value of the FNA depends on other variables. The equation is The degree of the FNA=33.685-1.358 x age.

Up to our knowledge no one did a correlation analysis study on the different parameters of the proximal end of the femur. This was a unique point in our study. Correlations among the TDH, TDN, VDH and VDN were done in the present study. The knowledge of correlations among the different parameters of the proximal end of the femur is a very important step to seal the gap between the Western design nails and the actually needed one for the Egyptian population, as these Western nails mostly are not suitable to the Egyptian population.

It could be concluded that the mean values of the main measurements of the proximal femur of Egyptians differed from the values found in other populations. There was a significant difference between the males and females for all the variables, both on the left side and on the right side. The males presented higher values than those of the females. Strong correlation between the different diameters on both sides was found. Also, a significant side difference of the FNA angle has been observed in Egyptian population.

We recommend use the current data to be used as a guideline to design a more suitable implant for the Egyptians. This will give better information to engineers and clinicians in the development of implants and practice related to the hip joint.

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