



## Article

### Femoral neck-shaft angle in Sohag population and its variation relating to age

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#### Abstract

The femur is the longest and strongest bone in the human body. It is about 45 cm in length in an average man. The femoral neck-shaft angle (NSA) is very important in the diagnosis and treatment of many pathological conditions relating to the femur and hip joint. Our study aims to evaluate the values of femoral NSA and detect the relationship between this angle and age in the Sohag population. 3-Patients & Methods CT scans of 300 patients (40. 90 years, range of 18 – 60 years; 150 females). CT scans were reformatted to three-dimensional pelvic models (3D) simulating standardized radiographic views of anteroposterior roentgenograms of the pelvis in the anterior pelvic plane (APP). NSA values were 129.45° (range 116.1°–146.7°; SD 4.88°) for patients aged from 18y to 39y & 129.48° (range 115.7°–145.9°; SD 5.25°) for patients aged from 40y to 60y. There was no statistically significant difference regarding NSA & age as p-value = .785 (p-value > .05). Correlation analysis revealed no significant relationship between NSA and age.

#### Keywords

Proximal femur 1, Neck-shaft angle (NSA) 2, Computerized Tomography (CT) 3, Morphometry 4, Age 5

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## 2. Introduction

The femur, or thigh bone, is the strongest and longest bone in the body, measuring about 45 cm in length in an ordinary man, or almost one-fourth of their height. It has a cylindrical shaft with an upper and lower end. The head, neck, greater and lesser trochanters, inter-trochanteric line, and inter-trochanteric crest make up the upper end. The neck is about 5 cm long, connects the head to the shaft, and is pointed upward, medially, and slightly forward, forming a 125-degree angle with the femur shaft in adults, but higher in children. The expanded neck-shaft angle allows for a wide range of hip joint movement, allowing the limb to swing freely (Sinha et al., 2017). The angle produced by the neck axis and the long axis of the femur shaft is known as the neck-shaft angle (NSA). It's also known as the femur neck angle, inclination angle, collodiaphyseal angle, cervicodiaphyseal angle (Anderson and Trinkaus, 1998) caput-collum-diaphyseal angle (CCD) (Shrestha et al., 2018), and Mikulicz angle (Sinha et al., 2017). The normal neck-shaft angle ranges from 115 to 140 degrees (with a mean of 126 degrees) (Shrestha et al., 2018). Men had a mean neck-shaft angle of 130.3 degrees, ranging from 121 to 138 degrees, whereas women had a lesser

mean femoral neck-shaft angle of 128.7 degrees, ranging from 119 to 137.2 degrees (Sinha et al., 2017).

The angle gradually lowers from roughly 150° in neonates to around 133° at 15 years old (Fischer et al., 2020). Coxa valga refers to an angle > 135 degrees. Coxa vara refers to an angle less than 120 degrees (Mishra et al., 2009). The neck-shaft angle is for diagnosing and treating a femur fracture at the upper end (Isaac et al., 1997).

Our study aims to evaluate the values of femoral NSA and detect the relationship between this angle and age in the Sohag population.

## 2. Materials and methods

Cross-Sectional Descriptive study analysis of NSA in hips in 300 normal Sohag healthy adults (≥18 & ≤ 60 years). The study gained the approval of the ethical committee (MREC) in the faculty of medicine, Sohag university, Egypt (*Soh-Med-21-04-05*). This study was registered at Clinical trials.gov (*NCT04846465*). Our study followed the principles of the declaration of Helsinki. Ethical approval and written consent from the participants were waived due to the retrospective design of the present study. However, their personal information will anonymize and de-identify before analysis. We conducted the study in the Departments of Radiology and Anatomy, Sohag Faculty of Medicine, affiliated to Sohag University, in Upper Egypt. The study was conducted from 1 January 2021 to 31 November 2021. Our study included 600 hip bones in 300 normal Sohag healthy adults (≥18 & ≤ 60 years).

We initially screened in picture archiving and communication system (PACS) the images of the participants who underwent computed tomography (CT) of the femur and acetabulum.

Inclusion criteria: Participants must be Sohag adults aged 18 or older, have eligible and enough imaging data for assessment and be free of the following illnesses that could influence NSA measurements. Exclusion criteria: Foreigners or non-Sohag population, age under 18 years, age over 60 years, incomplete imaging data; fracture, arthritis, tumor, deformity, or surgery on the proximal part of the femur or acetabulum, presence of metallic implants in the pelvis or proximal femur, immature skeletal system, incomplete availability of medical or radiologic data, and insufficient depiction of the proximal femur.

Groups of patients

Two groups

1. Patients aged 18-39 years old
2. Patients aged 40-60 years old.

Each group included 150 CT scans. Each hip (n = 600) was analyzed separately.

We used Computed Tomography (CT) in the determination and measurement of femoral neck-shaft angle through an anteroposterior scanogram of the pelvis and thigh. We used 16 slice CT scanner (Activation, Toshiba Medical, Tokyo, Japan). The scanning parameters were: Standard resolution, 120 kVp, 20–100 mAs, 0.75 s rotation time, one × 16 mm collimation, 15 pitch (pf 0.938/hp 15), Filter: fc17 soft tissue, 1 mm slice thickness, 0.8 mm increments, Window: WW 300/wl 50 soft and WW 1500/wl 200 bone, 15 s scan time, 17 mGy CTDIvol and 495 total DLP mGy.cm. All scans went below the lesser trochanter's bottom border. All data was stored in a picture archiving and communication system (PACS).

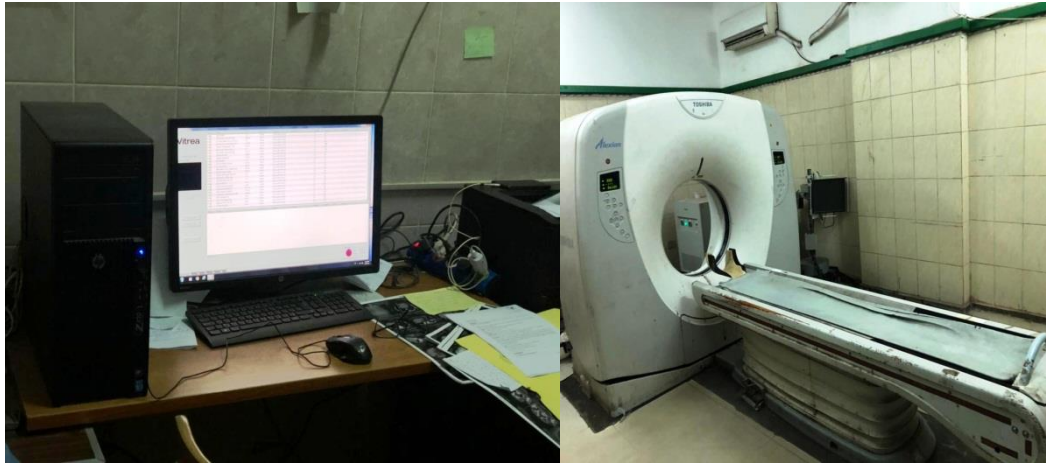


Figure 1. Work station & CT scanner in Radiology department in Sohag University Hospital  
Planes and reconstructions for measurements

We converted CT scans into three-dimensional pelvic models that simulated standardized radiographic views of the pelvis in the anterior pelvic plane on an anteroposterior roentgenogram (APP) (Jóźwiak et al., 2015)

#### Reconstruction of the anterior pelvic plane (APP)

We used the extended multiplanar reconstruction for the reconstruction (EMPR).

The coronal plane was the plane that passes through the anterior edge of the pubic symphysis in sagittal view and the anterior superior iliac spines (ASIS) in axial view, in view focused on the pelvis in all three planes.

Then, we centered the axial and sagittal images on the symphysis.

After that, we rotated the coronal and axial planes until both ASIS in the coronal reconstruction on the same axial plane (Figure 2a).

After that, we chose a parallel plane through the femoral head, and the EMPR slice thickness was increased from 1 to 200 mm, resulting in a pseudo anteroposterior roentgenogram of the pelvis (Figure 2b).

Then, using the Müller method, determine the angle of the femur neck shaft.

Using this method, we were able to measure both the RT and LT angles at the same time.



Figure 2a. Extended multiplanar reconstruction of the anterior pelvic pla

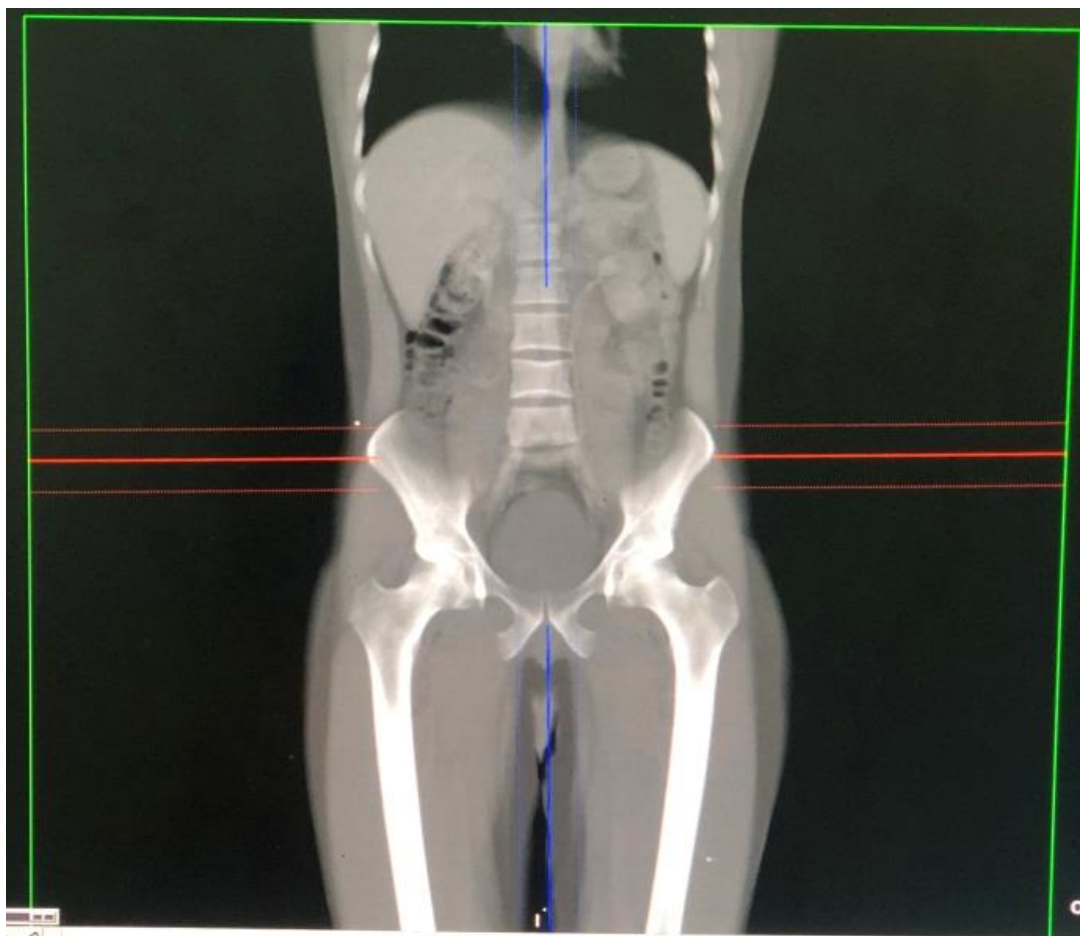
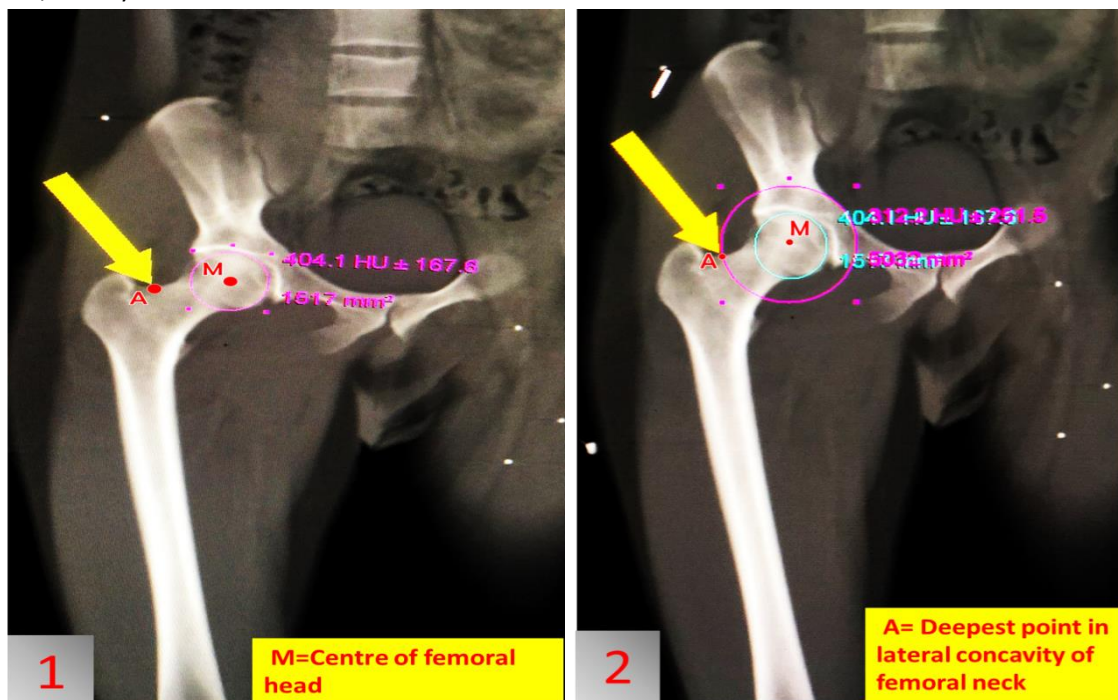


Figure 2 b. Simulated anteroposterior pelvic radiograph in the anterior pelvic planeMüller method for an accurate reconstruction of the NSA

We used a circle template or a computer-assisted approach to find the femoral head's center. The lateral section (outermost point) of the epiphysis and the medial corner of the femoral neck served as reference points for the circular arc. (Figure 3.1)

1. On the lateral border of the femoral neck, we marked the point of the deepest concavity (Figure 3. 1)
2. Draw another circle across that spot, this time using the femoral head as the center (Figure 3. 2)
3. The circle's intersections with the femoral neck were linked (Figure 3.3). Draw a line perpendicular to that line through the center of the femoral head. That line represented the femoral neck axis (FNA) (Figure 3. 4)
4. Draw a line perpendicular to that line through the center of the femoral head. The femoral neck axis (FNA) was that line (Figure 3. 4)
5. At two points along the femur shaft, draw two circles. The lower boundary of the lesser trochanter was the center of circle one, and the second circle was 2 cm below it. Locate the circles within the femurs outside borders.
6. Drawn line through the middle of two circles. This line represented the femoral shaft axis (FLA) (Figure 3. 5)
7. The NSA was the meeting point of the FLA and the FNA (Figure 3.6) (Waldt et al., 2013; Boese et al., 2016)



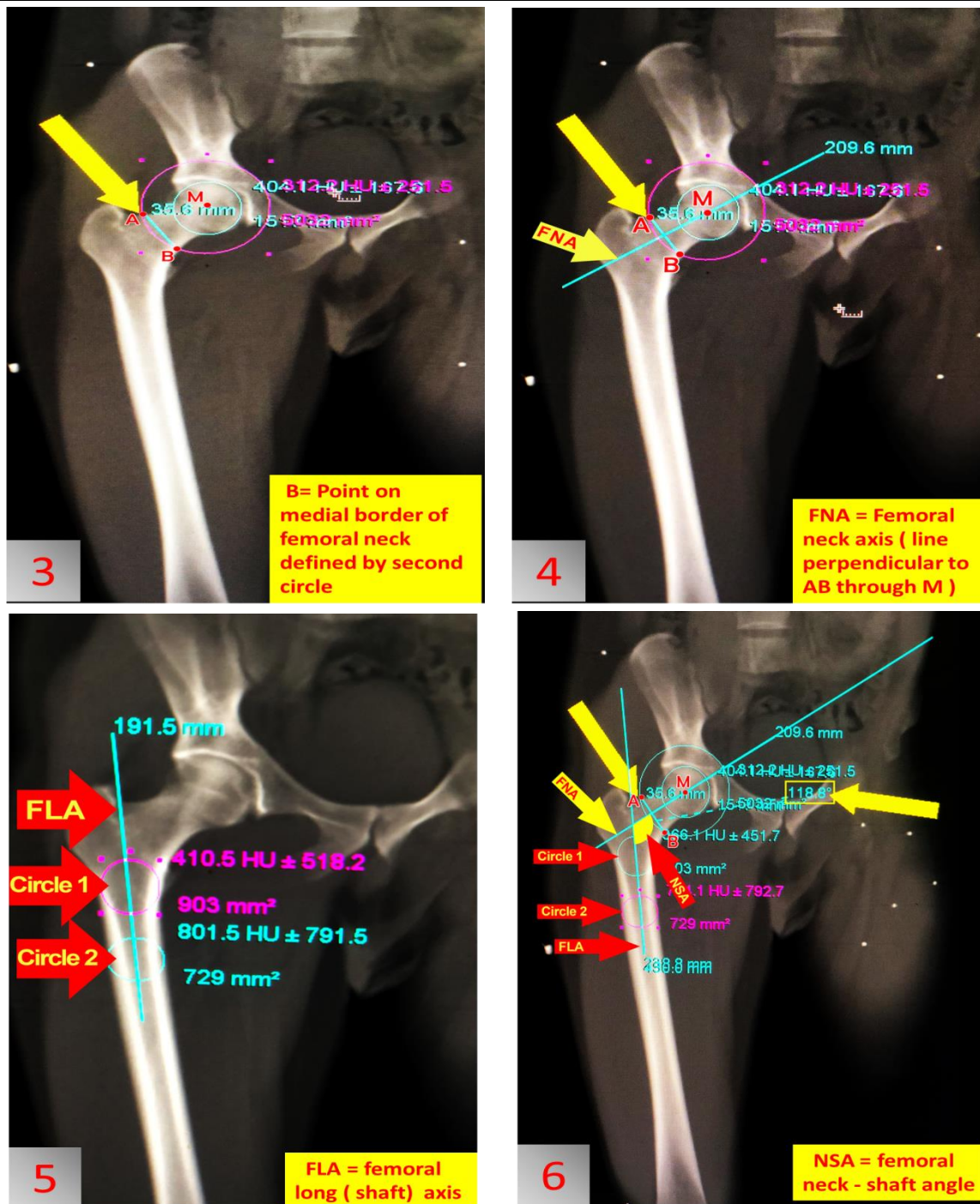


Figure 3. Muller method  
Morphometric and Statistical analysis

Variable ranges, absolute mean values, and standard deviation (SD) were presented for descriptive analysis. We used The Kolmogorov-Smirnoff test to determine whether the variables were normally distributed or not. We used The Spearman correlation coefficient ( $\rho$ ) to describe non-Gaussian distributed variable correlations. For non-normally distributed variables, we used the two-tailed Wilcoxon matched pair test for exploratory analysis. The Mann–Whitney–U test or the Kruskal–Wallis test was for the age factor and the NSA. The significance level was at  $p$  0.05. We used IBM SPSS Statistics and Microsoft Excel 2010 version 14.0.4734.1000 for statistical analysis.

### 3. Results

The mean age of all 300 patients was 40.90 years (18–60, SD 12.556 years).

Age-dependent NSA measurements were shown in table 2.

It was evident from table (2) that Age-dependent NSA measurements show no significant difference ( $p > .05$ ).

Table 1. shows the mean values ( $\bar{x}$ ) & standard deviation (SD) and standard error (SR) of age-dependent femur neck-shaft angle (NSA) of 600 femur bone of patients of Sohag governorate by reconstruction of the anterior pelvic plane (APP) (2021)

	AGE group AGE (18-39)			AGE (40-60)			P value
	Mean	Range	Standard Deviation	Mean	Range	Standard Deviation	
NSA	129.45	116.10 - 146.70	4.88	129.48	115.70 - 145.90	5.25	0.785

Spearman's rank correlation coefficients between femur neck-shaft angle( NSA) and age were given in Table 2.

Correlation analysis revealed no significant relationship between NSA and age.

Table 2. shows Spearman's rank correlation coefficients between femur neck-shaft angle (NSA) and age of 600 femur bones of patients of Sohag governorate (2021)

Projection NSA	AGE in YEARS	
	spearman's	P value
	0.034	0.399

#### 4. Discussion

The present study showed that NSA (APP) values were  $129.45^\circ \pm 4.88^\circ$  for patients aged from 18y to 39y &  $129.48^\circ \pm 5.25^\circ$  for patients aged from 40y to 60y. There was no statistically significant difference regarding NSA & age as  $p$ -value  $> .05$ . Correlation analysis revealed no relationship between NSA and age.

These results were consistent with Shrestha et al. (2018) They discovered that NSA did not differ substantially with age after the age of 21 and that neither RNSA nor LNSA ( $p=0.66$  and  $p=0.16$  respectively) changed much with age. As a result, they discovered that age has no bearing on the outcome.

Furthermore, Ziabari et al. (2020) discovered that NSA did not differ significantly between age groups.

Also, Gilligan et al. (2013) discovered that there was no consistent change with increasing age. The mean ages and correlations with NSA for these samples, both separately and together, we're all somewhat negative, indicating a minor trend toward a marginal reduction in NSA during adulthood, although none of these correlations approached statistical significance despite acceptable sample numbers.

On the other hand, Boese et al. (2016) discovered that age has a substantial impact on the NSA. Varus hips are more common in both sexes as they get older, whereas valgus hips are less common, which could be due to physiologic changes and lower bone mineral density. A substantial relationship between NSA and age was discovered using correlation analysis.

Also, Zaghoul et al. (2020) Our research found a statistically significant drop in NSA as people get older, confirming the influence of aging on femoral NSA.

Also, Boese et al. (2016) found significant differences between age groups ( $p < 0.001$  in all planes). Only weak negative associations between age and M NSA were found using the Spearman rho correlation coefficient (Scout:  $\rho = 0.351$ ; APP:  $\rho = 0.190$ ; FNP:  $\rho = 0.209$ ;  $p < 0.001$  for all).

## 5. Conclusion

Based on the outcome of the present study, we concluded that regarding NSA: correlation analysis revealed no significant relationship between NSA and age.

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الملخص العربي  
**التباين في زاوية عنق عظم الفخذ في مجتمع سوهاج حسب العمر**  
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عظم الفخذ هو أطول وأقوى عظمة في جسم الإنسان. يبلغ طوله في الإنسان حوالي 45 سم. تعتبر زاوية عنق عظم الفخذ (NSA) مهمة جدًا في تشخيص وعلاج العديد من الحالات المرضية المتعلقة بمفصل الفخذ والورك. يهدف العمل إلى تحديد القيم الطبيعية لزاوية عنق عظم الفخذ والكشف عن العوامل التي قد تؤثر على هذه الزاوية، مثل العمر عند البالغين المصريين من سوهاج. المرضى والطرق المستخدمة: التصوير المقطعي المحوسب لـ 300 مريض (متوسط العمر 40.90 سنة، المدى 18-60 سنة 150 إناث). تمت إعادة تنسيق فحوصات التصوير المقطعي المحوسب لنماذج الحوض ثلاثية الأبعاد التي تحاكي مناظر التصوير الشعاعي المعيارية للمخططات الشعاعية الأمامية الخلفية للحوض في مستوى الحوض الأمامي (APP). كانت قيم (NSA(APP) = 129.45° (النطاق 116.1° - 146.7°؛ الانحراف المعياري 4.88°) للمرضى الذين تتراوح أعمارهم من 18 عامًا إلى 39 عامًا و 129.48° (النطاق 115.7° - 145.9°؛ الانحراف المعياري 5.25°) للمرضى الذين تتراوح أعمارهم من 40 عامًا إلى 60 عامًا. لم يكن هناك فرق معتد به إحصائياً فيما يتعلق NSA & العمر حيث إن قيمة  $p = 0.785$  (قيمة  $p < 0.05$ ). كشف تحليل الارتباط عن عدم وجود علاقة ذات دلالة إحصائية بين NSA والعمر.